Customer needs management for product innovation : segmentation modeling and ontology-based approaches

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**NANYANG
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**CUSTOMER NEEDS MANAGEMENT FOR PRODUCT
INNOVATION:
SEGMENTATION MODELING AND ONTOLOGY-
BASED APPROACHES**

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**SCHOOL OF MECHANICAL AND AEROSPACE
ENGINEERING**

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**Customer Needs Management for Product Innovation:
Segmentation Modeling and Ontology-Based
Approaches**

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ABSTRACT

Customer satisfaction has always been important for a product. Attaining customer satisfaction requires identifying genuine customer needs and establishing the relationship between customer needs and product features. Involving innovative customers in the product development process has been considered an effective way for customer needs management. However, previous studies are limited in innovative customer identification. In particular, they ignore the mismatching problems in customer needs representation between customer needs and intangible product characteristics. To address these limitations, there is a need for an integrated framework that is able to cover both the customer domain and product design domain at the stages of customer needs identification and product specification establishment in product development life cycle.

This thesis aims at building a novel customer needs management system (CNMS) that provides the link between the customer domain and product design domain. The customer needs management system is established based on an Involvement-Thinking-Feeling (ITF) segmentation model and an ontology-learning customer needs representation (OCNR) system. The ITF model can be used to study the innovative characteristics of customers as well as help identify large groups of customers with different degrees of innovativeness. Using the OCNR system, high level customer needs related to low level product characteristics can be represented by extracting non-taxonomic relations between concepts.

Furthermore, the CNMS can also help realize automated customer needs acquisition, translation and representation.

Three case studies were conducted to validate the CNMS. The results from these case studies indicated that the ITF model can help identify more innovative customers in an easier way. In particular, 59 innovative customers are identified by the ITF model while at most 25 lead users (i.e., passionate customer) could be found using the lead user criteria. The customer needs ontology derived from the proposed system contained more semantics compared with those from the existing ontology learning systems. Specifically, 204 non-taxonomic relations were extracted from the customer needs ontology while only 24 from the expert-generated ontology. Besides, the hit rate of the customer needs ontology for the concepts and relations were around 80% which is considered high enough so that most of the useful information can be accounted for by the extracted concepts and semantic relations. In addition, the non-taxonomic relations generated by the OCNR system received the lowest noise score compared to those by the existing ontology learning systems. All these findings suggested that the proposed CNMS can provide useful inputs for the succeeding stages in the product development process.

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LIST OF PUBLICATIONS

Journal Papers:

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CHAPTER 1

INTRODUCTION

This chapter explains the problem leading to this research, which is identified as the deficiency in past research for customer needs management. Customer needs management is of critical importance for achieving greater customer satisfaction. In this chapter, research objectives and scopes are defined, and an outline of a technological roadmap for this research is provided.

1.1 Background

Empirical research has shown the importance of continually introducing new products (Delin, 2007). However, more than 80% of new products fail in today's fast-paced market (Delin, 2007). Nowadays, customers are better educated and have greater access to information, and thus become more demanding than ever before (Alam and Perry, 2002). This trend urges product designers to appreciate customers' growing sophisticated needs and improve customer satisfaction (Alam and Perry, 2002).

Achieving customer satisfaction through the design process begins with customer needs management. Customer needs information can help enterprises specify product characteristics that customers seek, and add values for products. Only those companies that can effectively acquire customers' genuine needs and

address these needs in product design could succeed in the marketplace (McKay et al., 2001). Therefore, it is crucial to accurately identify genuine customer needs and to implement them in product design (Ulrich and Eppinger, 2008).

In the existing customer needs management research, customer-oriented product design is an effective design strategy (Mao et al., 2005). In order to facilitate obtaining genuine customer needs, the customer-oriented product design requires integrating innovative customers into the product development process (Gruner and Homburg, 2000; Khurana and Rosenthal, 1998). Customer involvement emphasizes the innovative inputs from customers during the product development process (Kaulio, 1998).

By involving customers in early product design stage, customers' roles could shift from source of basic needs to source of desires, and further to source of creativity. Customers become co-creators, co-designers and innovators. Integrating inputs from innovative customers in product design process is believed to be a powerful means of reducing failure rates of new products (Rohrbeck et al., 2008). Thus, it is crucial to identify the innovative customers and involve them into the product development process.

A number of researches (Kristensson et al., 2004; Lethje, 2004, Nambisian, 2002; Von Hippel 1986;) have emphasized the importance of innovative customers and their inputs in the product design process, and conducted much work in identifying the essential innovative customer characteristics. However, the past

research related to innovative customer identification has two major limitations. First, traditional innovative customer identification methods (e.g. focus group, survey, interview) lack the capability to identify large groups of innovative customers efficiently given the constrained resources and limited time (Spann, Ernst, Skiera, & Soll, 2009). In particular, innovative customers were identified only as those who have all the lead user characteristics. Those who have the innovative potential but lack one perspective of lead user characteristics were always ignored. Second, the innovative characteristics of customers from many perspectives, such as lifestyles, psychographics, usage behaviors, were not well studied. As a result, a well-tested criterion for innovative customer identification is missing in product design.

How to represent customer needs is another important issue that shall be addressed by the customer needs management research. Different methods have been proposed in this aspect including the classic psychological models (Maslow, 1943; Alderfer, 1967) and many AI (Artificial intelligence) techniques, such as fuzzy systems (Turksen and Willson, 1992), evolutionary computation (Fogel et al., 1966), intelligent agents (Gentili et al., 2001) and expert systems (Chen and Occena, 2000; Hauge and Stauffer, 1993a). These methods were able to address domain-specific customer needs and represent customer needs in subjective and objective ways. However, two major challenges still exist. First, customer needs are expressed using written statements that are derived directly from the

interpretation of the customers' linguistic descriptions (Kuřar et al., 2007). However, this interpretation process almost always involves much imprecise information and vague descriptions (Zhai et al., 2009). The second challenge lies in that high-level customer needs, which are defined as ambiguous and abstract customer needs (e.g., sporty cars and cute cameras) , need to be embodied by designers through low-level product characteristics, which is defined as tangible and concrete product features, such as colors, materials, and shapes (Cao et al., 2011). The high-level customer needs are often fuzzy and vague that makes it difficult to connect low-level characteristics of the product with customers' genuine high-level needs in product design.

1.2 Objectives

The research presented in this thesis is expected to make contributions to innovative customer identification and customer needs representation, and further build a customer needs management system. The research questions that the candidate attempts to address in this thesis are:

1. How to identify large groups of innovative customers efficiently?
2. How to develop a well-tested criterion for innovative customer identification?
3. How to develop precise customer need statements?
4. How to embodying high-level customer needs?

Therefore, the objectives of this study are:

1. To identify large groups of innovative customers with different degrees of innovativeness in product design.
2. To explore a universal criterion and the potential variables regarding innovative characteristics of customers from a broad scope of disciplines.
3. To build a knowledge-based technique that is able to overcome the limitation due to imprecise information and vague descriptions in the customer needs representation process.
4. To embody high-level customer needs by using low-level product characteristics.

1.3 Scope

Accordingly, the scope of this research is as follows:

1. This research will covers classical theories and methods in customer needs management, such as customer segmentation, customer involvement, and lead user theory together with data mining, natural language processing, and artificial intelligence (AI) methods.
2. This study is conducted from a broad scope of disciplines i.e., marketing theory and cognitive psychology, to get universal criteria of customer's characteristics of innovativeness.

3. This study focuses on the front-end design process, especially the phase of customer needs management.
4. The proposed system will be evaluated only using tangible products (i.e., ‘digital camera’) in the case study. Intangible products, such as software and service, are not included in the evaluation.

1.4 Thesis Organization of the Thesis

This thesis is organized as follows. Chapter 2 provides a comprehensive literature review of the state-of-the-art research in terms of two essential domains: customer domain and product design domain. The literature review is organized according to the different stages of the customer needs management process, including customer needs acquisition, customer needs representation, and product specifications establishment. Chapter 3 depicts the framework of a conceptual model for customer needs management. Chapter 4 presents a customer segmentation model for innovative customer identification and illustrates the feasibility and potential of the customer segmentation model using a case study. Chapter 5 proposes an ontology learning system for customer needs representation and uses a case study of digital camera reviews to justify the usefulness of the proposed prototype ontology-based customer needs representation system. Chapter 6 validates the overall customer needs management system framework using a case

study. Chapter 7 summarizes the thesis with a conclusion and suggestions for future work.

CHAPTER 2

LITERATURE REVIEW

This thesis focuses on the customer needs management process. Section 2.1 gives an overall picture of the position of customer needs management in the product development process. Section 2.2 provides an overview of the research dealing with the general aspects of the customer needs management in the front-end product development process. Sections 2.3, 2.4 and 2.5 present the research in separate stages of customer needs management: customer needs acquisition, customer needs representation and product specifications establishment, respectively. Section 2.6 discusses the fundamental elements related to customer needs management. Finally, through critical evaluation of the existing solutions to the customer needs management problems, the gap of the research are identified and stated.

2.1 Customer needs management in the product development process

In a conventional model, a product development process is defined as a sequence of steps or activities including conceiving, designing and commercializing a product (Ulrich and Eppinger, 2008). To date, a number of well

accepted models of the product design process have been proposed (e.g., Baxter, 1995; Suh, 1990; Ulrich and Eppinger, 2008). Among these models, the classic model proposed by Ulrich and Eppinger (2008) is one of the most advocated (Fig. 2.1).

The front-end process is the chaotic initial period of the new product development process (Verworn et al., 2008). It is essential for product development since 50% of the development time is spent in this phase (Smith et al., 1999). The front-end process includes all activities from the search for new opportunities to development of a concept. It ends when the company approves and begins formal development of the concept (Koen et al., 2001).

Figure 2.1 General product development process (Ulrich and Eppinger, 2008)

According to Ulrich and Eppinger's model (2008), product development begins with the front-end process that involves a planning phase and a concept development stage (Fig. 2.1). In the planning phase, corporate strategies are developed and assessments of technology developments and market objectives are specified. The output of the planning phase is the project's mission statement,

which serves as the input required to begin the concept development phase and as a guide to the development team. The concept development phase involves several sub-stages including customer requirement solicitation and product specifications establishment, concept generation, concept selection, concept testing and final specification (Fig. 2.2).

Figure 2.2 Concept development process (Ulrich and Eppinger, 2008)

Although Ulrich and Eppinger's model (2008) highlights the importance of the front-end process, especially the concept development phase in the whole product development process, many issues within the front-end process still need further systematic investigation. Specifically, the issue of defining product specifications by capturing, analyzing and understanding customer needs or voices of customer (VoC) has received great attention in recent years (Zhou et al., 2013). In other words, customer needs management needs to be well taken care of in the front-end process.

Understanding and fulfilling each individual customer's needs has been recognized as a great challenge for companies across industries (Jiao and Chen, 2006). As shown in Fig. 2.3, there are three main issues in customer needs

management: customer needs elicitation, analysis, and specification. Customer needs management is essentially concerned with the relationship between customer needs in the customer domain and product specifications or function requirements in the product domain or functional domain.

Figure 2.3 Customer needs management process (Jiao and Chen, 2006)

2.2 Research and approaches on customer needs management

With the increased complexity of products, sophisticated customer needs and intense competition in today's business environment, knowledge from different domains must be integrated in the product development process. Product development is an interdisciplinary activity requiring contributions from nearly all functions of the company, including manufacturing, purchasing, electronics, mechanical, industrial design, marketing and other extended functions (Ulrich and Eppinger, 2008). Amongst these functions, the four key functions are marketing, design, engineering (Ulrich and Eppinger, 2008) and psychology (Howard et al.,

2008). Jiao and Chen (2006) also pointed out product design bears a multidisciplinary characteristic that is engineering and marketing oriented. A large number of customer needs management approaches from multiple disciplines had been reported over the past two decades. Jiao and Chen (2006) classified the approaches for customer needs acquisition or elicitation into three groups: psychology-based approaches, artificial intelligence-based approaches, and knowledge discovery approaches, as shown in Fig. 2.4.

Figure 2.4 Multidisciplinary concerns on customer needs management

A number of complex customer behaviors, such as perceptions, motivations, attitudes, and personality, can be grouped under psychological factors for making rational decisions (Lancaster and Massingham, 1994). These psychological factors

affect customers' perceptions and decisions regarding a specific product. Kansei engineering is a technique to translate customers' psychological feelings about a product into perceptual product specifications (Nagamachi, 1995). Burchill and Fine (1997) applied the Kawakita Jiro (KJ) method and affinity diagrams to translate between the raw customer statements and well-refined customer needs to design elements. As a structured method based on Kelly's personal construct theory, the laddering technique has also been widely used to transform customers' psychological factors into functional specifications for design applications (Turksen and Willson, 1994).

Compared to subjective psychology-based approaches, techniques based on artificial intelligence (AI) appear to be more accurate due to their objective data collection and analysis (Jiao and Chen, 2006). Fuzzy systems (Turksen and Willson, 1992), neural networks (McCulloch and Pitts 1943), evolutionary computation (Fogel et al., 1966), intelligent agents (Gentili et al., 2001) and expert systems (Chen and Occena, 2000; Hauge and Stauffer, 1993a) are some of the AI techniques that have been employed to acquire customer needs. Integrated approaches that combined picture sorts and laddering methods, fuzzy evaluation, and neural network techniques were also proposed to solicit customer needs (Chen et al., 2002; Yan et al., 2002).

Although various approaches from a broad scope of disciplines have been proposed, how to obtain genuine customers needs has not been completely resolved.

The primary shortcoming with the current approaches is the lack of interaction with customers.

2.3 Customer needs acquisition

Acquiring accurate customer needs is essential in product development (Jiao and Chen, 2006). Many methods in the domain of customer needs acquisition have shown their applicability in needs elicitation, which is the first stage in customer needs management for product development (Shaw and Gaines, 1996). The stage of customer needs acquisition involves two aspects of research that address who are the target customers and how to acquire their needs, respectively. Both of these issues require customers to contribute their information and ideas. From designer's perspective, customer needs can be well addressed as long as the related technical specifications can be met. However, the specification process is never static but is instead quite dynamic throughout interacting with the product. Therefore, the demand for customer involvement in the product design process should be emphasized (Franke and Shah, 2003). Customer involvement can also be an important source for product innovation (Tietz et al., 2005). Better understanding of the interrelationship between customer satisfaction and customer's own justification of the design elements brings a brand new direction for managing

future customer needs. Besides, user innovation emphasizing ordinary end-users' involvement becomes an original supporting element in the design process.

Existing studies in user innovation limited the innovative customers to those lead users or professional users in industrial markets. However, integrating larger group of innovative customers from end users into the product design process becomes increasingly desirable (Kristensson et al., 2004). This means that ordinary customers can also develop their ideas, concepts and prototypes for new products. Therefore, end-user innovation may bring a new promising dimension to customer needs management because of their potential innovative inputs and the large number basis. However, involving ordinary customers also creates new challenges, such as how to distinguish between ordinary customers who have innovative characteristics and those who are just indifferent customers. It is also very difficult to distinguish between different types of innovative ordinary customers who show different aspects of innovativeness.

2.3.1 Customer involvement

Customer involvement is an efficient approach in customer-oriented product design for customer needs acquisition (Alam, 2002; Alam and Perry, 2002; Pitta and Franzak, 1996; von Hippel, 1986). An active engagement of customers in product development is required to integrate customers into customer needs acquisition activities.

Alam (2002) classified customer involvement into four levels: passive acquisition of input, information and feedback on specific issues, extensive consultation with customers, and representation. Kaulio (1998) grouped the degree of customer involvement into three levels: “design for”, “design with” and “design by”. An application of the “design for” strategy is Quality Function Deployment (QFD). In QFD, designers are the leading actors, while customers are just “objects” from which it is possible to elicit general needs. This strategy focuses on an initial diagnosis and deductive transformation of the initial needs into performance measures; the design process is guided by customer data (Kaulio, 1998). The “design with” strategy, in which customers provide feedback on one or more design concepts, is a way of maintaining a formal dialogue with the customers. Their reactions are then relayed to the designer. Because it is participative, the “design by” strategy is participative removes the division between the roles of customers and designers during the design process (Kaulio, 1998). Customers participate by making their desires known, as well as through active involvement in the development and selection of various design solutions. Therefore, customers are more actively engaged in the process of solving their own problems. Meanwhile, designer’s role is shifting as a facilitator who help to enhance customer’s chance to find solutions and actively engage customers in the design process (Kaulio, 1998). In contrast, only data on the customers are used in the “design for” strategy. In the “design with” strategy, customers may choose from an

array of solutions. In the “design by” strategy, customers actively participate in the design process.

Furthermore, Nambisan (2002) identified three types of benefits that customers can realize by participating in new product development: product or service related benefits, community related benefits and medium related benefits. The product or service related benefits include fulfilling customers’ peculiar needs, assuring the quality of products, knowledge enhancement, underlying technology usage and technology related curiosity. The community related benefits indicate that participation can enable customers to clearly perceive themselves as members of a community so that they can develop strong social identities and interpersonal relationships from interaction with the community. The medium related benefits are related to the positive customer experience provided by the communication medium (Nambisan, 2002). Among these benefits, product related benefits are primary drivers for customer involvement in the value creation process (Wayland and Cole, 1997).

The benefits of involving customers into the product development process to obtain customer needs have been clarified from past studies. However, which groups of customers should be involved and how should they be involved into the development process has not been well addressed in these research.

2.3.2 Innovative customer targeting

Past studies (Kristensson et al., 2004; Lethje, 2004, Nambisian, 2002; Von Hippel 1986;) suggested that innovative customers provided more accurate customer needs compared to ordinary customers in the customer involvement process. Therefore, identifying innovative customers and involving them in the product design process is extremely important to customer needs acquisition. However, how to target innovative customers and involve them into product design process remains a major challenge in the stage of customer needs acquisition.

2.3.2.1 Lead user theory for innovative customer targeting

The lead user theory, emerging from the studies of innovation, has been applied to the product development process (Brockhoff, 2003). Two key issues are concerned, i.e.,: 1) identifying lead users and 2) involving them in the design process. In order to identify the lead users, their characteristics must be identified (Alam, 2002; Edvardsson et al., 2006; Kaulio, 1998; Mannervik and Ramirez, 2006; Yang and Chen, 2008).

The lead user characteristics were widely used in previous researches to identify innovative customers from different perspectives (Gruner and Homburg, 2000; Luthje, 2004; Matthing et al., 2006; Morrison et al., 2004). Gruner and Homburg (2000) proposed four characteristics of innovative customers: technical attractiveness, financial attractiveness, closeness of relationship with customer, and

lead user characteristics. They found that involved customers, those with the financial means to purchase a product, and those with “end user” characteristics have a greater effect on the success of new products (Gruner and Homburg, 2000). However, this process is useful only with non-customized, mildly innovative new products and has been found to be less than useful in the context of new product innovation.

Using a large-scale empirical study, Luthje (2004) identified two independent dimensions of lead user characteristics: commitment to product field and innovation-related benefits. Morrison et al. (2004) and Matthing et al. (2006) defined the lead user characteristics from the perspectives of leading edge status and technology readiness.

Based on the lead user characteristics, past research defined different types of customers that are involved in the design process. For example, Mannervik and Ramirez (2006) presented a typology of four archetypes for customer involvement: form filler, interactive co-designer, real-time field source and integrated co-designer. These archetypes are based on a strategic perspective of the customer’s role as a co-innovator (Edvardsson et al., 2006). Von Hippel (1986) classified customers as average users and lead users. The average users are limited by their own expertise in terms of generating novel ideas or concepts. In contrast, the lead users, who are among the first to predict future conditions with strong potential for solving their present problems, are recognized as innovative customers. The lead

users were defined as being at the forefront of markets and having a great incentive to innovate. The lead users are also those who experienced the need for a given innovation earlier than the majority of the target markets (von Hippel, 1986). From this perspective, expertise and needs were found to be the essential attributes of the lead users (Bilgram et al., 2008).

However, past studies are limited in their understanding of whether specific customer characteristics can distinguish innovative customers from non-innovative customers and to what extent these innovative customers can undertake their innovation efforts (Luthje, 2004). Although some characteristics of the involved customers were suggested by a number of researchers, no integrative conceptualization of the underlying dimensions is available (Gruner and Homburg, 2000). In addition, most of the existing research on lead user theory has only segmented the customer into dichotomous lead users and non lead-users (or average users). Although most research employs the lead user theory to project an attractive return from lead users' innovation efforts, the lead users are scarce and few of them can be involved in innovation because of coordination constraints (Blazevic and Lievens, 2008). Further, the concepts on customer characteristics contain scattered information without providing a united and comprehensive model, and the study of customer involvement is often just from the product design perspective, without accounting for the information from marketing and psychological perspectives.

2.3.2.2 Market segmentation for innovative customer targeting

In modern marketing research, many researchers tried to classify customer types for different purposes. Market segmentation is the process to divide market into groups of customers based on defined characteristics such as purchase patterns (Bennett, 1996).

Marketers have used the market segmentation for years to learn about and understand customers' behaviors. Such segmentation enables producers to avoid head-on competition in the marketplace by differentiating their products and services based on the features such as price, styling, packaging, promotions, distribution method, and level of service.

Smith (1956) first introduced the concept of marketing segments to show the diversity or heterogeneity of customer needs. It was found that such concept allowed for more precise satisfaction of customers' varying desires. However, segmentation variables were not investigated in early segmentation research. Segmentation variables are defined as a set of selected attributes such as lifestyles, psychographics, demographics, usage behaviors, etc., which aggregate units in groups, in such a way that each group contains the most similar units (Chan et al., 2012).

Many effective segmentation techniques based on different segmentation variables have been developed (e.g., Cahill, 2006; Kotler and Armstrong, 1999).

Becker and Conner (1981) divided a consumer market based on “personality variables”, while Anderson et al. (1993) grouped customers according to social, economic and special segmentation variables. According to Cahill (2006), segmentation themes used to satisfy a number of criteria within the segment can also be divided into two major groups: those based on physical attributes (geographic, demographics and a combination of two geo-demographics) and those based on behavioral attributes of the customers (lifestyle, life stage, psychographics and usage). However, these variables, which are widely used to classify customer segment in many publications, cannot differentiate between the demographic and psychographic groupings of customers and thus are not useful in identifying sub-markets (Kotler and Armstrong, 1999).

Segmentation variables are not only found in conceptual studies, but also in some empirical studies in market segmentation theory. For empirical studies, the most frequently applied segmentation variables are demographics, geographic and economic (Hassan and Craft, 2005), and psychographics and values/attitudes (Abratt, 1993). The relevant literature on the market segmentation is summarized in Table 2.1.

Table 2.1 A Chronological Review of the Literature on Market Segmentation

Focus	Methodology	Segmentation variables
Recognition of differences in the needs of market segments ¹	Conceptual	N/A

Divide consumer market from “personality variable” ²	Conceptual	Personality variable
Group customers into segmentation variables ³	Conceptual	Social Economic Special variable
Marketing actions used to reach the chosen segments ⁴	Empirical	Social Economic Special variable psychographics Values/attitudes
Proposed four recognized segmentation variables ⁵	Conceptual	Geographic Demographic Psychographics Behavior variable
Determining major macro and micro variables with differential strategies ⁶	Empirical	Demographics Geographic Economic variable
Group two segmentation themes ⁷	Conceptual	Physical attributes Behavioral attributes

¹ Smith (1956); ² Becker and Conner (1981); ³ Anderson et al., (1993); ⁴ Abratt (1993); ⁵ Kotler (1997); ⁶ Hassan et al., (2003); ⁷ Cahill (2006)

Previous research on market segmentation is helpful in developing marketing strategies for different customer segments. However, past research limited the market segmentation in terms of providing insights during the development process of new products and focused primarily on the business-to-business context rather than on the context of developing new products (Kumar and Reinartz, 2012).

Market segmentation theory also lacks a complete view of customers and an analysis of relevant data to identify the underlying segments effectively.

Customer segmentation is an effective modeling approach in the market segmentation theory to divide a customer base into groups of individuals according to the factors such as needs, behaviors, and preferences. The customer segmentation approach provides a means for companies to effectively target groups

and to allocate marketing resources for the best results. Conceptually, the customer segmentation can be defined as the process of subdividing a market into distinct subsets of customers that behave in the same way or have similar needs (Foedermayr and Diamantopoulos, 2008). Thus, the customer segmentation aims to identify the taxonomy of different psychological or behavioral patterns within a given market or population.

Customer segments are created by analyzing the customer information from large data marts and data warehouses using data mining methods. Unlike the business rules used in traditional market segmentation theory (Kotler (1997), the customer segmentation methods can manage large numbers of attributes and reveal data-driven segments based on a specific segmentation model. The selection of segmentation methods depends on the specific objectives of the study (Tsipitsis and Chorianopoulos, 2010). For example, needs and attitudinal segmentation are often used to support new product development and key product characteristics to be communicated. Behavioral based segmentation is typically used to develop the customized product offering strategies.

In general, customer segmentation procedures include: deciding what data will be collected and how it will be gathered; collecting and integrating data from various sources; developing methods of data analysis for segmentation; establishing effective communication among relevant business units (such as marketing and customer service) about the segmentation; and implementing

applications to effectively deal with the data and respond to the information it provides (Aaker, 2001) .

Past research on customer segmentation techniques can be classified into two groups, namely supervised and unsupervised classification techniques. Cluster analysis methods represent the most common unsupervised market segmentation techniques in the literature and comprise a set of different techniques. Given a set of selected segmentation variables, these methodologies aggregate units in groups. Each group contains the most similar units and, at the same time, is the most dissimilar from the other groups. A recent study reported that clustering customer data into groups based on the fuzzy distance between customer data can help obtain more robust market segments resulting than other methods (Chan et al., 2012).

Another commonly used unsupervised method for customer segmentation is conjoint analysis (Green et al., 1981). It assesses the rank-order or overall value for alternatives with different profiles of attribute levels, and then uses the holistic judgement information to estimate discrete levels of single-attribute value functions by regressions, hierarchical Bayes models, or linear programming (Butler et al., 2008). Kohonen map or self-organized map is widely used for dimension reduction and clustering, concurrently for various applications of the multi-dimensional data (Rojanavas, 2009). Other artificial intelligent techniques, including simulated annealing algorithms (Bursco et al., 2002), neural network

(Boone and Roehm, 2002), and genetic algorithms (Liu and Ong, 2008), have also been applied to segment customers into clusters.

Besides unsupervised clustering methods, supervised classification methods are also applied for customer segmentation. Compared to unsupervised clustering methods, supervised classification requires generating representative parameters for each class before classification can occur, while unsupervised classification methods automatically identify the clusters from the dataset (Gonçalves et al. 2008). The unsupervised method is desirable where little a priori knowledge for classifying the data exists or when there is a need to avoid subjectivity in the classification process (Kelly et al. 2004). However, if supervision condition could be met, which means that membership of data points that can illustrate the general structure of the group is required in order to derive the classification rules, supervised data could be more accurate (Budayan et al., 2009).

In most marketing studies, customer segmentation is designed to increase customer value through careful customer targeting (Hwang et al., 2004). Different models in the customer segmentation have been developed to aid in developing marketing strategies for different customer segments, e.g., the lifetime value (LTV) model, based on customer value (Hwang et al., 2004), and the Recency, Frequency, Monetary (RFM) model, based on customer behavior (Hsieh, 2004). However, past research was limited in studying the innate correlation between customer segmentation variables and customers' innovative characteristics. For example,

customers' expertise related to products, which was mentioned earlier as an important behavioral variable in the customer segmentation, can help generate new products. However, the close relationship between customer expertise and customer innovative characteristics is ignored in the existing segmentation theory.

Customers offer a wide range of skills, sophistication and interests, and represent an untapped source of knowledge and competencies to companies during the process of their innovation activities (Blazevic and Lievens, 2008). Researchers have found that an alternative design team can be built by engaging the innovative customers whose expertise enables them to spot trends and make innovative contributions (Matthing et al., 2006). Therefore, customer expertise is a very important factor in market segmentation for innovative customer identification. It is necessary to identify and build the links that connect the customer segmentation to the innovative customer identification.

Past customer targeting research used customers' characteristics from both product design domain and customer domain to distinguish different types of customers. However, these studies did not specify whether specific customer characteristics can distinguish innovating customers from non-innovating customers and to what extent can they undertake their innovation efforts (Luthje, 2004).

2.3.3 Customer needs acquisition methods

Several methods of customer needs acquisition through customer involvement were suggested by Alam (2002), including face-to-face interviews; customer visits and meetings; brainstorming; customer observation and feedback; phone, fax and emails; and focus group discussions. These methods can be used at various stages in product development process. Among them, in-depth interviews, customer visits and team meetings are most commonly used (Alam, 2002). In addition to the traditional ways of discovering customer needs, the approach of online text mining has received increasing attention in the past few years, since more customer needs information is available from online sources such as online product reviews and online posts (Thelwall et al., 2010). Online product reviews often associate meta-data with each review that indicates positive and/or negative aspects of the products. Basically, the review data mining involves concept extraction and semantic relationships extraction. In text mining applications, concepts are often domain-specific terms that can be selected as keywords. The various types of relations between concepts can provide useful structure information for text mining (Kao and Poteet, 2007).

Natural language process (NLP), an application field of artificial intelligence (AI), is an experimental attempt to develop computer programs that help understand normal human speech patterns. Because it uses computers to analyze,

determine semantics, and translate between languages, the NLP can also be used in data mining research (Martinez, 2010).

There are two types of NLP approaches: the rationalist approach and the empiricist approach (e.g., Manning and Schutze, 1999). The rationalist approach assumes that heredity rather than the senses provides knowledge. The empiricist approach assumes the structure of language can be learned through statistical modeling of specified languages (Manning and Schutze, 1999).

Ideally, the NLP should be able to help determine both the structure and the meaning of text. It functions by breaking the sentences into small units and parsing them to obtain the grammatical structures. However, this process is extremely difficult because of the complexity, ambiguity, and grammatical idiosyncracies of languages (Martinez, 2010). Therefore, the issues in determining the semantics of individual words need to be further studied. Approaches such as part-of-speech tagging and parsing need to be further investigated in NLP research.

A standard process of NLP is that documents are broken up into paragraphs, paragraphs are broken into sentences, and sentences are broken into individual words. Words in a sentence are then tagged by Part of Speech (POS), and other features prior to the sentence are further parsed with grammatical analysis. Thus, parsers are typically built on sentence delimiters, tokenizes, stemmers and POS taggers. However, not all applications required a full suite of such tools (Jackson and Moulinier, 2002). Besides, wrong semantics could be extracted in certain

situations when using POS tag-based rules or shallow parsing techniques to extract concepts and relations.

2.4 Customer needs representation

The most important issue in the second stage of customer needs management is how to represent customer needs. The traditional process of interpretation of customer statements involves much imprecise information, which makes it very difficult to represent customer needs in the front-end process of product development. Past research on needs representation can be categorized into two groups: subjective representation method (e.g., the psychological models) and objective representation method (e.g., AI techniques) (Jiao and Chen, 2006).

2.4.1 Psychological models for customer needs representation

At any given time, the needs of customers vary widely. Biogenic needs arise from physiological states of tension such as hunger, thirst and discomfort. Psychogenic, needs arise from psychological states of tension such as the need for recognition, esteem and belonging. When the level of intensity causes action, the need becomes a motive (Kotler and Keller, 2007).

One of the most widely used need theories is Maslow's needs hierarchy proposed in 1943. Maslow (1943) claimed that people seek fulfillment and change through personal growth. Maslow conceptualized these needs or desire into a five-

level hierarchy, as shown in Fig. 2.5. The lower four layers of the pyramid are what Maslow called “deficiency needs” or “D-needs”, while the highest layer seeks to satisfy growth needs, which drives personal growth and self-actualization.

Figure 2.5 Maslow's Hierarchy of Needs (Maslow, 1943)

While Maslow's hierarchy makes sense from an intuitive standpoint, there is little evidence to support its hierarchical aspect. In fact, there is evidence that contradicts the order of needs specified by Maslow's hierarchy. For example, in some cultures, social needs are placed before any other types of needs. Maslow's hierarchy also has difficulty explaining cases such as the "starving artist", in which a person neglects lower needs in pursuit of higher ones. Finally, there is little evidence to suggest that people are motivated to satisfy only one need level at a time, except in situations where there is a conflict between needs (Tancock et al., 2010).

To address the shortcomings in Maslow's hierarchy, Alderfer (1967, 1969) developed the ERG (Existence, Relatedness and Growth) theory by aligning the needs hierarchy with empirical findings. Alderfer removed overlapping needs in Maslow's hierarchy, however, the result is still similar to Maslow's hierarchy, as shown in Fig. 2.6.

Figure 2.6 Hierarchy of ERG Needs Theory (Alderfer, 1967)

According to Alderfer's (1967, 1969) theory, man is motivated by three groups of needs, i.e., existence, related and growth (ERG). Existence needs include basic human needs necessary for existence, which are physiological and safety needs. Relatedness needs represent man's desires to maintain important interpersonal relationships, which are social acceptance, belongingness and status desires. Growth needs refer to man's desire for personal development, self-fulfilment and self-actualization.

The ERG theory allows different levels of needs to be pursued simultaneously and the order of needs to be different for different people. It also acknowledges that if a higher level need remains unfulfilled, the person may regress to lower level needs that appear easier to satisfy (Aydin et al., 2008).

Based on customers' hierarchy of needs, designers select, organize, and prioritize system design variables to satisfy these needs. Information about the needs may be gauged from different customer groups (Khalid and Helander, 2006). Therefore, the need structure, to a large extent, determines how the products should be designed.

2.4.2 Ontological methods for customer needs representation

Aside from psychological models, many AI techniques are also used in customer needs representation include fuzzy systems (Turksen and Willson, 1992), evolutionary computation (Fogel et al., 1966) intelligent agents (Gentili et al., 2001) and expert systems (Chen and Occena, 2000; Hauge and Stauffer, 1993a) . The use of knowledge discovery approaches, such as neural network (Chen et al., 2002) and association rule mining technique (Jiao and Zhang, 2005), are often combined with AI techniques to address domain-specific customer needs.

Ontology, in particular, as a prosperous AI method, uses concepts and relations to classify domain knowledge. As a formal and rigorous approach for knowledge representation, ontology can provide precise and unambiguous

semantics for terms (Lin et al., 1996). For these reasons, the potential of ontology in supporting product knowledge representation has attracted widespread attention from researchers in the product design domain (Lin et al., 1996).

Many studies used ontology to facilitate customer needs management (e.g., Baida et al., 2005; Bock et al., 2010; Lin et al., 1996; Smirnov et al., 2005). Among the first such reports, Lin et al. (1996) used ontology to support customer needs management and suggested that ontology should provide a uniform terminology shared by all the designers and engineers involved. Baida et al. (2005) proposed an ontological method to build need hierarchies within e-service. In this study, a customer needs hierarchy with well-defined hierarchical decompositions (e.g., AND/OR/XOR Structures) of customer needs was built to support a formal and machine interpretable understanding of services as well as physical goods in the field of ontology. More recently, Bock et al. (2010) presented a novel way to combine ontological and model-based techniques to facilitate product design. Specifically, they made use of ontology's rigorous semantics for flexible and accurate product design combination and refinement to meet customer needs. Generally speaking, using ontological methods, different interpretations of the same customer needs by different designers can be avoided, and thus the precision and unambiguity of the customer needs for product characteristics can be assured.

Although ontology is useful, the manual editing ontology is a tedious work. To improve efficiency, ontology learning has been used to support the ontology

tasks by deriving useful relations through data-driven techniques that can discover ontological knowledge on a larger scale and more quickly (Cimiano et al., 2006). A multitude of disciplines, such as formal modeling, semantic linguistics, knowledge engineering and machine learning, have been integrated with ontology learning to facilitate ontology construction (Maedche and Staab, 2000b). Due to the contributions of several disciplines, ontology learning has experienced much progress in the past decade.

Various ontology learning systems have been developed to extract the concepts from domain-specific documents and relations between these concepts (Cimiano et al., 2006). In these systems, ontologies including keywords and relations were built automatically, terms were interpreted semantically to deal with the semantic disambiguation, a content matching mechanism was combined with moderately expressive representation formalism, and the hierarchy of taxonomy was built using clustering techniques. However, using existing systems such as OntoLearn (Missikoff et al., 2002), only taxonomic relations (IS-A) can be extracted. Further, systems like Text-To-Onto (Maedche and Staab, 2000a) are also limited by the accuracy of the extracted semantic relations using Part of Speech (POS) tag only.

When applied in the product design domain, ontology learning is also limited by its use of only concepts and taxonomic relations for ontology modeling (Brunner et al., 2007). Non-taxonomy can help to decide the conceptual

relationship between concepts instead of simply “is-part” in a taxonomic hierarchy (Maedche et al., 2002). Therefore, use of non-taxonomic ontology learning can facilitate representing relations between high level customer needs and low level product characteristics. Cao (2011) mentioned that the non-taxonomic relations between high-level concepts and low-level features need to be identified in customer preference ontology building. However, in Cao’s research, the non-taxonomic relations are only structured between concepts across taxonomies. For example, the new relation “HAS FEATURE” is composed of “COL-SILVER” and “SH-KITTY-PHONE”, which simply combines two concepts from color taxonomy and shape taxonomy, respectively. To the best of the author’s knowledge, no attempts have been made to capture implicit conceptual non-taxonomic relations by using ontology learning systems for automated ontology building. Therefore, an ontology learning system that can overcome the above-mentioned limitations and build a product design domain ontology is needed.

2.5 Product specifications establishment

Product specifications are established and refined after the customer needs are identified. In this stage, precise product specifications are set based on customer needs, especially on innovative customer needs as stated earlier. Fung et al. (1998) defined product specifications as the mapping process from the voice of customers to the voice of designers, who define the design requirements with

design features or elements. The commonly used approaches for fulfilling customer needs include axiomatic design (Suh, 190), design for X (Huang, 1996), design structure matrix (DSM) (Pimmler and Eppinger, 1994), quality function deployment (QFD) (Bossert, 1991), and Kansei engineering (Nagamachi, 1989). Amongst them, QFD and Kansei engineering methods are the most representative approaches.

2.5.1 Quality function deployment

Quality function deployment (QFD) is a powerful tool to translate customer needs into design specifications (Prasad, 1998). The QFD process begins when designers endeavor to pinpoint customer needs, which are usually expressed in terms of qualitative characteristics. During the process of product development, customer needs are successively converted into internal company requisites, called product specifications. These specifications are generally the global characteristics of a given product which, if correctly developed, will be able to satisfy most, if not all, customer needs.

Therefore, QFD is a widely used technique that attempts to integrate two important functions in product development, marketing and engineering. The most important part of QFD is the customer needs analysis to help the designers make the connection between customer needs and product specifications.

QFD employs a house of quality (HoQ), which is a means of providing a conceptual outline for the design process, to identify and satisfy customer needs (Hauser and Clausing, 1988). The HoQ may also be helpful in creating a product that is as attractive as possible to the customer.

To enhance the effectiveness of QFD, Burchill and Fine (1997) used the affinity diagram to link initial and final surveys of customer needs. Zhai et al. (2009) introduced a rough set based QFD approach to address the imprecision inherent in product design. Huovila and Serén (1998) used both QFD technique and design structure matrix in an attempt to understand customer needs and begin working toward for the design process in the early stages of product conceptualization. Most of this work has occurred in the realm of customer involvement in the design process, while how to determine and use customer needs in QFD have not been well addressed.

QFD has been extensively researched as a practical method for transforming customer needs into design specifications in the early stages of product development (Yan et al., 2005). Fung et al. (1998) combined the analytic hierarchy process (AHP) and a fuzzy inference system (FIS) to address multi-dimensions of product quality and customer perceived values of QFD. Harding et al. (2001) suggested that a market-driven design system to integrate QFD techniques with marketing analyses would be useful. This system focused on particular product features yielding maximum customer satisfaction. However, the above-mentioned

approaches, which are highly dependent on the decisions made by domain experts and the reliability of the customer attributes, are difficult to assess accurately.

2.5.2 Kansei engineering

Psychological factors such as perceptions, motivations, attitudes and personality are used to analyze complex customer behaviors during the rational decision making process (Lancaster and Massingham, 1994). Kansei (a Japanese word for “sensibility”) engineering is a technique to transfer customers’ psychological feelings about the product into perceptual design elements (Nagamachi, 1989). Kansei engineering interprets user feelings and translates them into product design (Nagamachi, 2002). Kansei is obtained from interviews or observations of customers. A target Kansei or a concept is then broken down until a final Kansei is reached that can be directly linked to product design elements (Nagamachi, 2002).

Kansei engineering integrates emotion into the design of product. Kansei words are widely accepted as one of the most effective ways to express emotions about a product (Tsuchiya et al., 2005). Using Kansei words, customers can be guided to express their affective needs, their feelings and their emotional states (Jiao et al., 2006). As a result, Kansei engineering reinforces design objectives and makes design more attractive and consumer-oriented (Cai et al., 2003). Some Kansei adjectives, such as enjoyable, dignified, natural and comfortable, are used

to describe emotion related elements. The development of a dataset of Kansei words and their meanings helps minimize some repeated activities, as information collected in the past can be retrieved and used to create an image of products (Nagamachi, 2002).

Kansei engineering is widely considered as a reliable and flexible methodology to handle complex human emotional needs for product design (Mamaghani and Tajoddinib, 2010). It deals with two domains, customer psychological domain and product engineering domain.

Several other methodologies are comparable to Kansei engineering, including emotional design (Norman, 2004), engineering aesthetics (Liu, 2003a, 2003b), affective design (Chen et al., 2006) and Citarasa engineering (Khalid, 2006). Despite the differences among them, their goals are overlapped to a great extent: to explore the relationships between physical product design elements and their cognitive and especially emotional influences on the customer. The knowledge obtained from these methodologies can facilitate designing more satisfying products.

2.5.3 Quantitative methods

Customer needs identification is mainly concerned with the generation of concrete and precise customer need statements about product specifications based on raw customer statements (Stauffer and Slaughterbeck-Hyde, 1989). Fung et al.

(1998) defined product specifications based on the voice of designers (VoD) regarding product features or design characteristics. McAdams et al. (1999) identified the relationships between product specifications and customer needs through a matrix approach. Brahim et al. (1993) linked product specifications to performance test results using a neural network model. Yan et al. (2005) used a ladder hierarchy to develop a restricted Coulomb energy (RCE) neural network for analyzing design alternatives. Karsak et al. (2003) integrated an analytic network process and zero-one goal programming to define design requirements.

Statistical methods have also been used to find the relationship between customer needs and design requirements. For example, Han et al. (2000) applied multiple linear regression techniques to connect usability quality and design elements. Kim et al. (2003) proposed a general linear model to highlight the relationships between design factors and customer emotions. However, some vague customer needs, such as psychological needs, do not always have linear characteristics. Therefore, high level customer needs, which are often fuzzy and vague in nature, are nonlinear and not applicable to linear methods based on normal distribution (Nagamachi, 2006).

More specifically, because the semantic relations between customer needs and product specifications are somewhat vague and abstract, more improved AI methods are proposed to address them. For example, Tsuchiya et al. (1999) used a combination of genetic algorithms and fuzzy logic to improve driving comfort for

automobiles. Arakawa et al. (1999) utilized fitness function and optimization of Kansei using genetic algorithms to design products. Lai et al. (2006) used an artificial neural network in connecting their user model to software usability appraisal coefficients. Using a dominance-based rough set approach, Zhai et al. (2007) extracted imprecise customer knowledge. In addition, Inoue et al. (2007) ranked new products through a rough approximation using an analytical hierarchy process. Cognitive needs are reflected with the design components in the graphical user interfaces of the products. Zhou et al. (2011) also proposed a fuzzy reasoning algorithm for product design elements formulation.

Although there has been much research in the area of product specifications establishment, the mapping between customer needs and product specifications is still unclear. In addition, the product specifications establishment research only focuses on product specifications establishment stage without combining the inputs from customer needs identification stage. Therefore, there is a lack of research utilizing integrated framework and systematic methods that target at the entire customer needs management process, including customer involvement support and product specifications establishment.

2.6 Fundamental elements in customer needs management

Xu et al. (2009) claimed that there were three limitations in customer needs management process. To begin with, customer needs are usually qualitative and

tend to be unclear and not well-defined. Second, there is no real definitive structure in customer needs information. Third, the relationships between customer needs and product characteristics are frequently unknown during the early stages of the product development process. Due to these limitations, effectively managing customers and products becomes necessary in customer needs management (Jiao and Zhang, 2005). Jiao and Zhang's summary of the process of customer needs management (Jiao and Zhang, 2005) indicates that this process is closely related to two entities: customer elements and product elements.

2.6.1 Customer elements

Research on customer elements is basically concerned on customer value (CV) and customer satisfaction (CS) with the Kano model. These two elements are connected with customer needs management from customer's perspective.

2.6.1.1 Customer value

Customer value (CV) has been widely investigated in the last few decades, and the concept is viewed as fundamental for marketing activities (Holbrook, 1994). CV research has been conducted as the guiding theory not only in marketing research, but also in a variety of other research fields, such as strategy, psychology, sociology and product design. Despite the emphasis on the importance of CV

(Vantrappen, 1992; Woodruff, 1997), little research has developed an in-depth understanding of the concept (Sweeney and Soutar, 2001).

CV has various definitions from past literatures. Zeithaml (1988) asserted that CV came from customers' overall assessments to the usefulness of a product based on their perceptions of what is received and what is given. Gale (1994) defined CV as market perceived quality based on the price of the products and customers' options regarding them. CV was also defined as a relativistic (comparative, personal, situational) preference based on the customer's interaction with the product (Holbrook, 1994). Woodruff (1997) defined CV as a customer's preference and evaluation of the product characteristics, performance, and ability to address the customer's goal and proposed use. These aspects incorporate both desired and perceived value stemming from customers' learning, preferences, and evaluation, and link products with related goals and consequences. Thus, this definition explains customer value from a customer's perspective (Woodruff, 1997; Zeithaml, 1988). CV is considered a theoretical construct for the provided products or services (Spiteri and Dion, 2004). CV is not the same as customer satisfaction. The perceived CV is seen during the stages of the purchase process, while the customer satisfaction is a function of evaluation after the product has been purchased and used (Oliver, 1981). In other words, value perceptions may exist prior to the purchase or use of the product, while satisfaction is based on having used the product (Sweeney and Soutar, 2001). In addition, the customer

satisfaction is conceptualized as an one-dimensional construct, while the value is conceptualized as a multi-dimensional construct. The research on CV provides a very good theory construct for the customer or user modelling as well.

2.6.1.2 Kano model of customer satisfaction

In the stage of customer needs identification, a list of customer need statements should be generated. Generally, the need statements are organized into a hierarchical list consisting of the sets of primary, secondary and tertiary needs. The primary needs are the most general, while the secondary and tertiary needs are more detailed (Ulrich and Eppinger, 2008). For example, the primary needs for a screwdriver could be stated as “The SD is easy to store”, the secondary needs could be “The SD fits in toolbox easily”, and the tertiary needs could be “The SD maintain its charge when wet”. The need statements can be organized into the groups according to the similarity of the needs. A label representing within-group needs should be specified for each group to help eliminate redundant statements.

The Kano model (Kano et al., 1984) lists several categories of customer needs, all of which affect customer satisfaction in different ways: basic needs, performance needs and excitement needs. These needs can also be classified as must-be needs, one-dimensional needs and attractive needs. The basic needs are the things that the customers expect from the product but rarely mention. Although they are low on the satisfaction scale, the absence of basic needs is very dissatisfying, since they are expected by customers. The performance needs result

in satisfaction when they are fulfilled, and result in dissatisfaction when they are not fulfilled (Gustafsson et al., 1999). The exciting needs are items that are not expected but, if present, help to create customer delight (Gustafsson et al., 1999). The relationship between customer satisfaction and different types of customer needs facilitates customer needs management through the fulfillment of those needs. A schematic representation of the Kano model is provided in Fig. 2.7.

Figure 2.7 The Kano model for customer needs (Kano, 1984)

The Kano model uses a nominal scale to elicit customers' opinions. Such a scale is not useful in identifying whether a particular function truly falls under a

specific needs category. Also, the Kano model does not address customers' perceptions about the relative importance of different features of a product (Rahman, 2004). It provides only a rough sketch of the customer's satisfaction based on product performance, thereby allowing only qualitative assessment of product characteristics (Xu et al., 2009). Quantitative measures can be incorporated by assigning scales to determine the levels of customer satisfaction/dissatisfaction (Matzler and Hinterhuber, 1998). The result, however, is still qualitative in nature, and cannot precisely reflect the level of customer satisfaction (Berger, 1993).

2.6.2 Product elements

Research on product elements is basically concerned with product characteristics, product value, and product positioning. These three facets are closely related to customers' needs from a specific product and product features. There are also many relations between the product characteristics and the product value, as well as the product positioning.

2.6.2.1 Product characteristics

A characteristic is a quality or feature that is peculiar to a particular item and helps to identify it (Hubel and Lussow, 1984). Examples of the attributes contributing to the character of a product include selected material, processes used

for making and assembling, ergonomic qualities, function, aesthetics and cost. The way in which the attributes are synthesized determines the total character of the product.

The form, function and meaning are used as the top three important characteristics to identify a product (Hubel and Lussow, 1984). Form can be defined as light and shadow in space (Hubel and Lussow, 1984). A product can be conceived as the form from the inside and outside, solid or hollow, closed or open, evolving from monolithic to linear, etc (Hubel and Lussow, 1984). Functions are what a product is to accomplish by a user (Gause, 1989). Everything should serve a certain purpose, either be useful or to realize some functions. Meaning is related to associations, aspirations and yearnings. It refers to the things that are desired, possessed and cherished by people. It is also the sum total of people's background, lifestyle, friends, and society (Schifferstein and Hekkert, 2008). Recent studies showed that customers' preferences to products are largely motivated by product meaning (Creusen and Schoormans, 2005).

Feelings about products and what they mean to people are based on many factors, such as personal biases and prejudices. In other words, the meaning delivered by products is influenced and determined by individual special combinations of cultural, social, educational, religious and economic background, which are all social characteristics.

The social characteristics refer to the utility derived from the product's ability to enhance social self-concept (Sweeney and Soutar, 2001). The social characteristics help the owner of the product feel acceptable by others, make a good impression by other people and be given social approval (Orth et al., 2004).

The meaning of a product is also determined by a combination of both symbolic and aesthetic factors, called semantic characteristics. The semantic characteristics are concerned with the feeling of being beautiful or ugly, young or old, masculine or feminine, high class or low class, expensive or cheap, etc. (Schifferstein and Hekkert, 2008). Product characteristics include both tangible product characteristics, such as form and function, and intangible product characteristic, such as social characteristics and semantic meanings. Product meaning can also be used to describe the intangible product characteristics.

For the products that are very similar in tangible product characteristics on the market, it may hard for people to differentiate (Postrel, 2003). However, intangible characteristics, which are related to customer's needs and desires, are determined by different factors. It is easy to imagine that any given product can have completely different meanings for different people. In addition, because situations change and new things constantly appear, needs and desires always change. Thus, the products may take on new and different meanings. In sum, feelings about products and what they mean to us are based on different situations.

2.6.2.2 Product positioning

Product positioning refers to mapping between customer segments and product characteristics (Kaul and Rao, 1995). The product positioning involves decisions about the connection between perceptual product characteristics and customer heterogeneity in requirements. Managerial decisions about the product positioning and design deal mainly with changes in customer perception of a product and the various alternative products available to the customer. Therefore, the product positioning requires detailed knowledge of the various characteristics of all the products in a specific category (Kaul and Rao, 1995).

To maintain and enhance profits in the presence of competition, a company must continuously reposition or redesign its existing products or introduce new products. The success or failure of a product will be determined by the customer's perceptions of that product. A successful company will design products to suit the needs of each customer segment (Tsiptsis and Chorianopoulos, 2010).

Different methods were used for product positioning in past research. For example, Rhim and Cooper (2005) used a multidimensional scaling method for the product positioning. A joint space analysis, which entails the mapping between the locations of existing products and idea points for each individual or market segment, was also used for the product positioning (Sudharshan et al., 1987). Generic algorithms have been proven to outperform most existing optimal positioning algorithms in dealing with the choice set size heterogeneity between

customers' decision setting and variations in the size of individuals' choice sets (Balakrishnan and Jacob, 1996). Sudharshan et al. (1987) found that a probabilistic choice model tends to provide better solutions and a larger share projection for new product positioning. Psychological effects of products are also stressed as a valuable managerial planning tool in product positioning (Friedmann and Lessig, 1987). Through using product positioning, designers can model customers' choices of existing products, predict their responses to new products and identify optimal combinations of product characteristics (Zhang et al., 2007).

2.7 Summary

The work reviewed in this chapter covers different perspectives of the theories and methodologies related to customer needs management in product development. First of all, a general review of customer needs management was provided. Then, related research and methodologies at each stage of customer needs management (i.e., customer needs acquisition, customer needs representation, and product specifications fulfillment) are reviewed. Finally, the fundamental elements in customer domain and product design domain, such as customer value and product characteristics, are reviewed

It can be concluded from the literature reviews that effectively managing customer needs is vital for successive product design stages, especially for the stage of specifying product characteristics. Many methods and approaches, such as

quality function deployment (QFD) and Kansei engineering, have been developed to assist designers in identifying the relationship between customer needs and design characteristics (Lin et al., 2008). However, the output of QFD and related methods relied heavily on the inputs from customer need statements. Inaccurate customer need statements have adverse effects on the efficiency and effectiveness of the customer-oriented design process and make the development of successful products become difficult.

The front-end product development is a cyclical and iterative process that involves many interrelated activities and multiple disciplines. Conventionally, researchers collected customer information passively. However, customer involvement, especially innovative customer's involvement has been suggested to be able to improve product quality, and thus has attracted increasing attention from researchers recently. Studies of customer involvement from innovative customers are still problematic in that the criteria of customer's innovative characteristics and the way to find large group of innovative customers have not been well addressed. Another common limitation in the current customer needs management research is that the existing methods may not be able to provide accurate customer needs with precise definitions of specific terms given by the vague customer need statement. In addition, most existing methods are unable to identify the relations between these terms effectively. Therefore, the translation and representation of customer needs deserve more in-depth studies.

From the literature review as well as the discussions presented in Section 1.1, the gaps in previous research have been identified:

- 1) Existing research is not effective and efficient in terms of identifying large groups of innovative customers;
- 2) Existing research does not propose a well accepted criterion to categorize different types of customers using the innovative customers' characteristics from a broad perspective;
- 3) Existing research does not provide an effective and efficient way to translate the imprecise information from voice of customer into customer needs; and
- 4) Existing research does not embody the high-level customer needs with clear product characteristics representation.

These gaps provide the motivation to carry out an in-depth study of customer needs management in the following chapters. In particular, 1) a system of customer needs management that combines related knowledge from customer domain and product design domain is developed (Chapters 3 and 6); 2) a novel customer segmentation model is developed to help identify different types of innovative customer needs (Chapter 4); and 3) an ontology learning system is proposed to facilitate customer needs representation to product characteristics in a more accurate and precise way (Chapter 5).

CHAPTER 3

A CONCEPTUAL MODEL FOR CUSTOMER NEEDS MANAGEMENT

This chapter proposes a conceptual model that integrates knowledge from customer domain and product design domain into a unified framework. This model is expected to be able to obtain accurate customer need statements by classifying different types of customers based on innovative characteristics, acquiring customer needs by involving system identified innovative customers, and using the obtained customer needs to generate more accurate need statements.

3.1 Overview of the conceptual model

To obtain a better understanding of customer needs and product specifications, and to explicitly signify the relationships between customer domain and product design domain, several issues must be addressed: 1) how to identify innovative customers who work as mainstreams for product innovation; 2) how to develop a well-tested criterion for innovative customer identification; 3) how to represent the relationship between high level customer needs and low level product characteristics; and 4) how to obtain more accurate need statements based on the existing information.

To address the above-mentioned issues, a conceptual model is proposed to better manage customer needs. This conceptual model is based on the product design process suggested by Ulrich and Eppinger (2008) and illustrated in Fig. 3.1. In particular, the whole framework locates at the stage of customer needs identification in the product development process suggested by Ulrich and Eppinger, and combines the elements from both the customer domain and product domain.

Figure 3.1 The proposed customer needs management system in a product development process

The schematic diagram of the overall framework of proposed model is shown in Fig. 3.2. The proposed model has two inputs, which are customer data from customer research database and product data from product research and development center. The outputs of the model are customer need statements, which serve as inputs to the following stages in product development. Unlike the

conventional product design process, which separates customers and product designers, this new model tries to make both parties work collaboratively to contribute to product innovation. Customers and designers are the two core entities in a design task. Therefore, the model covers both the customer domain and the product domain in a united framework. The customer domain deals with the customer related research for customer data collection and innovative customer identification. The product domain covers related research in product data collection management and customer needs representation.

Figure 3.2 Schematic diagram of the overall CNMS framework

3.2 Research in the customer domain

Research in the customer domain focuses on establishing a customer model to identify innovative customers. In this model, customer segmentation, which has been well established in marketing research (Philip Kotler, 1997), could be used for

innovative customer identification. Customer segmentation, which looks at various psychographic tools and consumer behavior theories, has established well accepted criteria to identify different groups of customers. Therefore, it could be employed to solve the problem regarding the lack of universal criteria for innovative customer identification in product design. Besides, the customer segmentation divides customers into subsets with common needs or characteristics which can aid in better understanding and identifying customer needs.

However, the customer segmentation is only a general concept from marketing research. How to target different groups in this study and through which criteria to find related customer characteristics are not yet included in existing customer segmentation theory. In this study, since innovative customers are of interest, the author focuses on the characteristics of innovativeness. In this sense, customers are segmented into different types according to their characteristics of innovativeness in different dimensions. Within each dimension, a rating is needed to indicate the level of innovativeness (Fig. 3.3). The details on specifying the rating on the level of innovativeness is discussed in Chapter 4.

Figure 3.3 An instance of customer classification

According to the innovative customer characteristics from the marketing, lead user and psychological perspectives (Bilgram et al., 2008; Luthje, 2004; Snellman, 2000), this study aims to build a novel customer segmentation model for innovative customer identification with the most relevant dimensions of innovative characteristics and to represent main groups of innovative customers with different innovative scales in each dimension. The segmentation strategies begin with the selection of the dimensions that represent the main attributes of potential or existing groups of customers. These dimensions, which may cover cognitive, psychological and behavioral characteristics of customers, are selected as input into

a customer segmentation model and to categorize the customers into different core groups based on the innovativeness of customer characteristics.

By using classification techniques, ordinary customers can be further classified as passionate innovator, average innovator, and indifferent innovator based on the degrees of their innovativeness. Passionate innovators are the most innovative customer groups or lead users, average innovators are those not lead users but show innovative characteristics in certain dimensions. Hidden innovators are those who show little innovativeness or do not show innovative characteristics at all. The number of customers decreases as the innovative degree increases (Füller and Matzler, 2007) (Fig. 3.4). Different innovative customers play different roles in the product design process.

Figure 3.4 Customers' role in new product innovation

Different strategies are used for different types of customers in the product design process. For hidden innovators, the level of customer participation is low, and thus no inputs are required from them in the design process (Füller and Matzler, 2007). However, both average and passionate innovative customers are required to actively interact with designers and products during the product design process to provide their views and talents.

3.3 Research in the product design domain

The product design domain research focus on studying customer needs, product characteristics, and relations between customer needs and product characteristics. Fig. 3.5 illustrates the basic framework in the product design domain dealing with customer needs representation. In general, the customer needs can be described as a set of features or attributes. It is supposed that customer needs are represented by $CNs \sim C^*(C_1, C_2, \dots, C_n)$, where n denotes the total number of customer needs. The product characteristics are represented by $PCs \sim P^*(P_1, P_2, \dots, P_m)$, where m denotes the total number of product characteristics. Based on the instant data, the relationships between customer needs and product characteristics can be extracted, noted as $C^* \Rightarrow P^*$, where the symbol $\Rightarrow$ indicates either taxonomic relations or non-taxonomic relations.

Figure 3.5 Relationship between customer needs and product characteristics

Product characteristics can be either tangible or intangible. Tangible product characteristics, which refer to measurable ones, are described as product forms and product functions including appearance, size, weight, etc. Intangible product characteristics, which refer to immeasurable ones, are described as social related elements and emotional related elements. Elements such as social connection, image building, brand awareness and lifestyle are used to describe social related

elements. Kansei words such as enjoyable, dignified, natural and comfortable are used to describe emotional related elements.

There are two types of relations between customer needs and product characteristics: taxonomic relations and non-taxonomic relations. Taxonomic relations indicate the relations between customer needs and product characteristics are “is-a” or “whole-part” relations, e.g., mode --> manual mode/auto mode or quality --> video quality --> HD video quality. The taxonomic relations are expressed as solid lines in Fig. 3.5. Non-taxonomic relations indicate that the relations between customers and product characteristics are not simply taxonomic relations. Non-taxonomic relations facilitate representing relations between high level customer needs and low level product characteristics, e.g., auto control -> joyful camera or battery life & wide angle -> convenient camera. The non-taxonomic relations are expressed as dashed lines in Fig. 3.5.

To address the limitations in the existing customer needs representation research, various ontology construction approaches have been developed to facilitate knowledge representation in the product design domain (e.g., Baida et al., 2005; Lin et al., 1996; Smirnov et al., 2005). As a formal and rigorous approach for knowledge representation, ontology can provide precise and unambiguous semantics for terms by specifying the differences between terms (Lin et al., 1996). Additionally, the ontology is used to make the domain knowledge and human assumptions explicit by presenting the relationships between concepts. Specific to

customer needs management, use of ontology's rigorous language semantics allows for flexible and accurate product design combination and refinement to meet the customer needs. In addition, by using ontological methods, different interpretations of the same customer needs by different designers can be avoided, and thus the precision and unambiguity of the customer needs for product characteristics can be guaranteed.

3.4 Summary of the Conceptual Model

Based on the description of each component in both customer domain and product domain under the united framework, the process of the overall model is constructed as shown in Fig. 3.6.

Figure 3.6 The process of the conceptual model for Customer Needs Management

In summary, the proposed model (Fig. 3.6) aims to provide an overall framework to integrate customer domain and product domain in the product development process. A novel ITF customer segmentation model is proposed in the customer domain, in which different perspectives of customer innovativeness are discussed. The fundamental theories on marketing, psychology and product design provide a deep knowledge basis for customer segmentation. Subsequently, an OCNR system is proposed for customer needs representation. Along with the technical framework, the main challenges and possible solutions are identified. The detailed problem formulation, methodology, and case studies related to customer segmentation modeling and customer needs representation are presented in Chapters 4-7, respectively.

CHAPTER 4

A CUSTOMER SEGMENTATION MODEL

This chapter aims to propose a customer segmentation model. The key issues in building the segmentation model are identified. The model construction process is presented, including selecting customer segmentation variables and building the customer segments. Different types of innovators are analyzed. Strategies used by different types of innovators are also discussed in this chapter.

4.1 Problem formulation

Previous studies involving customers in new product development were mostly focused on how to elicit the customers' requirements (Alam, 2002; Brockhoff, 2003; Gruner and Homburg, 2000; Shieh et al, 2008). The findings from field interviews as well as statistical analysis showed that the characteristics of the involved customers had a significant effect on new product success (Gruner and Homburg, 2000). Therefore, understanding the characteristics of the customers becomes very important in the product design process. Past studies revealed that innovative customers could be a very important source of new product ideas for companies (e.g., Luthje, 2004). Thus, effective identification of innovative customers is imperative for obtaining valuable input about customer needs.

However, it is still unclear how to define and identify different types of innovative customers before engaging them into the product design process.

4.2 Model construction process

In this section, the process of building a customer segmentation model is presented. As seen from Fig. 4.1, the process consists of five phases including customer data collection, customer data pre-processing, customer segmentation model building , and model validation,

Figure 4.1 An overview of the model building process

4.2.1 Customer data collection

Customer data is collected from different kinds of customer data such as psychographic (lifestyles, values, personality etc.), demographic (age, gender,

marital status etc.) and usage pattern (e.g., frequency of purchase, method of purchase, location of purchase etc.). The common methods to collect the customer data are using customer complaints/feedbacks, customer profiles, customer transaction records, and survey responses. Among these methods, online customer profiles become more and more important due to the convenience of the online data mining. Therefore, in this work, the data are collected from online customer profiles.

4.2.2 Data pre-processing

A natural language processing (NLP) tool is needed to extract keywords from raw text documents. In this study, keyword extraction is conducted in two phases: 1) candidate term extraction from text with certain linguistic filters; and 2) domain-specific keywords selection. A group of NLP methods (i.e., the POS tag-based rules) are employed to extract keywords from text following the below steps (Jiang and Tan, 2010):

- (1) Extract terms from texts. As keywords could be nouns (NN), verbs (VB) and adjectives (JJ) in texts, lexical units with the NN, VB and JJ tags are collected.
- (2) Remove articles and descriptive adjectives such as “a”, “many”, and “several” from terms extracted.

- (3) Group all the possible sets of words from the extracted term as candidate keywords.
- (4) Use domain relevance measures to determine candidate keyword's relevance to a specific domain.

4.2.3 Model building

The segmentation model building consists of three steps sequentially: 1) selecting the most relevant innovative variables or dimensions to represent innovative customers; 2) classifying customers into different innovative segments based on the level of innovative dimensions; and 3) formulating a customer segmentation model.

Step1: Selecting customer segmentation variables

When selecting the most important dimensions of customer's innovative characteristics, many segmentation variables have been investigated. In the market segmentation theory, customers can be segmented using the variables such as lifestyles, psychographics, demographics, usage behaviors, etc. In the empirical studies, the most frequently applied variables are psychographics (Abratt, 1993), demographics, and geographic and behavior variables (Hassan and Craft, 2005). In past studies, user expertise (behavior) and motivation (psychological) have been

identified as two of the most important variables accounting for lead/innovative user characteristics (Bilgram et al., 2008; Hassan and Craft, 2005; Luthje, 2004).

The psychographics (motivation to innovate) are used to account for customer's innovative characteristics in nearly all the lead user studies. Therefore, one dimension of the proposed model is defined by a psychographics variable which is "feeling".

Innovative characteristics can be accounted for by behaviours (Morrison et al., 2004). Among all behaviour variables, knowledge and experience are recognized as being highly related with innovativeness and independent to each other (Luthje, 2004; Schreier et al., 2008). Therefore, the proposed model also takes these two variables into account. In particular, the knowledge and experience variables are accounted for by the dimensions of 'thinking' and 'involvement', respectively, in the proposed model. Based on the above statements, customer segmentation variables are selected from three dimensions, which are 'involvement', 'thinking' and 'feeling', so-called ITF model, as shown in Fig 4.2.

Figure 4.2 Dimensions of Customer Segmentation ITF model

1. *Involvement*

‘Involvement’ is a behaviour variable that closely accounts for user experience and user interaction. ‘Involvement’ has been proved to be able to distinguish between innovating and non-innovating customers and to be positively correlated with customers’ innovativeness characteristics (Franke and Shah, 2003). ‘Involvement’ refers to the physical participation of customers when they are learning about or buying a product. ‘Involvement’ is based on different levels of customers’ previous experience in interacting with the products. The involvement level is dependent on personal relevance, perceived risk and attitudes. High level of involvement implies that customers have close interaction with the products and would readily engage in intense information processing and detailed decision

making for such products. Low involvement of customers implies that there is little effort made by the customers in interacting with the product.

2. *Thinking*

‘Thinking’ is also a behaviour variable that makes use of customers’ knowledge of product and technology, and is positively correlated with customer’s innovativeness (Luthje, 2004). It empowers customers to convert their requirements into preliminary solutions. ‘Thinking’ refers to the processing of information and the amount of knowledge required from customers. Customers with high levels of thinking would process information quicker and in more detail compared to customers with low levels of thinking.

3. *Feeling*

The *psychographic variable* ‘feeling’ including both extrinsic and intrinsic motivations which has a positive influence on customers’ innovativeness (Lakhani and von Hippel, 2003; Lettl, 2004). ‘Feeling’ refers to the emotional attachment or preference for the product by customers. ‘Feeling’ is more related to individual’s personality affect and preference. This variable conveys a feeling of enjoyment, exploration and creativity of customers and enables them to make full use of their potential innovativeness (Reichwald et al., 2004). Customers with high levels of

feeling would have higher motivation and more emotional attachment to the products compared to customers with low levels of feeling.

These three variables describe the innovativeness characteristics of customers from three different perspectives. At the same time, they are closely related to customers' characteristics of innovativeness as a whole (Bilgram et al., 2008).

Step 2: Innovative customer segments pre-definition

Several types of customers with different degrees of innovativeness are pre-defined at this step.

Type 1 – Passionate Innovators

Passionate innovators are defined as the customers with high levels of involvement, thinking and feeling toward the product. They are quite similar to lead users defined in past research (Morrison et al., 2000). Passionate innovators frequently use the products. They also have strong interests in the product, have sufficient knowledge about the product and can likely foresee the opportunity to use the product. Passionate innovators are ideal innovative sources, but they are very rare. The time and cost spent in finding such customers can often be unaffordable by ordinary companies.

Type 2 – Involved Innovators

Customers that show high levels in both involvement and thinking dimensions are defined as involved innovators. This group of customers has the ability and expertise to be an expert for the product. They are often professionals or experienced people with high expertise in the domain.

Type 3 – Devoted Innovators

Customers corresponding to high levels in both involvement and feeling dimensions are devoted innovators. The devoted innovators are those who get involved with the product and use it to meet their personal interests. This group of customers has the motivation to be involved in product innovation. Even if they do not have explicit expertise about the products, they can acquire the necessary expertise from learning and communication with designers.

Type 4 – Amateur Innovators

Customers who show high-level in both thinking and feeling dimensions are amateur innovators. The amateur innovators also have the motivation to get involved in the product design process for product innovation. Even they have no experience in using such products or get involved into the product design process, they are potentially show innovativeness if they are asked to provide inputs for product innovation.

Type 5 – Indifferent Innovators

Indifferent innovators are customers corresponding to low levels in all three dimensions. The indifferent innovators are the customers who use products just to fill basic needs and have very little expertise concerning the products. As they seldom really use the product, their involvement level should be much lower and their contribution to new product innovation is thus very low.

Type 6 – Neutral Innovators

The remainder of the customers are defined as neutral innovators. In this study, they are regarded as indirect innovators who are required neither to participate directly nor to provide feedback or input to the proposed system. They may have shown some innovative characteristics in a certain dimension, but overall their innovativeness is relatively much lower compared to the innovative customers. However, it is still possible to find some potential design ideas from observing or analyzing their behaviours.

The customer segments are illustrated in Fig. 4.3. Passionate innovators, involved innovators, devoted innovators and amateur innovators are grouped into innovative customer segments. The other four segments including 3 segments of neutral innovators and 1 segment of indifferent innovators are grouped into non-innovative customer segments.

Figure 4.3 Customer segments using the ITF model

Step 3: Customer segments formulation

After defining customer's innovativeness variables and innovative customer segments, the index of innovativeness that is defined as follows to formula the degree of certain customer segment's innovativeness. Typically, weighting values are determined subjectively. In this study each dimension is assigned the equal weights to decide a certain customers' innovativeness, given that the original goal of this study is to find the customers who show innovativeness at any of dimensions.

$$\text{Index of Innovativeness} = \sum_{i=1}^n D_i \quad (4.1)$$

where $n=3$ is the number of segmentation dimensions (i.e., involvement, thinking and feeling); D_i is used to represent the level of each segmentation dimension (i.e. low or high), and its value at each level of segmentation dimensions are presented in Table 4.2. In this study, the level of dimension is decided by the frequency of the keywords used to describe customer's characteristics. Generally speaking, the higher frequency of the representative keywords used in each dimension for a specific customer, the more confident this customer show high level in such dimension. To differentiate between different dimensions, a different value will be assigned to a customer who presents innovativeness in certain dimension (Table 4.1). The coding of "1", "3", "5" is to make sure the value for index of innovativeness is different among different types of customers.

Table 4.1 Values of D_i in Eq. 4.1 at each level of dimensions

Dimensions	High Level Value	Low Level Value
Involvement D_1	1	0
Thinking D_2	3	0
Feeling D_3	5	0

According to the index of innovativeness, different types of customers can be identified with respect to their innovativeness (Table 4.2). Passionate innovators, involved innovators, devoted innovators and amateur innovators are defined as innovative customers as they show innovativeness (i.e. high-level) in at least two

dimensions in the ITF model. The remainder of the customers are identified as non-innovative customers.

Table 4.2 Different types of customer segments

Customer Type		Involvement D_1	Thinking D_2	Feeling D_3	Index of Innovativeness
Innovative Customers	Passionate	High	High	High	9
	Amateur	Low	High	High	8
	Devoted	High	Low	High	6
	Involved	High	High	Low	4
Non-Innovative Customers	Neutral	High	Low	Low	1
	Neutral	Low	High	Low	3
	Neutral	Low	Low	High	5
	Indifferent	Low	Low	Low	0

4.2.4 Customer classification

After the customer segmentation model is built, a supervised data mining method is used for customer classification.

In this study, the supervised classification approach which requires generating representative parameters for each class before classification is used. Compared to the unsupervised approach, more extended feature words can be extracted by the supervised approach by learning from the representative customers. The clear positive correlation between the numbers of feature words and the accuracy (Fig. 4.5) demonstrates the feasibility and robustness of the supervised classification approach.

Confident keywords that are associated with the innovative dimensions are defined manually at the very beginning. Based on those confident keywords, the representative customers are found. Those representative customers are used as a

training set with the labelled data to obtain more confident keywords. After this learning process, the classified customer segments are obtained.

Specifically, the supervised data mining method involves four steps:

Step 1: Confident keyword definition.

Only general descriptions of the customers are given in the general customer datasets. Thus, it is very difficult to obtain accurate words (features) to describe the intrinsic characteristics of the customers regarding different segmentations. However, some confidence keywords that are mostly related to each segment can be defined manually. These confidence keywords can the best describe customers' innovative characteristics.

Step 2: Find representative customers for each segment.

The keywords of features are used to identify the most representative customers for each group. Specifically, by using the proposed customer data pre-processing method, the frequencies of confidence words from each segment for each customer are determined. The customer is considered to be representative if the word frequency in a dimension is greater than 1.

Step 3: Keyword discovery with the labeled customer data.

As mentioned previously, the manually defined words are insufficient in terms of describing the characteristics of all customers. However, the most representative customers for each dimension can provide more keywords for the corresponding dimension. Hence, the representative customers with the pre-defined key feature words are labeled. The labeled data is further used to extract more keywords of features by measuring if the word frequency in a dimension is greater than 1, same mechanism as in Step 2.

Step 4: Supervised classification by using all keywords of features.

Finally, keywords from the representative customers as well as the augmented feature words are used to do final customer classifications. In this study, the nearest neighbour matching is used for customer classification. The nearest-neighbour matching is a direct method that uses a numerical function to compute the degree of similarity. Usually, cases with higher degree of similarities are retrieved. A typical numerical function is shown in the following formula (Chiu, 2002).

$$\frac{\sum_{i=1}^n Wi * sim(f_i^I, f_i^R)}{\sum_{i=1}^n Wi} \quad (4.2)$$

where Wi is the weight of the i th feature; f_i^I is the value of the i th dimension for the input case; f_i^R is the value of the i th feature for the retrieved case; $sim()$ is the similarity function for f_i^I and f_i^R ; $n = 3$. The similarity function is calculated

based on how many matched keywords can be obtained from each dimension. $n=3$ indicated the number of dimensions are 3.

The identified nearest-neighbour cases are considered to be similar. However, the matching process can only be executed with prior known weighting values as well as clearly defined similarity functions. Typically, weighting values are determined subjectively. In this study, they were assigned the equal weights for simplicity.

By using the nearest-neighbour method and the keywords from both manual process and keyword discovery process, customers can be classified into different segments: passionate innovators, amateur innovators, involved innovators, devoted innovators, neutral innovators and indifferent innovators.

4.2.5 Model Evaluation

Model evaluation is conducted using the testing set from three perspectives: 1) comparing the results between auto classification and manual classification; 2) comparing the accuracy of groups with different keyword numbers; and 3) benchmark evaluation with existing methods.

4.2.5.1. Comparing the results between auto classification and manual classification

After the customer classification model (as described above) is finalized, the segment information for each customer using the test data can be obtained automatically. Subsequently, a comparison between model-generated results and manual classification is done to determine if the model generated results matched the results from manual classification. Manual classification is done on the test cases following the same criteria as the ITF segmentation model.

4.2.5.2. Comparing the results during keyword discovery process

Besides, in order to show the feasibility and robustness of the proposed classification method, the relationship between the classification accuracy and the number of the keywords of feature is examined. Subsequently, such a relationship is compared between auto classification and manual classification. In particular, this comparison starts with the predefined keywords. With more and more keywords determined during the keyword discovery process as described above, the auto classification and manual classification results are obtained and compared accordingly using the same test data.

4.2.5.3. Benchmark evaluation with existing methods

In addition, the results are compared with the benchmark method (Grobelnik & Mladenic, 2005). The benchmark method selects feature words randomly without manually defining the confident keywords at the beginning of the

classification. The accuracy of the proposed method here and the benchmark method are compared in the segmentation process with different numbers of keywords.

4.3 A case study using the ITF model

A case study of the ITF segmentation model was conducted for innovative customer identification using customer data from Amazon.com. Model evaluation was conducted to validate the results obtained from the model. Additionally, discussions of the results and strategies for each segment were also presented. It was hypothesized that (1) the proposed segmentation model could deal well with huge numbers of customer segmentation; and (2) the proposed system would be able to help find the targeted innovative customer segments. The case study follows the model construction process as presented in Section 4.2.

4.3.1 Customer data collection

In this study, the data for analysis were self-summary data collected from amazon.com customers. Six hundred customer summaries were analyzed. 500 of them were used for customer segmentation using the proposed model, and the rest (i.e., 100 summaries) were used as the test data.

4.3.2 Data pre-processing

The pre-processing for a certain customer case is as follows:

A customer profile data from amazon.com is:

“I am a Homemaker! My escape is being a voracious romance reader, so of course I have become addicted to amazon.com. I enjoy my quiet time immensely, and reading is one of my favorite hobbies.”

The whole text is chunking into small lexical units as follows with the NN, VB and JJ tags with natural language processing:

((S (NP (PRP I)) (VP (VBP am) (NP (DT a) (NN Homemaker!))))) ((S (NP (PRP\$ My) (NN escape)) (VP (VBZ is) (VP (VBG being) (NP (DT a) (JJ voracious) (NN romance) (NN reader,)) (SBAR (RB so) (S (PP (IN of) (NP (NN course)))) (NP (PRP I)) (VP (VBP have) (VP (VBN become) (VP (VBN addicted) (S (VP (TO to) (VP (VB amazon.com.))))))))))) ((S (NP (PRP I)) (VP (VBP enjoy) (NP (NP (PRP\$ my) (JJ quiet) (NN time)) (SBAR (S (NP (NN immensely,) (CC and) (NN reading)) (VP (VBZ is) (NP (NP (CD one)) (PP (IN of) (NP (PRP\$ my) (JJ favorite) (NN hobbies.)))))))))))

Only lexical units with the NN, VB and JJ tags were collected as keywords, Articles and descriptive adjectives such as “a”, “many”, and “several” were

removed. Based on a candidate keyword's relevance to a specific domain, several keywords were generated from this customer case:

NN: homemaker, romance, reader, amazon.com, time, reading, hobbies;

VB: escape, have, become, addict, enjoy;

JJ: voracious, quiet, favourite

4.3.3 Customer segmentation process

After obtaining the keywords from customer summaries, the keyword-based segmentation was conducted.

Step 1: Confident keyword definition.

In this study, 40 key words were defined manually based on the pre-defined customer model and index of innovativeness at the very beginning of the process from each dimension (Eq 4.1 and Table 4.1) (Table 4.3).

Table 4.3 The keywords of features in each dimension

Classification Dimensions	Keywords
High Level in Involvement	amazon, author, blog, email, homepage, movie, music, website, often, personal, publish, read, review, weekly
High Level in Thinking	classic, degree, doctor, consulting, engineering, experience, fiction, historical, information, knowledge, non-fiction, pop, scientific

High Level in Feeling	amazing, avid, enjoy, fanatic, fans, favorite, geek, hobby, interests, like, love, passionate, pleasant
-----------------------	--

Step 2: Find representative customers for each segment.

The customer was considered to be representative if the word frequency in a dimension was greater than 1. With this scheme, 158 of 500 customers were selected as representative customers. These representative customers were those who corresponded to the relatively higher frequency of the pre-defined keywords of features (Fig. 4.4). As can be seen from Fig. 4.4, the frequencies of the manually generated keywords of features based on the pre-defined criteria for identifying representative customers can be considered to be high, since the frequency of keywords was more than 3 for most of the representative customers.

Figure 4.4 Frequency of pre-defined keywords of feature for 158 representative customers

Step 3: Keyword discovery with the labeled customer data.

The 148 representative customers with the pre-defined key feature words were labeled. The selected keywords were those that showed up at least three times. After the keywords discovery process, another 78 keywords were discovered (Table 4.4).

Table 4.4 The discovered keywords of features in each dimension

Classification	Keywords
Dimensions	
keywords in involvement	monthly, time, column, share, synthesis, reviewer, writer, musician, performer, producer, time, react, rewarding, commit, reading, writing, write, CD, books, journalist, editor, librarian, cartoonist, own book, collection

keywords in thinking	human, science, art, wisdom, wise, critical, founder, professor, literary, novels, life, new features, generalist, specialist, soundly, instructor, PhD, jazz, country, blue, philosophy, professional, teacher, university, literature
keywords in feeling	wonderful, imagination, happy, romance, enjoyable, motive, diverse, heart, good, interesting, care, diversity, musical, taste, junkie, book-lover, seeker, adventurous, pastime, grace, winning, American living, lifestyle

Step 4: Customer classification by using all keywords of features.

Based on the nearest-neighbour method (Eq. 4.2) and index of innovativeness (Eq. 4.1), 500 customers were classified into six different types with the keywords extracted from Steps 1 and 3. Examples of the results of classification are shown in Table 4.5.

Table 4.5 Examples of classified customers based on keywords.

Customer Summary	Keywords Extraction	Classification
<p>ACIW8J8AQI2</p> <p>“I like reading, so I read a lot. I used to be a PhD student, recently I became a doctor. The rest of my life is interesting enough to keep me occupied most of the time. I sincerely hope you like my reviews and you are always welcome to react on one of the review.”</p>	<p>like, reading, read, PhD, student, doctor, keep, hope, interesting, life, reviews, react, time</p>	<p>Type 1: Passionate Innovator</p>
<p>A2TV5S1J3VH</p> <p>“I am System Engineer. I have hand-on experience with Cisco, Lucent, Marconi, 3com products. My interest is seeking knowledge, especially networking. I am pleased to share my reviews to all of you. Hope the reviews can help you.”</p>	<p>system, engineer, experience, products, interest, knowledge, seeking, networking, hope, reviews, share</p>	<p>Type 2: Involved Innovator</p>
<p>AUW3HCCTUOA</p> <p>“I like all types of rock and electronic music. My favorite is Nine Inch Nails, Nirvana and Deftones. Also a big film fan, from The Matrix to Taxi Driver, just anything good. My website at http://www.entertainment.inuk.com contains more of me.”</p>	<p>music, like, types, rock, electronic, film, good, anything, favorite, fan, my website</p>	<p>Type 3: Devoted Innovator</p>
<p>AFDJ2HOZI58</p> <p>“I'm a 27 years old Spaniard from Barcelona. Music is one of my passions. I like jazz, bossa nova, MPB (Brazilian Popular Music), samba, the French chanson, boleros, Spanish pop music, flamenco and international pop (especially the sixties).”</p>	<p>years, music, passions, like, jazz, pop music, popular, international, French, Spanish, Brazilian, Popular, samba</p>	<p>Type 4: Amateur Innovator</p>
<p>A2M0P6W13XW</p> <p>“Eustace has enjoyed many careers. Early stage work included the production of Magic Shows. Following a career in Banking he switched to Insurance and eventually became CEO of a large underwriting company. He eventually sold the company.”</p>	<p>early, stage, enjoyed, careers, work, following, banking, insurance, sold, switched, CEO, production, Magic Shows, company</p>	<p>Type 5: Neutral Innovator</p>
<p>AH4IRHFUFER</p> <p>“I am a very old soul. Unfortunately, I don't expect too much wisdom.”</p>	<p>old soul, unfortunately, no wisdom, expect,</p>	<p>Type 6: Indifferent Innovator</p>

4.3.4 Results from model evaluation

The segmentation patterns identified above were then checked against the testing set. As mentioned earlier, there were a total of 600 customer information items. Manual classification was done on the 100 test cases following the same criteria as the ITF segmentation model. The matching accuracy is summarized in Table 4.6.

Table 4.6 A summary of the accuracy of each type of customers from auto classification

Customer Types	Hit Items	Total Items	Accuracy
Innovative customers	59	68	86.8%
Passionate innovators	25	27	92.6%
Involved innovators	14	17	82.3%
Devoted innovators	15	18	83.3%
Amateur innovators	5	6	83.3%
Non-innovative customers	18	33	54.5%
Neutral innovators	13	21	61.9%
Indifferent innovators	5	11	45.5%
Overall customers	77	100	77%

In order to show the feasibility and robustness of the classification method, a test was further done to check the relationship between the accuracy of the classification and the number of the keywords of feature. This work started with the 40 predefined keywords. Then, during the keyword discovery process, four more groups of keywords were selected that had 60, 80, 100, and 120 keywords, respectively. These five groups of keywords were used to do the customer segmentation for the same 100 test cases. After that, the results from the customer segmentation were compared with those from manual classification. The

comparison results show that the accuracy increased obviously as more feature keywords were learned from representative customers. Specifically, the original accuracy was just 39% and the final accuracy was 77% (Fig. 4.5).

The above-mentioned results were compared with the benchmark method (Grobelnik & Mladenic, 2005). In the benchmark method, feature words are selected randomly by the system, all the keywords are classified without pre-defining the confident keywords, and the learning mechanism from confident keywords are not applied. Therefore, with the number of selected keywords increases, there is no significant increase regarding the classification accuracy when using the benchmark method. As shown in Fig 4.5, the results from the proposed methods with keyword discovery outperformed the random keywords of feature classification. These results demonstrated the fidelity of the keyword segmentation strategies.

Figure 4.5 A comparison of results between keyword discovery and random selection.

4.4 Discussions

According to the data presented in Table 4.6, the average accuracy for the different segments of customers is 77%. This indicates that most of the classification results from the proposed model are correct. In addition, the number of identified lead users (i.e. passionate customers) is 25 while 59 customers are identified to be innovative customers. These results show that compared with the lead user theory, the customer segmentation model can help obtain more innovative customers.

The results from empirical study also suggest that the proposed model can identify more innovative customers. In past studies, only lead users with lead user characteristics from all the perspectives were identified. But in this study, customers who have shown “high level” in any two of the three listed innovative characteristics are identified as innovative customers. The percentage of the identified innovative customers among the selected customer sample is 25%, which is higher than the data presented in a traditional survey-based research (Luthje, 2004). Besides, using the proposed methods in the present study, passionate innovators (or lead users, innovative customers) can be found at very low costs, as all the data are collected from Internet.

Another interesting finding is that the accuracy for non-innovative customers is not very good, at only 54.5%. However, this poor accuracy is not important here

since the focus of this study is on identifying innovative customers. Note that the overall accuracy for identifying innovative customers is 86.8%. Thus, it could be assumed that the segmentation model is very successful in classifying customers and identifying innovative customers.

In addition, the validity of the criteria in defining the different types of customers can be guaranteed. As Fig. 4.5 shows, the frequencies of the manually generated keywords of features based on the pre-defined criteria for identifying representative customers are very high. Furthermore, the methods proposed in this work to segment different types of customers by feature words are novel and have advantages over other methods. In particular, by learning from the representative customers, more extended feature words can be extracted. The clear positive correlation between the numbers of feature words and the accuracy (Fig. 4.5) also demonstrates the feasibility and robustness of the methods.

The results also show implications for product development. The innovative customers provide their own ideas for new products and make suggestions for improving existing products. They also work as contributing consultants by means of customer reviews (Zipkin, 2001). The identification of innovative customers through sources from the Internet shows inherent advantages, with low cost and huge customer capabilities (Nambisan, 2002). In addition, the resource can be collected from both online and offline customers without requiring them to react at the same time.

With the motivation to fulfill their needs, innovative customers have the passion to be actively involved in the whole design process. These innovators are the main contributors to product development since they desire new knowledge co-production and extra value co-creation for the new products. Through the interactive learning process, both designers' and customers' innovative capability and competence are enhanced. For non-innovative innovators, there are different strategies. For neutral innovators, different solutions or concepts are displayed for customers, allowing them to select or reject different proposed solutions, e.g., during concepts selection stage. For indifferent innovators, static information from some purchase or registration transaction data is needed as the only input in the design process.

Therefore, innovative customers, including passionate innovators, involved innovators, devoted innovators and amateur innovators, are required to actively interact with designers and products during the whole design process to provide their input, while for non-innovative customers, customer involvement is only required in specific situations.

4.5 Summary

A three-dimensional customer segmentation model (i.e., the ITF model) was developed for innovative customer identification. Specifically, in this model, customers were classified from three different dimensions: involvement, thinking,

and feeling. Moreover, a group of NLP methods (i.e., the POS tag-based rules) were employed to extract keywords from text of raw customer information. A supervised classification method was used to find different segments of customers. Furthermore, the segmentation patterns generated from the classification process were checked against human evaluation. By comparing the findings from the present and previous studies, the proposed model can help identify more innovative customers more easily.

Using the proposed ITF segmentation model, a case study was conducted to classify customers. Compared to the traditional methods such as interviews and focus groups, this work provides an efficient way of obtaining knowledge from the online community. Since the online information is easy to collect and process through automated NLP tools, it shows great advantages in terms of both time and cost. Furthermore, due to the fact that innovative customer needs inputs are stated as a main source for product innovation, the proposed ITF segmentation model can enhance product innovation by providing inputs from more innovative customers.

This research also has some limitations. Firstly, in the case study, amazon.com was used as a service product for analysis. Future research could be extended to other products, such as software and service products. Such an extension can help identify innovative customers from a different perspective. Secondly, only 600 customer cases were studied to demonstrate the whole process.

More cases could be included to further enhance the fidelity of the model and proposed methods.

In summary, this work has great potential for identifying innovative customers in product innovation. Future research includes further extending the existing customer segmentation model in the latter stages of the product development process and investigating how to involve different segments in the product development process based on the proposed ITF model. The latter work can help tackle the problems caused by the shortage of established resources in the product design domain.

CHAPTER 5

ONTOLOGY-LEARNING CUSTOMER NEEDS REPRESENTATION SYSTEM

After identifying innovative customers using the ITF model presented in Chapter 4, some questions can be raised regarding the translation and representation of the innovative customers' needs, i.e., how to avoid the imprecise information and vague description during the translation process and how to embody the high level customer needs with product characteristics for needs representation. This study aims to address these questions by establishing an ontology learning system that is able to automatically translate customer needs into a customer needs ontology and to account for non-taxonomic relations. In particular, natural language processing (NLP) tools are embedded in the system for customer statements pre-processing. Subsequently, a set of algorithms is employed to extract the key concepts and taxonomic and non-taxonomic relations between concepts from the customer statements. Specifically, a word-property based method is originally proposed to extract more non-taxonomic relations. A case study was conducted to illustrate the proposed ontology learning system. It is hypothesized that 1) the built ontology would contain more semantics than the existing systems, and that 2) the proposed system is able to provide accurate concepts and relations.

5.1 An overview

In this work, an ontology learning system, the Ontology-learning Customer Needs Representation (OCNR) system, for building customer needs ontology is proposed. The OCNR is adapted from an existing ontology learning system, i.e. CRCTOL (Jiang and Tan, 2010). The CRCTOL has been proven superior to alternative systems, e.g., Text2Onto, due to its ability to extract ontology that is more concise and accurate, and contains a richer semantics in terms of the range and number of semantic relations (Jiang and Tan 2010). Fig. 5.1 shows the framework of the OCNR system. The proposed OCNR system comprises three main components, namely Natural Language Processing (NLP) Component, Algorithms Library, and Domain Lexicon. The input of the system is the raw data from the voice of customers (VoC), e.g. customer review. Natural language processing is applied to pre-process raw data from customer reviews with a set of NLP tools. After that, key concepts and taxonomic and non-taxonomic relations are extracted from the processed text using a set of algorithms. The output of OCNR is a customer needs ontology based on the extracted concepts and relations.

Figure 5.1 A framework of the OCNR system

5.2 Customer statement data acquisition

Several methods are available for collecting customer statement data, such as brainstorming, focus groups, interviews, customer complaints, and customer reviews (Kusar et al., 2007). Amongst these methods, online customer reviews become more and more important for customer needs acquisition since more and more customers are willing to share their thoughts and opinions online (Lee, 2007).

Therefore, in this work, data are collected from online customer reviews. The online user-generated product reviews provide product information such as the pros and cons of a product. For example, for digital cameras, a possible pro is “Excellent image quality” and a possible con is “Tiny buttons”. The assumption is

that the pro/con lists contain customers' needs for both explicit and implicit product characteristics.

5.3 Natural language processing

Customer statements obtained from online customer reviews are typically raw text data. NLP is applied for linguistic pre-processing and raw text analysis. The NLP components in the OCNR system use toolsets like Stanford's Log-linear POS Tagger (Toutanova et al., 2003) to tag words and the Berkeley Parser (Petrov et al., 2006) to identify constituents and their interrelationships in the sentences. With these NLP components, a full text parsing technique is applied for text analysis. Specifically, the full-text parsing techniques can develop parse trees that provide grammatical relations between phrases or words in the customer statements. The implementations of these tasks of natural language processing to customer review are shown in Table 5.1.

Table 5.1 An example of natural language processing to customer review

Tasks	Example
Raw text	... It gives me the ability to capture many special moments in an instant...
POS	... ("It", "PRP"), ("gives", "VBZ"), ("me", "PRP"), ("ability", "NN"), ("capture", "VB"), ("many", "JJ"), ("instant", "NN")...

Chunk	[S:It] [V:gives] [O:me] [O: the ability] ...
Filter	(“me”, “PRP”)
Syntactic analysis	Parse tree

The Domain Lexicon, which contains terms specific to the domain knowledge, is used in NLP components for document analysis. The domain lexicon is built manually to record concepts and semantic relations updated by users during the ontology learning process.

5.4 Ontology learning system architecture

The OCNR system is capable of performing the functions of concept extraction and semantic relation extraction. In this study, domain-specific terms are interpreted semantically for concept extraction, a string matching mechanism and lexico-syntactic pattern recognition are used to extract taxonomic relations, and a rule-based method combined with the full-text parsing technique is adopted for non-taxonomic relation extraction.

5.4.1 Concept extraction

In order to establish a domain ontology to account for customer needs for product characteristics, the first step is to determine what concepts are important in the domain of interest. Terms are linguistic representations of concepts in the text (Sagar et al., 1980), Hence, the purpose of concept extraction is to identify the

domain-specific terms from the text. This study uses a two-phase concepts extraction: candidate term extraction from text with certain linguistic filters and domain-specific term selection with statistical measures. Specifically, a group of NLP methods (e.g., the part-of-speech [POS] tag-based rules) are employed to extract terms from text. Statistical measures are then applied to evaluate the extracted terms, from which only candidates with high ranks are selected as concepts.

The procedure is described as follows (Jiang and Tan, 2010):

- (1) Extract all possible terms from texts. Concepts are *nouns* or *noun phrases (NP)* in texts, so the only lexical units that are collected are those with the *NP* tag.
- (2) Articles and descriptive adjectives (“*a*”, “*many*”, “*several*”, *etc.*) are removed from the terms extracted.
- (3) Candidate terms are determined by grouping all possible sets of words from the extracted terms.
- (4) Use Domain Relevance Measure to evaluate candidate keyword’s relevance to the target domain. It assumes that terms with a higher occurrence frequency should naturally be more important in a certain domain. For example, there are 2 terms: “door” and “shield”, and the first one shows higher DR measure compared to the later one in product design domain because of the high domain frequency and likelihood ratio. While in other fields, such as terrorist domain,

the later term may show higher DR measure. The details of the domain relevance measure can be founded in Jiang and Tan (2010).

After the process, the important concepts can be extracted. For example, by going through the whole process, two concepts are extracted from the sentence “*The digital camera has high resolution*”: “*digital camera*” and “*resolution*”.

5.4.2 Taxonomic relation extraction

There are two important semantic relations in domain ontology, including taxonomic and non-taxonomic relations. Taxonomic relations are the basic ones. String matching based on term structure is a simple method for taxonomic relation extraction. Several measures as described below are applied in the string matching methods when extracting taxonomic relations.

(1) Assume there are term1 [*head*] and term2 [*word, head*] in the ontology. A taxonomic relation is built between [*head*] and [*word, head*] (‘head’ is the syntactic head of the term). For example, if there are term1 [*price*] and term2 [*low, price*] in the ontology, a taxonomic relation is built between price taxonomy1 and price-taxonomy2.

(2) WordNet (Fellbaum, 1998) is used to facilitate taxonomic relation extraction. WordNet, like a traditional dictionary, contains terms and glosses based on

different characteristics, including Noun, Verb, Adjective, and Adverb. The following are heuristics adopted by WordNet.

- a. Assume *term1* and *term2* are in WordNet and there exists a taxonomic relation between these two terms. A taxonomic relation (*term1*, *term2*) is extracted. For example, if *term1*: [*color*] and *term2*: [*white*] exist in WordNet, a taxonomic relation exists between *term1* and *term2*, and the taxonomic relation (*color*, *white*) is extracted.
 - b. Assume *term1* (*word1₁*, ..., *word1_n*, *head1*) and *term2* (*word2₁*, ..., *word2_m*, *head2*), if *term1* holds the taxonomic relation with *term0*, and *head1* and *head2* belong to the same subset in WordNet, a taxonomic relation is also extracted for *term2* and *term0*. For example, if *term0* (*black*, ..., *green*, *color*), *term1* (*black*, ..., *green*, *dark color*) and *term2* (*navy blue*, ..., *red*, *dark color*), a relation is also extracted from *term0* and *term2*.
- (3) Besides the above-mentioned string matching methods, lexico-syntactic patterns recognition is also used to extract taxonomic relations. An example of using this method is that if a sentence contains a lexico-syntactic pattern “a kind of” (NP1 is a kind of NP0), a taxonomic relation between NP1 and NP0 is then extracted.

5.4.3 Adapted rule-based method for non-taxonomic relation extraction

In this study, an adapted rule-based method by combining full text parsing techniques is proposed for non-taxonomic relation extraction. Similar to other approaches for non-taxonomic relation extraction (Buitelaar et al., 2004; Ciaramita et al., 2005), it is assumed that verbs can indicate non-taxonomic relations between concepts. A semantic relation of (Concept, Relation, Concept) is extracted if there exists a lexical relation in the raw text with the form of (N_1, V, N_2) , where N_1 and N_2 are nouns or noun phrases, and V is a verb or verb phrase (Fellbaum, 1998). A rule-based method based on a full-text parsing technique is used to avoid inaccurate grammar relations between terms (Chen et al., 2011b), in which the noun and verb terms are identified by the regular expressions as follows:

Noun: $(DT) ? (JJ)^* (NN/NNS/NNP/NNPS)^+$

Verb: $(VB/VBD/VBN/VBZ)^+$

where DT represents an article; JJ represents an adjective; NN, NNS, NNP, and NNPS stand for different categories of nouns; and VB, VBD, VBN and VBZ are different tenses of verbs; '?' decides whether or not there is such a determinant (usually an article) that can group the noun terms.; '*' means zero or more adjectives; '+' separates expressions.

The rule-based method is able to extract (N, V, N) tuples from text. These tuples represent the non-taxonomic relations between the extracted concepts. For example, "the cameras have a flash" is a term where "cameras" is a plural noun

(*NNS*), “flash” is a singular noun (*NN*), and “have” is a base form verb (*VB*). A new tuple is generated as (camera, has, flash).

If only Part of Speech (POS) tag-based rules or shallow parsing techniques are used to extract non-taxonomic relations, wrong semantics could be extracted in certain situations. For example, for the sentence “The digital camera at night has clear images”, the relation (*night, has, clear image*) will be extracted by using the rule (*N, V, N*) which is wrong in a semantic sense. To deal with this problem, a full text parsing technique is used (Chen et al., 2011b). By analyzing the parse tree generated by the full text parsing technique, the true subject of the verb in a complex sentence can be determined.

5.5 A word-property based method for non-taxonomic relation extraction

Based on the adapted rule-based method presented in the previous section, a word-property based method is proposed in this research to extract more non-taxonomic relations. In the traditional rule-based method, the parse trees can provide grammatical relations between phrases or words. However, some important non-taxonomic relations which do not fit into the rules are still missing. For instance, in order to extract non-taxonomic relations from the sentence: “I need *a cute camera with pink color and cartoon shape*”, the relation between “*cute*

camera” and “*pink color*”, and the relation between “*cute camera*” and “*cartoon shape*” cannot be detected using the existing rule-based methods.

To tackle this problem, a word-property based method is proposed in this study to complement the rule-based method for non-taxonomic relations extraction. In this method, a non-taxonomic relation of $(Concept_1, Concept_2)$ is extracted if these two concepts can be frequently found from text simultaneously.

Many relations between customer needs and product characteristics are not one-to-one relations. An association rule mining mechanism is developed to reveal the complex relations between various words from the existing database. These words are from concepts either in customer needs or in product characteristics. A customer review can be considered a transaction record. The association rules are extracted from transaction data based on certain parameters, such as support and confidence. The confidence denotes the strength of an association, and the support indicates the frequency of the occurring patterns in the rule. Each association rule extracted from transaction data indicates a particular relationship between the transaction data sets.

In this research, the form of an association rule is written as follows:

$$Word1_0 \wedge Word1_1 \dots \wedge Word1_K \Rightarrow Word2_0 \wedge Word2_1 \dots \wedge Word2_L$$

$$[Support=p\%; Confidence=c\%]$$

where associations rule $\Rightarrow$ indicates a relation between the precedent *word1_set* (i.e. *Word1_0*, *Word1_1*, ..., *Word1_K*) to the consequence *word2_set* (i.e. *Word2_0*, *Word2_1*, ..., *Word2_L*); “^” stands for “AND”. The *confidence*, *c*%, denotes the percentage of the occurrence of *word1_set* when *word2_set* occurs, and the *support*, *p*%, indicates the percentage that *word1_set* and *word2_set* occur simultaneously in the record.

The proposed OCNR system uses *support* and *confidence* to determine if there are potential non-taxonomic relations between words. A data mining tool, Weka 3.7 (<http://www.cs.waikato.ac.nz/ml/weka/>) is employed to find the non-relationships between concepts with empirically set minimum *support* 0.1 and minimum *confidence* 0.2 (Zhang et al., 2006). For example, “a camera feels cute” is a term where “camera” is *word1* and “cute” is *word2*. By analyzing the frequency of “cute” and “camera” that appear at the same time, the OCNR system can determine the non-taxonomic relation between “cute” and “camera”. Using this method, it can also determine the relationship between “cute camera” and “pink color”, and the relationship between “cute camera” and “cartoon shape”, from the phrase “a cute camera with pink color and cartoon shape”. These relations cannot be detected using the above-mentioned ‘N-V-N’ rule-based methods. Armed with the proposed word-property based method, more non-taxonomic relations can be extracted. The steps of using the word-property based method to extract more non-

taxnomic relations between customer needs and product characteristic are illustrated in Fig. 5.2:

Figure 5.2 Process of word-property based method for non-taxonomic relation extraction

Step 1: Determine all the concepts generated from the previous steps

Step2: Obtain the itemsets of concepts. Both customer needs and product characteristics can be described as a set of concepts. Each set of data indicates a particular relation.

Step 3: Obtain the frequent itemsets of concepts. All the datasets are used as inputs to the proposed system. Based on the frequency, sub-itemsets of concepts are obtained.

Step 4: Obtain non-taxonomic relations. Non-taxonomic relations are extracted based on the setting of support and confidence in Weka data-mining tool.

5.6 Case study

In this section, a case study is used to illustrate the proposed ontology learning system process for acquiring a customer need ontology. Certain customer needs from online customer reviews were identified and analyzed in this process.

5.6.1 Data Acquisition

The data for analysis were obtained from online customer reviews from Epinions.com (<http://www.epinions.com/>). The customer reviews provide product information such as the pros and cons of a product. For digital cameras, a possible pro is “Excellent image quality” and a possible con is “Tiny buttons”. Based on this assumption, after splitting and filtering the pro/con lists, customer needs for Digital Cameras can be determined from customer reviews.

A set of 2000 online digital camera reviews were collected. These reviews were on 500 different digital cameras with the price ranging from below \$80 to above \$500. The digital cameras differed in target user population and varied in size and weight. Table 5.2 shows some samples of customers’ statements on digital cameras from Epinions.com.

Table 5.2 Example of customer reviews from Epinions.com

ID.	Camera mode	Pros	Cons
1.	Nikon S4000 Digital Camera	The camera has the best picture quality I’ve seen. Navigation, key arrangement, video quality and kit lens.	I don’t like the touch screen
2.	Canon PowerShot SD780 IS / IXUS 100 IS Digital Camera	The camera has medium price and picture quality.	Buttons are a bit tiny, several steps to get optimal image in unique lighting environments

3.	Canon PowerShot SX210 IS Digital Camera	The sensor could be improved. Auto-focus is very fast.	Grainy LCD screen and Expensive
4.	FUJIFILM FinePix S1800 12 MP Digital Camera	The camera is great for cinematic looking with HD video.	Poor metering, few aperture settings
5.	Sony Cyber-Shot DSC-W150 Digital Camera	The camera has manual focus. Improve ISO with less noise.	Need good lighting
6.	Canon PowerShot SD1100 IS / IXUS 80 IS Digital Camera	The camera has good video effect in low light.	Older technology now, lack of controls w/o CHDK, small lens
...	...	...	...

5.6.2 NLP for data pre-processing

After obtaining the raw data from customer reviews, semantic pre-processing was conducted for linguistic translation. Natural language processing mechanism was used for linguistic pre-processing and text analytics. The tasks in natural language processing include part-of-speech tagging, chunking, syntactic parsing, and semantic analysis. Examples of results from NLP are shown in Table 5.3.

Table 5.3 Example of customer reviews after NLP

1.	((S (NP (DT The) (NN camera)) (VP (VBZ has) (NP (ADJP (JJS best) (NN picture)) (NN quality)) (S (NP (PRP I)) (VP (VBP 've) (NP (RB Ever) (NN Seen))))))
2.	((S (NP (DT The) (NN camera)) (VP (VBZ has) (NP (NP (NN medium) (NN Price)) (, ,) (NP (NN picture) (NN quality)) (, ,) (NP (VBN improved) (NN sensor)) (, ,) (CC and) (NP (NP (ADJP (RB very) (JJ fast)) (NN autofocus)) (PP (IN in) (NP (DT the) (NN viewfinder) (, ,) (NN navigation) (NX (NX (JJ key) (NN arrangement)) (, ,) (NX (JJ video) (NN quality)) (CC and) (NX (JJ kit) (NN lens))))))
3.	((S (NP (DT The) (NN camera)) (VP (VBZ is) (ADJP (JJ great)) (PP (IN for) (S (NP (NNP Cinematic)) (VP (VBG looking) (PP (IN with) (NP (NNP HD) (NN video))))))
4.	((S (ADVP (RB Overall)) (, ,) (NP (PRP I)) (VP (VBP see) (NP (DT the) (NN camera)) (PP (IN for) (NP (PRP me))) (ADVP (RB personally)) (PP (IN as) (NP (DT a) (JJ big) (NN win) (CC and) (JJ great) (NN start))) (PP (IN into) (NP (NP (DT the) (NN realm)) (PP (IN of) (NP (NN photography))))))
5.	((S (NP (DT The) (NN camera)) (VP (VBZ has) (NP (NP (NP (NNP Manual) (NNP Focus) (NNP Subject)) (NP (NP (NNP Tracking) (NNP Auto) (NNP Focus)) (PRN (-LRB- -LRB-) (ADJP (JJ useful) (PP (IN for) (NP (NN steadicam)))) (-RRB- -RRB-)) (NNS 21mbps)) (PRN (-LRB- -LRB-) (S (ADVP (RB so) (RB far)) (, ,) (VP (MD might) (VP (VB be) (ADJP (JJ able) (S (VP (TO to) (VP (VB push) (NP (PRP it)) (ADVP (RBR higher)))))) (-RRB- -RRB-)) (NP (NP (NNP Improved) (NNP ISO)) (, ,) (NP (NP (JJR less) (NN noise)) (PP (IN in) (NP (JJR lower) (NN light))))))

6. ((S (NP (DT The) (NN camera)) (VP (VBZ has) (NP (NNP Good) (NNP Video) (NNP Effect))))

5.6.3 Customer needs ontology generation

By putting the raw customer reviews into the OCNR system, a group of concepts and relations were extracted. Fig. 5.3 shows the result files generated by the prototype OCNR system.

Figure 5.3 Output files generated by the prototype OCNR system

Specifically, 145 concepts were extracted from the selected customer reviews in OCNR system. These concepts are described by either nouns or noun phrases (Table 5.4).

Table 5.4 Examples of digital camera concepts extracted from online customer reviews

Camera	digital camera	vibration control	HD video	auto mode
Picture	image	huge zoom	image quality	auto focus
Video	mode	Flash	manual mode	LCD screen
Megapixels	easy grip	Size	battery life	metal material
Quality	shutter	low-light usage	video quality	desktop connector
Color	lens	wide angle	ease of use	optical zoom
light weight	screen	Price	body design	reasonable price
Function	material	sensor	flash location	swivel screen
Angle	IT connection	frame	shutter speed	view finder
convenient camera	fashionable camera	typical family usage	sturdy camera	professional camera

Using the taxonomic relation extraction process, 82 taxonomic relations were found between the extracted concepts (Table 5.5). Taxonomic relations can link more than two concepts. For example, manual mode is subclass of concept “mode”, and there is a taxonomic relation between these two concepts.

Table 5.5 Examples of digital camera taxonomic relations extracted from online customer reviews

camera -> digital camera	quality --> image quality --> low-light image quality
quality --> image quality	quality --> image quality --> day-light image quality
quality --> video quality	quality --> video quality --> HD video quality
quality --> color quality	location--> flash location --> proper flash location
zoom --> optical zoom	video --> HD video --> 1080p HD video
zoom --> mega zoom	battery -> battery life -> long battery life
mode --> auto mode	color --> light color --> silver
mode --> manual mode	usage --> light usage--> low light usage
weight --> low weight	material --> sturdy material--> metal material
weight --> heavy weight	screen -> LCD screen -> swivel LCD screen
image-->low-light image	camera -> digital camera -> DSLR

Using the rule based method in the OCNR system, 169 non-taxonomic relations were extracted. These non-taxonomic relations were represented in the way that the concepts were connected by verbs. Examples of non taxonomic relations (Concept, Relation, Concept) in the form of (N, V, N) are shown in Table 5.6.

Table 5.6 Examples of Digital camera non-taxonomic relations extracted by rule base method

camera --> have --> shutter control	mode-->supply-->range
camera-->shoot-->picture	file format-->recognize_by-->computer
camera--> take --> video	flash-->provide-->range
camera-->use-->angle	flash-->eliminate-->red-eye
camera-->have-->battery life	size-->fit-->shirt pocket
camera-->provide-->AF	button-->indicate-->battery power
camera-->set-->range	light-->impact-->shooting
camera-->work_in--> low light	focus-->reframe-->picture

Further, by using the word property based method, 35 more non-taxonomic relations were extracted (Table 5.7). These non taxonomic relations may help reflect the connections between abstract concepts (e.g., “convenient camera” and “professional camera”) and concrete product characteristics (e.g., “lightweight”, “wide angle” and “fast AF”). Compared to the rule-based method, the word property based method is more flexible in terms of extracting non-taxonomic relations, since it finds the relations based on frequency of the concepts without having to specify a verb to connect them. Moreover, by using the word property

based method, more implicit relations between concepts can be found. These extracted non-taxonomic relations are able to bridge the gap between high level customer needs and low level product characteristics.

Table 5.7 Examples of Digital camera non-taxonomic relations extracted by word property based method

manual control-> professional camera	fast AF & manual control -> decent camera
accessory -> convenient camera	lightweight -> comfortable camera
ease of use -> intuitive camera	lightweight -> typical family camera
fast AF -> decent camera	ease of use -> convenient camera
color -> fashionable camera	battery life & wide angle -> convenient camera
nice looking -> fashionable camera	lens range & battery life -> convenient camera
ease of use -> fashionable camera	reasonable price & battery life -> convenient camera
sensor -> joyful camera	wide angle -> convenient camera
wide angle -> amazing camera	view finder -> professional camera
wide angle -> professional camera	fast AF & lens range -> joyful camera
auto control -> joyful camera	reasonable price -> typical family camera
ease of use -> comfortable camera	metal material -> sturdy camera
ease of use -> typical family camera	auto control -> typical family camera

After specifying the concepts, taxonomic relations, and non-taxonomic relations, the customer needs ontology for digital cameras was determined. Fig. 5.4 illustrates parts of customer needs ontology, in which the taxonomic relations are linked by dotted lines and the non-taxonomic relations are linked by dashed lines.

Figure 5.4 A customer needs ontology representation for digital cameras

5.6.4 OCNR system evaluation

Paradigmatic evaluation method and subjective evaluation method were used to determine if the resulted ontology provided more concepts and semantic relations compared to the expert generated ontology. Moreover, the quality of the ontology was also evaluated in terms of the extracted concepts, taxonomic relations and non-taxonomic relations.

5.6.4.1 Paradigmatic evaluation

The expert-generated ontology from the online buying guide at Epinions.com was used as a benchmark ontology in paradigmatic evaluation. Fig. 5.5 shows the expert-generated ontology.

Figure 5.5 An expert-generated ontology for digital cameras

There were 48 concepts, 55 taxonomic relations, and 24 non taxonomic relations in the expert-generated ontology from the online buying guide. Examples of these concepts and relations are shown in Tables 5.8 and 5.9, respectively.

Table 5.8 Examples of digital camera concepts by experts from online buying guides in Epinions.com

AF Speed	price	optical zoom
Size	Memory	digital zoom
computer connectivity	Viewfinders	battery life
Ergonomics	movie mode	Lens
casual usage	picture quality	Megapixels
compact camera	professional usage	HD Video

professional camera	standard camera	Light weight
premier feature	advance feature	simple feature

Table 5.9 Examples of digital camera relations in Epinions.com

usage-> casual usage	price -> low price
usage -> intermediate usage	size -> compact size
usage -> professional usage	picture quality -> sharp picture quality
size -> small size	simple camera -> price
casual usage -> price	professional usage -> feature
casual usage -> picture quality	professional usage -> price

By comparing the customer needs ontology and the benchmark ontology (i.e., expert-generated ontology), it appears that the proposed ontology learning approach could generate more concepts and richer semantics relations compared. Details of the comparison results in terms of the numbers of the concepts, taxonomic relations, and non-taxonomic relations are given in Table 5.10.

Table 5.10 Paradigmatic Evaluation result

System	Concepts	Taxonomic relations	Non-taxonomic relations
Expert-generated ontology	48	55	24
Customer needs ontology	145	82	204

Seen from the Table 5.10, only 48 concepts are extracted from the expert generated ontology and 145 concepts are extracted from the customer needs ontology proposed by this study. Regarding the relations, the expert generated ontology help extract 55 taxonomic relations and 24 non-taxonomic relations while

the proposed customer needs ontology generate 82 taxonomic relations and 204 non-taxonomic relations. This result well presented the efficiency of the proposed ontology in extracting non-taxonomic relations.

Additionally, the number of concepts and relations in the ontology that can directly reflect the concepts and relations derived from the online buying guides was calculated. There are 42 concepts, 39 taxonomic relations, and 20 non-taxonomic relations from the online buying guide can be found in the established ontology. The precision is 87.5% for concepts, 70.9% for taxonomic relations, and 83.3% for non-taxonomic relations. Although these hit rates are not perfect (i.e., equal to or very close to 100%), they are considered high enough that most of the useful information can be accounted for by the extracted concepts and semantic relations.

5.6.4.2 Subjective evaluation

As mentioned earlier, there were a total of 145 concepts, 82 taxonomic relations and 204 non-taxonomic relations extracted in the proposed customer needs ontology. However, many of these concepts and relations are not accounted for in the ontology from the online buying guide. Therefore, subjective evaluation was conducted to examine the overall accuracy of the extracted concepts and relations from the established ontology.

In the subjective evaluation, 42 college students with backgrounds in product design were asked to evaluate the accuracy of the extracted concepts and semantic relations in the established ontology. Each student was asked to rate 30 randomly selected concepts, 15 randomly selected taxonomic relations, 20 randomly selected non-taxonomic relations determined by the rule-based method and 20 randomly selected non-taxonomic relations determined by the word property method.

Two criteria that are Goodness of concepts and Noise of taxonomic and non-taxonomic relations were used in the evaluation. The students were required to use 5-point Likert scales to rate the Goodness of concepts (1: strongly disagree – 5: strongly agree) and Noise of relations (1: strongly agree – 5: strongly disagree). Goodness of concept reflects the degree to which the selected concepts are good enough to be kept in the ontology. Noise of taxonomic and non-taxonomic relations account for the degree to which the semantic relations contain wrong information or nonsensical data that cannot help people understand the relationship between different concepts of the digital camera. For example, for goodness of concepts, rating score 1 indicates the participant strongly disagree that the concept is important, and 5 indicates that the participant strongly agree that the concept is important. For noise of taxonomic and non-taxonomic relations, rating score 1 indicates that participant strongly agree that the relation is an important taxonomic/non-taxonomic relation with little wrong information and 5 indicates the

participant strongly disagree that the relation is an important taxonomic/non-taxonomic relation with little wrong information.

Subjective evaluation results are summarized in Table 5.11. The rating scores for the goodness of concept and for the noise of relations are close to 5 and close to 1, respectively. This indicates that most of the respondents selected “strongly agree” for the questions asked. These results suggest that, compared with the expert-generated ontology, the established customer needs ontology may provide not only more concepts and richer semantics relations, but also accurate concepts and relations. Note that the noises of non-taxonomic relations are very low, i.e., 1.52 and 1.45.

Compared to the existing ontology system, e.g., Text2onto system, which only used rule-based methods or shadow text parsing techniques, the proposed system which applied word-property based method could help obtain more accurate non-taxonomic relation. Also seen from Table 5.11, 35 more non-taxonomic relations are extracted by using Method II (word-property based method) with very low noise which is lacked in other systems.

Additionally, non-taxonomic relations generated by the word-property method, which was proposed in the OCNR system, received the lowest noise score compared to non-taxonomic relations by rule-based methods and generated taxonomic relations. Therefore, the proposed system and method get better results compared to the relevant system and methods.

Table 5.11 Subjective Evaluation Results

Main goals	Sub goals	Number	Results (average score)
Customer Needs Representation	Goodness of Concept	145	4.22
	Noise of taxonomic relation	82	1.60
	Noise of non-taxonomic relation (Method I)	169	1.52
	Noise of non-taxonomic relation (Method II)	35	1.45

5.7 Discussions

In this chapter, an ontology learning system named OCNR system was developed for ontology-based customer needs representation. Specifically, in the proposed OCNR system, a set of predefined linguistic filters (i.e., the POS tag-based rules) were employed to extract single-word and multiword terms from text. Statistical measures were used to measure the terms and only terms with high DM relevancy were selected as concepts. In addition, string matching was used in WordNet and lexico-syntactic patterns recognition to extract taxonomic relations. Furthermore, non-taxonomic relations were extracted using an adapted rule-based method. Then, a word-property method is applied to extract more intangible customer needs through non-taxonomic relations. According to the findings from the present studies, concepts and semantic relations may be better defined using the proposed word-property method as a complement compared to using the rule-based method alone.

The main contribution of this work is that the OCNR system is able to realize automated customer needs translation and representation. This can help reduce the

heavy burden caused by manually translating customer statements into need statements. By representing the conceptualized customer needs in a formal specification, the established custom needs ontology in the OCNR system can find domain-specific concepts and relations between these concepts. It can also lead to more accurate customer need statements and further enhances the customer satisfaction. These attractive features make the proposed ontology-based approach a useful tool in the front-end product design process.

The contributions of this work are summarized as follows: 1) an ontology based approach is adopted in dealing with the problem of inaccurate translation of VoC, based on the results, it is effective to improve the accuracy; 2) an adapted rule based method and a word-property based method are proposed to solve the problem of embodying high level needs. Both methods are able to extract non-taxnomic relations between the low level product features and high level customer need; and 3) NLP and ontology are used in a new context of product development for automated customer needs translation and representation.

5.8 Summary

In this section, the OCNR system, an ontology learning system, was proposed in this chapter for customer needs representation. The proposed OCNR system can automatically translate customer needs into a customer needs ontology and extract both taxonomic and non-taxonomic relations. NLP tools were

embedded in the system for customer statements pre-processing. A set of algorithms were employed to extract the key concepts and taxonomic and non-taxonomic relations between concepts from customer statements.

Through a case study, the customer statements on digital cameras were collected using online customer reviews. Then, a customer needs ontology was built from the collected statements using the ontology learning system. Paradigmatic evaluation method and subjective evaluation method were used to evaluate the obtained customer needs ontology. It was found that the customer needs ontology derived from the proposed system contained more semantics compared with those from existing ontology learning systems. In addition, the proposed system was also able to provide accurate concepts and relations based on which, more accurate need statements can be obtained. These findings suggest that the proposed ontology learning system can be used to provide a knowledge-based guide for the succeeding stages in the product development process. In summary, this work appears to be promising in improving product design through well representing customer needs, which served as the most important inputs for the subsequent stages in a product development process.

CHAPTER 6

A CASE STUDY FOR SYSTEM ILLUSTRATION

In this chapter, the process of the overall system illustration was presented using a case study. System evaluations, including terminology evaluation and high level need statements evaluation, were conducted. Results and findings from the customer needs management system implementation were also discussed and summarized in this chapter.

6.1 Implementation process

The customer need management system (CNMS) that combines both the OCNR module and ITF customer segmentation module was implemented in this chapter. The implementation process consists of four steps: raw customer data collection, customer segmentation, customer needs representation, need statements generation (Fig. 6.1).

Figure 6.1 Framework of methodology for system implementation

After acquiring raw customer data, the ITF segmentation model is applied to identify innovative customers, as illustrated in Chapter 4. Raw customer statements are then obtained from innovative customers. These raw customer statements are put into the OCNR system to obtain a customer needs ontology. Based on the concepts and relations described in the customer needs ontology, customer need statements are generated. The implementation of the system using a case study is presented in detail as follows:

Step 1: Acquiring raw customer data

The raw customer data for the implementation process was obtained from Epinions.com, which can provide relevant customer data as well as customer review data. Specifically, the data for analysis was self-summary data collected from 500 members of Epinions.com. The customer data was from the “author

popularity” and “about author” categories under the customer profiles. The “author popularity” and “about author” were written by the customers themselves.

Step 2: Customer segmentation with ITF model

In this step, the ITF model was applied to identify innovative customers. By using the segmentation methods as discussed in Chapters 4 and 5, innovative customers were identified by using the keyword-based segmentation method. As a result, 292 customers were identified as innovative customers and 208 customers were identified as non-innovative customers in this study. Among the innovative customers, 106 were identified as passionate innovators, 69 were involved innovators, 91 were devoted innovators, and 26 were amateur innovators. Among the non-innovative customers, 155 were neutral innovators and 53 were indifferent innovators. The distribution of the different types of innovators can be found in Fig. 6.2.

Figure 6.2 Customer segmentation results based on ITF model

Step 3: Customer representation with OCNR system

After innovative customers were identified, customer reviews through the innovative customers were picked up as inputs to the OCNR system. At this stage, the OCNR system was applied to automatically analyze the customer reviews and represent them using a customer needs ontology, as indicated in Chapters 5.

Step 4: Need statements generation

After building the customer needs ontology, customer need statements can be generated based on the concepts and relations in the customer needs ontology. The

statements account for either taxonomic relation or non-taxonomic relation. Based on the guidelines from Ulrich and Eppinger's research (2008), each relation only specifies one need statement. After the process, a group of customer need statements were obtained. The extracted concepts and relations were organized in the customer needs ontology for need statements generation. Examples of the need statements generated from the customer needs ontology are shown in Table 6.1.

Table 6.1 Examples of need statements generated from customer needs ontology

Number	Customer Need statement
1	The digital camera provides fast AF.
2	The digital camera takes HD Video.
3	The digital camera has long battery life.
4	The digital camera is lightweight.
6	The digital camera is for typical family usage.
7	The digital camera is comfortable for easy grip.
8	The digital camera works in low light locations.
9	The digital camera indicates battery power level.
10	The digital camera is convenient with auto control.
11	The digital camera is professional with manual control.
12	The digital camera is convenient camera and lightweight.
...	

6.2 System evaluations

Subjective evaluation methods were used to determine if the terminology used in customer need statements were good enough compared to the expert generated ontology. Moreover, the quality of the high-level customer need statements was also evaluated.

The evaluation measures were the accuracy of terminology and the accuracy of high-level need statements. Both measures were subjectively obtained from the participants. In particular, higher accuracy of the terminology indicates that the selected terminology is better at reducing inconsistency in terminology usage between different individuals; higher accuracy of high-level needs indicates that the high level need statements are better at accounting for the customers' real needs for product characteristics.

6.2.1 Terminology evaluation

Four persons, two of whom with engineering background and the rest are with product design background, were asked to interpret customer needs directly based on 40 randomly selected customer statements from customer reviews. They are all had the industrial experiences as a mechanical engineer or a designer, and were well experienced as experts to interpret the raw customer needs into need statements. These experts were divided into two groups according to their backgrounds, namely design group and engineer group. They were asked to

interpret the customer needs by group. Table 6.2 shows the examples of customer need statements generated by the proposed system and by the participants.

Table 6.2 Examples of the generated customer need statements

Customer Statement	Interpreted Need (by design group)	Interpreted Need (by engineering group)	Interpreted Need (by ontology system)
“I need its grip; it feels comfortable”	“The camera is comfortable when grip”	“A grip is needed”	“The camera is comfortable for easy grip”
“I use it for shooting perfect photos for typical family or kids’ events even in dim light.”	1. “The camera can shoot perfect photos in typical family or kids’ events” 2. “The camera can shoot perfect photos in dim-light situations”	“The camera can work in typical family or kids’ events” “The camera can work in dim-light places”	“The camera is for typical family usage” “The camera can work in low-light conditions”
... ..			

Compared to the need statements interpreted by the participants, the need statements generated from the customer needs ontology used better-defined and clearer terminologies such as “fast AF”, “typical family usage”, “battery power level”, etc., and delivered clearer relations between terminologies such as “camera-

-> take --> HD video”, “auto control -> convenient camera” etc. These features make the need statements generated from the customer needs ontology be more acceptable.

6.2.2 High level need statements evaluation

In the second stage of evaluation, 48 participants with backgrounds in mechanical engineering and product design were asked to evaluate the accuracy of the generated customer need statements from customer needs ontology. All of them have the industrial experience in product development. Each person was asked to rate 40 randomly selected customer need statements. The participants were required to use 5-point Likert scales to evaluate the accuracy of the generated customer need statements with 1 and 5 indicating the participant strongly disagree and agree, respectively, that the need statement is accurate with little wrong information in terminology usage and needs embodiment. The subjective evaluation results for customer need statements are shown in table 6.3. The rating scores for the accuracy of the generated customer need statement indicated that most of the respondents selected “strongly agree” for the random selected need statements. These results suggest that, the established customer needs management system can provide valuable need statements. In this situation, the need statements generated from non-taxonomic relations with scores more than 4 out of 5 could be

selected as high level need statements and used as the inputs for the following stages.

Table 6.3 Subjective evaluation results

Customer need statement	Mean Rating
The camera should have shutter control.	4.33
The camera shoot HD photos.	4.57
The camera takes high-definition video.	4.42
The camera uses wide angle	4.27
The camera has long battery life.	4.53
The camera provides auto focus.	4.63
The camera can set range.	4.23
The camera works in low light.	4.42
The camera file format can be recognized by computer.	4.54
The camera flash can provide range.	4.27
The camera flash can eliminate red-eye.	4.35
The camera can fit shirt pocket.	4.27
The camera screen can indicate battery power.	4.56
The camera avoid light impact on shooting.	4.42
The camera focus can reframe pictures.	4.29
The camera size should be comfortable.	4.38
The camera has reasonable price.	4.46
The camera can assure high level quality.	4.60
The camera is professional with manual control.	4.60
The camera is convenient with auto control.	4.66
The camera is decent with fast auto-focus.	4.53
The camera is fashionable with nice looking.	4.23
The camera is cute with color.	4.21
The camera is professional with view finder.	4.49
The camera is typical family with auto control.	4.45
The camera is convenient with ease of use.	4.70
The camera is cute with plastic materials.	4.06
The camera is decent with fast AF and manual control.	4.53
The camera is convenient with long batter life and wide angle.	4.51
The camera is convenient with lens range and long batter life.	4.34
The camera is professional with wide angel.	4.43
The camera is professional with fast AF and wide length range.	4.43
The camera is cute with cartoon shape.	4.23
The camera is sturdy with metal material.	4.28

6.3 Discussion

In this chapter, the overall CNMS framework, which combines the ITF module and OCNR module, was presented. Using the ITF model, 292 innovative customers were identified among the selected 500 customers. Among the innovative customers, 106 were identified as passionate customers who have full innovative characteristics, and 155 were average innovative customers who may lack of one or two dimensions of innovative characteristics. Although the average innovative customers were often ignored in other lead user studies, they can still provide very valuable inputs for customer need statement generation (Kristensson. et al., 2003).

Using the OCNR system, a customer needs ontology for the product of digital cameras was built. In the OCNR system, a group of NLP methods (i.e., the POS tag-based rules) was used to extract single-word terms and multiword terms from text. After which the extracted terms were ranked using statistical measures, from which only terms with high ranks were selected as concepts. Based on the discussions in the previous chapter (i.e. Chapter 5), these measures can help well define the terminologies and relations. As the online information can be easily accessed and processed through automated NLP tools embedded with the linguistic filters and statistical measures, the use of the OCNR system can help save both time and cost with the automation mechanism.

In addition, in the OCNR system, string matching in WordNet and lexico-syntactic patterns recognition are used to extract taxonomic relations, and rule-based methods and word-property methods are applied to extract non-taxonomic relations. These relations could be well-defined and serve as the bases for developing customer need statements. The high-level customer needs could be embodied through the non-taxonomic relations.

The obtained customer needs ontology can facilitate generating need statements in a straightforward and easy manner. For example, for the relation “camera-->work_in-->low light conditions” presented in the customer needs ontology, a need statement can be generated directly as “The camera works in low light conditions”. Besides, both the concepts and relations in the ontology are accurate, which greatly enhances the accuracy of the generated need statements.

Compared to the need statements interpreted by designers and engineers, the need statements generated from customer needs ontology use very uni-defined terminology for concepts (e.g., “comfortable camera”, “easy grip”, “typical family usage”, “low light conditions”, etc.) and relations (e.g., “work_in”, “is_for” etc.). While the terminology used by designers and engineers are quite different (Please see Table 6.2). This can make it easier for people to understand the abstracted concepts and relations from the need statements. Therefore, use of customer needs ontology for need statements generation can reduce the confusion in the process of customer statements translation. In addition, since all the concepts and relations are

obtained from a well-established ontology, the accuracy of the need statements based on these concepts and relations can be guaranteed.

The customer needs ontology built by the important concepts and relations is able to facilitate matching customer needs with product characteristics in the product development process. As discussed earlier, a common problem in the current product design is that it is very difficult to identify the relationship between the high-level customer needs and the low-level product characteristics. The non-taxonomic relations obtained from the customer needs ontology can help figure out this relationship. For example, the non-taxonomic relation “manual control-> professional camera” indicates that a high level customer need (i.e., professional camera) can be accounted for by selecting certain product characteristics (i.e., manual control).

6.4 Summary

In this chapter, a case study was used to illustrate how the proposed CNMS system works. It was found that the established CNMS is able to help identify innovative customers and figure out their needs for products. Since innovative customer needs inputs are stated as a main source for product innovation, the proposed CNMS system can enhance product innovation by providing more accurate customer needs from innovative customers.

At the same time, the CNMS can help obtain well-defined terminologies and relations for describing the customers’ needs, and ensure the accuracy of the high-

level need statements. These findings suggest that use of the CNMS can enhance the fidelity of customer need statements, and thus has great potential in facilitating customer needs management in the product development process.

CHAPTER 7

CONCLUSIONS AND FUTURE WORK

This concluding chapter summarizes the findings and contributions of the thesis. The limitations and future work are also discussed.

7.1 Findings and contributions

By reviewing the literature in the field of customer needs management, four existing problems have been identified: 1) it is difficult to identify large groups of innovative customers; 2) the innovative characteristics of customers have not been well studied; 3) there exists imprecise information and vague descriptions in the customer needs representation process; and 4) there exists the mismatch between high level customer needs and product characteristics embodiment.

This research addresses these problems by developing a novel customer needs management system (CNMS), which is based on a customer segmentation module (ITF model) and an ontology learning module (OCNR system). Three case studies were conducted to validate the framework of CNMS. The first case study was to illustrate the feasibility and potential of the ITF model. Comparisons between different groups of customer data and comparisons between models with

and without learning mechanisms were conducted based on a sound experiment design. The advantages of the keyword based segmentation methodology were validated. The second case study was to justify the applicability of the OCNR system. Paradigmatic and subjective evaluation was combined for customer needs ontology validation. In the third case study, the CNMS was implemented and the accuracy of the need statements generated from the CNMS was examined.

The findings from this study can be summarized as follows:

- (1) By comparing the findings from the present and previous studies, the proposed ITF model could help identify more innovative customers in an efficient and effective way. Besides, as all the related information and data sources were from the Internet. Using online customer data has inherent advantages, such as low cost and huge customer data.
- (2) Automated NLP tools were used to help collect and process online customer and product information and automatically generate customer need statements. This makes it possible to reduce the heavy burden caused by manually translating and representing customer statements. This work provides an efficient way to obtain information from online community and represent the information automatically.
- (3) By combining methods from market segmentation, psychology, and lead user theory in product design, an integrative conceptualization of the

underlying dimensions of customer innovative characteristics was obtained. Accordingly, more accurate customer segmentation, which could distinguish innovative customers from non-innovative customers, was specified. This novel segmentation model is also able to help identify different types of innovative customers.

- (4) By using ontology learning system, the customer needs ontology derived from the proposed system contained more semantics compared with those from existing ontology learning systems. In addition, more accurate concepts and relations were extracted, and thus more accurate need statements were obtained.
- (5) By representing customer needs using ontological based methods, the OCNR system can represent high level customer needs for intangible product characteristics through extracting non-taxonomic relations between concepts.

The main conclusions of this work can be summarized as follows:

- (1) The proposed CNMS can help improve the accuracy of need statements on the product to ensure consistency and facilitate subsequent effective translation into product specifications. It integrates knowledge from both the customer domain and product domain and serves as a united framework for better understanding customers and their needs.

- (2) An integrated customer segmentation model for innovative customer identifications has been proposed (i.e., ITF model). Through the ITF model, the innovative characteristics of customers have been studied from a large scope of research. The established ITF model can also identify large groups of innovative customers with different degrees of innovativeness. This can guarantee a full customer involvement strategy with innovative customers' voice.
- (3) A novel OCNR system for customer needs representation and customer need statements generation has been built in this study. Basically, the OCNR system can represent high level customer needs for product characteristics in a better way by extracting non-taxonomic relations between concepts. Furthermore, the OCNR system is able to realize automated customer needs translation and representation and represent the conceptualized customer needs in a formal specification.

7.2 Limitations and future research

This research is limited in the following aspects.

- (1) In the innovative customer identification module, the strategies of involving different types of customer segments are not implemented in this study. In other words, it is unclear how customers with different degrees of innovativeness actively interact with designers and products during the practical product design process using a suitable platform.

- (2) In the customer needs representation module, the established ontology is based on very limited domain ontology resource. To improve the performance of the OCNR module, additional knowledge support in product design domain is needed.
- (3) The proposed CNMS system was evaluated by only using tangible products (i.e., 'digital camera'). Intangible products, such as software and service, were not covered in the evaluation.
- (4) The current customer segmentation formulation is a score-based method which can only provide subjective measures.

In order to overcome the limitations discussed above, future work may include:

- (1) Different customer involvement strategies based on customer segments should be investigated in the near future. In particular, due to the increasing advent of virtual design platform, technology such as multi-agent systems, multi-agent systems, which can provide a group of interacting autonomous agents, should be considered as a potential solution to implementing such process.
- (2) Future research should extend the product design domain ontology resource and involve additional knowledge support such as dictionary and lexicon to improve the performance of the OCNR system.

- (3) Additional research and case studies on intangible products, such as software and service, should be conducted using the proposed framework in future research.
- (4) The proposed approaches and methods in the study could be enhanced by improving the currently used customer segmentation formulation methods and semantic extraction methods. It would be more meaningful to use less subjective measures to enhance the fidelity of the segmentation formulation methods. Thus, advanced customer segmentation methods e.g., fuzzy clustering methods could be used or benchmarked in the future work. Besides, in order to capture the semantics, methods such as rough set in the machine learning field, could be used to enhance the existing method and in turn conduct certain performance comparison in the case studies.

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Appendix

Raw customer reviews data from Epinions.com:

Customer No	Customer Reviews
1	The camera has best picture quality I've Ever Seen.
2	The camera has medium Price, picture quality, improved sensor, and very fast autofocus in the viewfinder, navigation key arrangement, video quality and kit lens.
3	The camera has auto Focus in Live View (Monitor), Battery Price and battery grip.
4	Overall, I see the camera for me personally as a big win and great start into the realm of photography.
5	Already have the first pictures of friends known to inspire strong and I am still very much indeed to learn, but also much joy in it.
6	One or the other shortcoming (10min video, equipment incomplete: BDA, USB cable, a relatively high price) must put up with it.
7	Only the swivelling display of the camera in conjunction with the HD video would have been the icing on the cake, but you cannot have it all.
8	For beginners like me certainly a great device and it makes me not care that I'm probably gone the Nikon PR campaign for the trap with the easiest-to-use DSLR.
9	If you ask me that where is cheap price for the camera.
10	The camera is great for Cinematic looking with HD video.
11	The camera has Manual Control of ISO, F-stop, Shutter speed, White balance in video mode (by using AE-Lock).
12	The camera has Manual Focus Subject Tracking Auto Focus (useful for steadicam) 21mbps (so far, might be able to push it higher) Improved ISO, less noise in lower light.
13	The camera has Good Video Effect.
14	The camera has microphone input.
15	I produce independent television and short films utilizing the camera.
16	I decided to move into DSLR video production specifically due to this camera.
17	I've shot still photography for years on Nikon with beautiful results.
18	With this camera I can now get those looks on video without buying overly expensive 35mm adapters for video cameras.
19	I don't see any more than you'd get on normal CMOS sensors as long as you aren't a moron and know how to operate video/film cameras.
20	I've gotten bit rates up to 21mbps, which for some people is too low, but if you're like me and shooting with HDTV or the web in mind I think it's an appropriate bit rate.
21	You are able to use manual controls for shooting, you just have to lock them with the AE-Lock button before you move into live view.
22	All exposure functions (ISO, F-stop, Shutter, White balance) can be locked giving you for all extents and purposes full manual control in video mode.
23	Manual focus and Exposure compensation are available to tweak while recording.
24	Subject Tracking AF is useful for tracking and steady camera shots, but outside of that I wouldn't really consider using automatic features, not because they're not good, just because it's unprofessional.
25	It doesn't have microphone inputs, but I record to a separate audio recorder anyways.
26	With the camera's 35mm F1.8 DX prime lens this camera is capable of some really stunning cinematic HD video.
27	Against Canon cameras in a similar price range the camera appeared much more

	cinematic in quality, whereas the Canon had more of a video look to me.
28	The camera is over all a good camera.
29	I love the pictures and the video is perfect to up load to you tube and more.
30	I take photography at weddings and more and that camera has been a very good complement to my work.
31	The camera is easy to carry lightweight comfortable giving a break to the hands and wrists and acquisitions tremendous family use.
32	The camera is a Great camera quality for the price.
33	The camera's Price is really reasonable.
34	The camera's Quality is great.
35	The camera is ergonomically correct and feels comfortable in your hand Sleek Design.
36	Nothing worth mentioning but I'm no professional.
37	I hadn't use the site for very long I really like the camera, thought I use it for a lot of "at home" use.
38	My Facebook pictures look tight.
39	The camera has nice color reproduction, 24 mm wide-angle, Design, Features, Excellent outdoor image quality.
40	The camera has very good indoor image quality using proper settings, excellent image stabilization, and fast focus on subjects
41	The camera is Ease of use.
42	The camera has proper location of flash, good video quality.
43	When I first purchased this camera I began shooting pictures indoors and this is a terrible way to start since like most compacts this is not one of its strong points.
44	I did manage to get a few nice low-light pictures by using a feature called pro low-light.
45	Many of these pictures printed very well even at 8x10.
46	I tested the camera which was better in image quality in terms of noise.
47	The camera offered better indoor pictures without fussing with the settings, and like I mentioned you can achieve nice indoor pictures with the camera.
48	Getting decent quality pictures is quite simple when you begin to explore its features and what they all mean.
49	I never use auto mode for anything as it locks down too many options for me.
50	So a clear understanding of the cameras limitations will help you achieve nicer pictures.
51	So I would have to give this camera good review with indoor image quality being a minor negative for me.
52	Indoor picture taking can be corrected well enough to find them acceptable.
53	Everything else about this camera is ideal as I have accepted its limitations.
54	Video recording is a let-down, so don't try to use this as your only video camera.
55	The video quality isn't terrible but the camera has a problem focusing on the subject while zooming in and out.
56	Also you can hear the sound of the motor as the camera is focusing.
57	I just wanted to mention that but this is not a problem for me since I rarely shoot video.
58	We do have a dedicated video camcorder for that.
59	Ease of Use would be a con but not for me.
60	The problem that the some people would have understands how to use this camera outside of the auto modes.
61	I don't think this camera is a good choice for someone who is impatient and doesn't want to learn.
62	The auto modes still produce good results, but it's my experience that better image quality is achieved with more manual control.
63	So overall I would recommend this camera to the user who wishes to learn more about it.

64	It is not the average point and shoots so if all you do is auto you will be pleased under certain conditions.
65	Using a combination of the cameras other features will please you with even better details resulting in higher picture quality.
66	The camera is almost foolproof.
67	The camera has Pop up flash.
68	EXR mode is like a "Super Auto" setting and takes all the decisions regarding macro or portrait or landscape together with indoor lighting or outdoor.
69	Two exposures are then combined to give the best picture possible.
70	If you have not ordered the SD memory card with the camera it does have a small internal memory to get you started.
71	You can shoot in different aspect ratios to fill the widescreen on your monitor but the default setting is the old 4x3 ratio.
72	Changing the ratios will be seen on the camera screen with this model rather than just using a guideline.
73	As soon as you switch the camera you will see an obvious annoyance and why it does not get 5 stars.
74	The built-in flash rises automatically on the top left and without any request.
75	There is no way to click it permanently back down into place again as it just springs back up.
76	I found it was always awkwardly in the way where you usually hold the camera for taking shots.
77	If it had been positioned in the middle it would be OK.
78	The battery has to be removed for charging although more recent and cheaper Fuji models just plugged in to recharge.
79	As with the camera I have found that macro and close up shots are excellent on the EXR setting but landscape shots in very good light need some adjustment in Photoshop on the computer to return some colour saturation.
80	Setting the ISO to 400 rather than the default 800 and selecting a film simulation of Velvia gives a more vibrant result and is worth trying.
81	The panoramic function is a new feature which I am still trying out but initial results are as not as good as some software solutions I have used.
82	As it has an external charger a spare battery would be a useful extra.
83	I am very pleased with the camera so far.
84	The camera has good Image quality.
85	The camera has long Battery life.
86	The lens on the camera is awesome.
87	You can call it red dot mania or a Lumix or anything else, but the lens is a Leica.
88	With three aspect ratios to choose from, I really like the wide angle feature it provides.
89	The thumb wheel on the back of the camera is also very nice for changing aperture or shutter speeds.
90	The camera has superb lens resulting in superb pictures.
91	The camera has reasonable Price.
92	This wee beauty camera produces some fine photography with the bright and sharp lens.
93	I have taken photographs in the dark using only the available light (moon and street lighting).
94	I got superb results.
95	The camera is great when used at the widest angle – 24 mm at f2 produces amazing work.
96	The camera has Exceptional picture quality, reasonable price, and good design.
97	Although it may seem expensive but if you compare the price against the Leica X1, it is

	relatively cheap and the picture quality cannot be matched by the Leica.
98	For those who prefer a nice looking camera to enhance their exterior deficiencies, buy something shiny and colorful, for those who want a camera that can take exceptional quality pictures, buy this Fujifilm X100.
99	The camera's all round performance is great
100	I would like to own this but not at that price if it was £150 cheaper, I would really consider buying it.
101	Pictures are simply sharp.
102	Sensor is at least four times bigger and supposed to be somehow up-to-date and one cannot assume that F2 lens would be that much sharper and lighter.
103	I am looking at this and the Leica X1.
104	This is far more functional with interchangeable lenses and video ability.
105	I would love to know how the two cameras compare in image quality - which for me is of prime importance.
106	I have spent too much money in the past buying.
107	The latest camera is great.
108	One-size-fits-all cameras and been pretty disappointed, despite always doing my homework and
109	If I have to save for longer to be able to buy a quality camera that will last me years - producing crisp images, then wait I will.
110	So I will watch this space carefully.
111	The camera has Good picture quality and good video quality.
112	The camera is Overall-a-good-camera.
113	The camera has High quality lens AND swivel screen for macro use, good Design, small size etc.
114	Ideal zoom is 24mm-180mm EQV.
115	The camera is not expensive so get professional DSLR.
116	The camera should be small and have a swivel screen.
117	DSLR's get left at home because they are unwieldy and lumber you with a huge should bag.
118	The camera has Tank-like build quality.
119	The camera is Expensive.
120	I'm looking to upgrade from a basic compact camera.
121	The camera has Great image quality, Shoots HD video, Battery lasts a LONG time.
122	Articulating screen is very nice, 5.3 fps, built-in mic doesn't sound too bad considering that it's a built in mic.
123	The camera has quick auto focus in video/live view mode, battery grip.
124	The image quality of the EOS 60D is excellent and on par with the 7D for shooting the typical family or kids events.
125	As an owner of the 30D, 40D and 7D - I find the 60D IQ, handling and overall performance makes it worthy of the xxD designation.
126	Some reviews focus on the changes to body materials, but the 60D body is as solid as the 7D without any squeaks or flexing.
127	The density of the material used is quite substantial and the hand grip feels comfortable.
128	The articulating LCD display is smooth and closes tightly.
129	The buttons and controller are re-organized to accommodate the moving display.
130	The top display is easy to use.
131	The flash and shutter mechanism operate like the rest of DSLRs.
132	The 60D's reduced weight, dimensions and lower cost over the 7D make the 60D a great choice for xxD owners.
133	After using the 7D for a year, I find the 60D more comfortable in my hands. Not that 7D

	is bad, but it's increased weight and size always seemed to cross a comfort threshold when carrying around.
134	The low light (high ISO 1600-3200) performance of the 60D appears to be superior to any Canon, including my 7D, which I have owned.
135	The 60D WB performance in indoor lighting is in line with other Canons so similar adjustments can be made in your work flow.
136	While the 7D AF specs are better than the 60D, images are just as good for normal situations. Canon seemed to know what was important to most users and put it in the 60D and their experience with the EOS line is ever present here.
137	The camera has fantastic pictures, autofocus in video mode and is very simple to use.
138	Having taken delivery of our new 60D the day we flew out on holiday we had no time to read the manual.
139	However it was very easy to use and we hardly ever needed to move it off the fully auto mode to get some amazing pictures.
140	The only time we tried out the other modes was to shoot video clips, or to force it to autofocus on the item in the centre of the frame.
141	Although it shoots great full HD video clips, it will only re-focus if you press a button, and usually it takes 1/2 second of hunting before it re-focuses properly.
142	Not great mid video clip so it doesn't quite replace a proper video camera yet.
143	I am no photographer, and probably will not use half the functions available.
144	The camera takes better pictures so I would definitely recommend it.
145	The camera takes great photos.
146	The camera has good video clips and couldn't be easier to use.
147	The software is quite cool - you can remotely control almost every aspect of it via the usb cable.
148	The camera has good Image quality, Simple to Operate, Fast Auto Focus, Night Shots, Battery Life, and Grip.
149	The camera is easy to use and image quality is fine. It is a little hard to hold and not good for long videos. I think it is a good DSLR for a beginner.
150	The camera has amazing image quality and HD video.
151	This little thing of the camera is amazing.
152	Image quality is fantastic, especially in low light and great noise reduction up to 1600 ISO.
153	The camera is so simple to operate.
154	Battery life could be better.
155	Having only just purchased the camera, my first picture amazed me with its image quality.
156	The camera just does more than I expected so, easily.
157	This is definitely a no fuss "point and shoot" with all the benefits of a mid to high range DSLR.
158	The camera is just good about everything.
159	The camera provides good Image quality, fast speed and absolute fun.
160	I was looking for a camera with movie function.
161	It makes my old 200 like something out of the ark.
162	This camera provides fast AF.
163	This camera gets the burst right with a good class 6 card and you get more than the 7 shots.
164	The camera's video is fine.
165	I never shoot for longer than say 3 or 4 minutes so not had the over-heating.
166	The camera is very good for the price.
167	The camera is small and light.

168	The camera has insanely fast AF on burst for the money.
169	The camera has LCD mount and its EVF is as good as an OVF.
170	No foreseeable drop in IQ from using the translucent mirror of the camera.
171	I was still amazed by how quickly the camera can take individually focused shots too.
172	I bought the camera with the 18-55 and 55-200 lens as a starter Alpha, mighty impressed so far.
173	The camera is Very intuitive.
174	I can understand the grip may be a little small for some (my hands aren't massive but even then my pinky is slipping off the bottom of the body).
175	The EVF isn't for everyone but it's comfortable to hold and I haven't yet thought of any particular part where I would really crave an OVF over the EVF, especially when you consider
176	If you're an average Joe looking for a very decent starter SLR style camera with pretty awesome performance I can only sing praise for it.
177	This is coming from someone who was always put off by SLRs and Alphas in general in the past.
178	The camera has Lightweight and video shooting.
179	Just bought the camera and used it to shoot video.
180	After 9 min of shooting the camera goes into a safe mode due to overheating.
181	Apparently due to a faulty image sensor design it overheats at about 9 mins with the image stabilization on.
182	If you turn it off, it extends for 29 min.
183	If you are buying this camera to take videos, it is certainly a bad choice.
184	Really fast auto focus and the grip.
185	I was convinced to buy the camera.
186	I had some difficulties holding the camera, but I find a way to hold it.
187	The camera has Wonderful build quality, bright AMOLED screen, fast Schneider lens, and remote control.
188	The camera just felt right in my hands.
189	Everything of the camera felt right.
190	The camera felt good.
191	I had originally gone to the shops to confirm my opinion on what I had read.
192	I was going to purchase a LX5.
193	I was turned off by the 5s build.
194	I also really liked the bright AMOLED screen of the EX1.
195	The camera can flip or rotate.
196	There has been many a time I wish I could do that.
197	I would like an ELF.
198	However, the one for the LX5 is just plain dull.
199	An optical viewfinder is better and clearer.
200	I also purchased one for the EX1.
201	I have been very pleased with the clarity and contrast of the Schneider lens for the EX1.
202	It may have a narrower zoom range than the LX5.
203	However, that doesn't matter to me.
204	About 86% of my shots are a max wide angle.
205	The camera has a wider wide angle lens.
206	The camera is fast.
207	The video is HD, However, I thought that's what a camcorder is for.
208	The camera may not be for everyone.
209	What the camera has, has to fit.

210	The camera has a super build, really great FAST lens, and a very bright screen.
211	The camera is a great little camera.
212	The camera is a photographer's camera.
213	When I started working as a pro-photographer 35 years ago, we understood the 1st rule: lenses take pictures and cameras hold film.
214	Now in the new digital age not much has changed.
215	The lens alone on this camera is worth more than the purchase price.
216	The camera has small Size and HD Video.
217	I get a video camera.
218	Bottom line is real easy: This camera takes superb still photos that easily put down the standard Far from the entry level DSLRs that cost three times as much.
219	The camera has Great Pictures and Body Design.
220	The low-light photos turned out better than expected.
221	The camera has Proper flash location.
222	I felt that the shots took too long to focus during my children's active moments, although they turned out very clear and bright.
223	I'm contemplating returning it just because of the placement of the flash.
224	I have accidentally covered it so many times already (in two days) that I am frustrated.
225	When I remembered to place my finger on the edge of the body, it slipped off, causing the camera to fall (thank you wrist strap).
226	Hi-qual compact w/pro-style speed and ISO range.
227	Scene modes supply full range of light in most situations.
228	Focus is fast.
229	Fill flash works well.
230	The camera has Pop-up flash and software eliminate red-eye.
231	The camera has Hi-Res display outstanding.
232	The camera has fast Shutter speed and f-stop display when the shutter release is half depressed.
233	The camera has Vibration control.
234	Make camera's battery indicator "always on."
235	The camera comes closer to all of my needs than any compact I have yet seen.
236	The camera fits easily in my shirt pocket and appears well-made enough to carry in a pants pocket, but time will tell.
237	This is reasonably close to a good pocket camera for a pro looking for something to carry around without the hassle of the SLR bag, lenses, etc.
238	A few more manual controls (there is ISO control in "Menu") would make it perfect.
239	I rate this camera 4/5 star in the compact class.
240	Thanks to Nikon for sticking their neck out with the range of settings they use to enable this technology to provide such high quality results.
241	This camera pushes the limits of high-ISO and slow speeds which, I am sure, has caused some to say their pictures are "grainy" or "blurry".
242	I noticed most of my shots in "Party" mode were at 1/8 sec.
243	They came out fine but remember to steady your grip when shooting in dim light, just like you did with film when you were pushing the slow-speed limits to capture a shot.
244	I'm pleased the camera set the speed and ISO ranges as wide as they did in the scene modes, however, I'm sure future versions will improve on vibration control.
245	We expected grainy results when we pushed Tri-X to 1600 and that was on 864 sq. mm of film.
246	Obviously, they are improving all the time but a larger sensor would help (see recommendations below).
247	I have not yet evaluated the HD movie but I like the dedicated button, the zoom works

	smoothly and the brief tests I ran look fine.
248	Before I purchased the S8100 I searched for reviews and found very few. The couple of decent reviews clued me that this might be a good purchase.
249	I have been a semi-pro photographer for over 40 years (many weddings, portraits, a couple of model portfolios, etc) and maintained my own darkroom (color, B&W).
250	Early on, I used the camera for film. More recently, I've had several digital cameras over the past decade.
251	I have been looking for a pocket digital that would provide an accurate "fill flash" for portraits and back-lit scenes.
252	The camera provides detail in dim light while not washing out faces with flash (provide a smooth range of zones 0-10).
253	The camera provides a wide angle for group shots.
254	The camera provides at least 250-300mm focal length (35mm equiv) for pulling in distant shots.
255	The camera provides a wide f-stop of 2.0-2.5 to isolate subjects.
256	The camera provides a small f-stop of 8.0-11 to allow a near-infinite depth-of-field.
257	The camera provides an ISO range up to at least 1600 for low light shots.
258	Enough speed to shoot several times quickly or catch an event before it is over.
259	I could do all this with my F3 and I want it in my pocket digital as well.
260	There is room for improvement.
261	Maybe this would be the "Pro" model?
262	It would have to be NO LARGER than the current S8100.
263	I would pay \$100-150 more for this version and give my S8100 to a family member. - Increase the sensor size to 1/1.7. (Still a BSI-CMOS)" -Widen Focal length to 25-300mm (35mm equiv). - Add RAW capture (JPEG/JPEG+RAW/RAW).
264	The camera included an HDMI cable in the box.
265	The camera has a ISO number to speed and f-stop data on screen before shutter release.
266	The camera adds 2-3' to the flash coverage.
267	The camera has a "Hi/Reg" button on the back to save battery power, although I would accept fewer shots to get more flash coverage.
268	The camera has a remote shutter control (optional).
269	The camera has a "Manual" option to the mode dial to enable the following.
270	The camera has a toggle on the back for metering control "Matrix/Center-weighted/Spot".
271	Of course, holding the shutter-release down half way would lock the focus allowing metering for a spot, then re-framing the picture.
272	The camera has an f-stop control on the front lower right of the lens.
273	The camera has a shutter speed control somewhere.
274	I suggest replace +/- on the Rotary Multi-Selector and put +/- in the menu system next to ISO.
275	The camera is the Best point and shoots on the market.
276	The camera has Backlight CMOS sensor.
277	The camera has In-camera high dynamic range (HDR) 3200 ASA.
278	The camera has instruction manual.
279	The camera is Family usage.
280	Thanks to the camera, I was able to share really amazing photographs with family usage
281	What makes this camera so spectacular is its ability to shoot perfect daylight photos in really low light conditions.
282	The Neonatal Intensive Care Unit was very dim almost dark and with the flash turned OFF I was amazed at the perfect exposure, perfect color saturation, daylight balanced pictures taken under extreme artificial lighting conditions.

283	With quality like this the lines between point and shoot and DSLR are becoming very blurry.
284	The best features are the backlight CMOS sensor which enhanced low light shooting conditions and the 3200 ASA.
285	The camera has high dynamic range (HDR) function, which merges images of the same scene to achieve a single image with a broad range of tonal detail.
286	With quality like this the lines between point and shoot and DSLR are becoming blurred.
287	The camera has great value at the price.
288	The camera has huge optical zoom, Great 1080 p video, fast, good value for the money.
289	The camera has Pop up flash location, manual controls and battery charge.
290	Overall, the camera is great at a great price.
291	The camera's price is 249 with a case and 4 gig memory card.
292	The 1080p video is very good for a small compact camera like this one.
293	Don't be fooled by the camera in the video review.
294	Like any other techno marvel you don't want to drop it.
295	The camera is Great for a mega zoom and auto settings.
296	The camera has Lens, good image quality
297	The camera has nice long zoom lens.
298	The camera has Zoom capability, strong construction.
299	Zoom lens would not retract.
300	The camera is an excellent all around camera, especially for travel.
301	Excellent picture quality, ease of use, good range of optical zoom (30mm to 300mm) covers most subjects.
302	The camera is Quality built.
303	The camera has battery lasts long enough for a reasonable amount of pictures.
304	The camera has Back-up battery, as for most digital cameras.
305	The camera has 4-GB memory.
306	The camera has good grip available for the left hand.
307	I studied the pictures Nikon recommends how to hold the camera, I guess if I follow the recommendation and get used to it, and it's OK.
308	Overall, I like this camera very much.
309	I have owned at least 15 cameras, and out of the 15 so far I like this one the best.
310	The other was a film camera from ancient time ago.
311	One certainly can't beat the ease of use, not having to lug around 25 pounds of camera equipment, especially bothersome on a trip to be enjoyed.
312	Excellent for quick pictures with a great zoom
313	The camera is Easy to operate.
314	The camera is good in low light.
315	Flash has fewer red-eyes than my other compacts.
316	Video controls are separate from the picture controls so it's quick to switch from stills to video.
317	I also like the wheel for changing settings and reviewing pictures.
318	The camera has Fast Shutter speeds.
319	The camera has Increasing IOS in automatic settings.
320	This could change as I become more familiar with the camera operation choosing different settings.
321	The camera has Manual control for setting shutter speed and IOS.
322	I have looked an operated many different point-and-shoot cameras and this one has the highest megapixels with fastest lag times between shots and focus speeds are quick.
323	It's the best camera I have found in this category and price range.

324	Probably one of the best point and shoots out
325	The camera has Vivid low light shots, clarity, and the 1080 p filming
326	The camera looks great.
327	The flash on the left that pops up, sometimes I have to force mine open.
328	I wasn't so sure when I go a Nikon for Christmas since I have always been a canon person, but this camera quickly impressed me for a point -n-shoot.
329	Very clear photos, can take them rather quickly, and shoots pretty nicely in 1080p (very crisp).
330	Battery life is OK, overall I would say its worth the money if you can get one that doesn't have the minor glitches like mine, and if you don't mind being cautious of the flash.
331	The camera has Great pictures.
332	The camera has Good body design.
333	The low-light photos turned out better than expected.
334	The camera has proper flash location.
335	I felt that the shots took too long to focus during my children's active moments, although they turned out very clear and bright.
336	I'm contemplating returning it just because of the placement of the flash.
337	I have accidentally covered it so many times already (in two days) that I am frustrated.
338	When I remembered to place my finger on the edge of the body, it slipped off, causing the camera to fall.
339	The camera has Brilliant image quality.
340	The camera has excellent low-light performance.
341	The camera takes beautiful night portrait pictures sharp and clear day-light pictures.
342	The camera is one of the slimmest in its class.
343	The camera has Strong metal casing.
344	The camera has Long battery life.
345	The night landscape and night portrait shooting modes work extraordinarily well to take pictures in urban areas.
346	Day-light pictures are of exceptional clarity.
347	If there is a lot of back-light the results might not be perfect but are still very impressive.
348	The camera is pretty good for just over \$200.
349	The camera has Lot of bang for the buck.
350	The camera is Small size fits shirt pocket.
351	The camera takes pretty good pictures.
352	The camera has Battery level display.
353	Shooting recovery time is short.
354	The camera has proper Flash location.
355	An Excellent Camera has good Quality and performance.
356	The camera is a little expensive.
357	The camera is an excellent product.
358	The camera has excellent picture quality, exceptionally good night mode, and amazingly clear macro mode.
359	Image quality in the dark is amazing and it feels like the camera knows exactly what to do.
360	The lens is undoubtedly the best in its class. I went in thinking of buying the S6000 but the S8100 was just too hard to resist.
361	The camera Beat other cameras by a mile and overcome their drawbacks.
362	The software is appealing and the GUI is easy to get around.
363	A great camera though is using Picasa instead of the provided software

364	Amazing point and shoot for the cost.
365	Excellent low light shooting and macro shooting and the 1080p video is great.
366	The camera has panoramic shooting.
367	The price is low.
368	I couldn't find another point and shoot to match the quality.
369	Great Portable Camera has good pictures with awesome video.
370	The camera has CMOS, 10X optical zoom, Pocket sized, HD video.
371	This camera is super quick on startup, very good shutter lag between shots, good low light shots, and the video is superb.
372	The camera has zoom, video focusing in low light.
373	The camera is easy and quick.
374	The camera starts up and is taking pictures before my kids have a chance to ruin the shot.
375	The camera got good time between shots .
376	The camera is very portable.
377	The great video quality definitely offsets the noise picked up by using zoom during video recording.
378	Many other pocket sized cameras with HD video won't even let you use zoom during video recording.
379	I also really like being able to take pictures during video capture; however, the picture size is greatly reduced.
380	Size was the primary reason for getting this camera, but I was not willing to skimp on quality of picture.
381	I have had a camera with 12X optical zoom.
382	I wanted something that gave me as close to 12X as possible while still giving good picture quality as well as HD video and it had to fit in my pocket.
383	This camera does just what I wanted it to do.
384	A great camera shoots well and VERY fast.
385	The movie mode works great, quality is superb.
386	Movie mode can shoot in long time increments.
387	The camera has Excellent photos, good zoom.
388	Sturdy construction and flash is in proper location.
389	This camera takes great photos and had great speed.
390	The camera has Good features, good quality parts and large LCD screen
391	The camera has Good features, Good photos and nice video.
392	The 1080p video looked nice.
393	I was pleased with the quality of the photos.
394	I purchased and returned this camera.
395	It's getting a lot of press, but I was not pleased with the quality of the photos.
396	The video looked great, but the photos looked much worse than on my old canon sd1100 which I'm still using.
397	The camera is the Most Fun Camera Ever.
398	The camera has GPS, BEST HD movie recording 1080i at 60fps or 720p at 30 fps.
399	The camera has good Picture Quality, fast Shutter Speed, accurate Sound and 10FPS at full resolution.
400	The camera takes Clear, Crisp pictures & movies.
401	Twilight mode is great.
402	A limited manual control is nice.
403	The camera has manual modes.
404	The camera has Noise reduction.

405	Manual controls are very lacking.
406	There's a reason this camera is selling out everywhere at the moment.
407	I've had more fun taking pictures the last week than I have ever had with any other camera.
408	You know how your old point-and-shoot camera has a bunch of different modes and probably some "scene modes" that you can hunt around for in menus and which never really seem to do much?
409	The HX5V has all this stuff on steroids and it's both powerful and useful and easy to get to.
410	The large mode dial on the top of the camera lets you jump back and forth between the different modes (panorama, fully auto, Hand Held Twilight, etc.).
411	I believe the settings are saved in each mode so you rarely have to change anything.
412	No hunting through menus to get to another mode, just spin the dial and off you go.
413	The HX5V is small and easy to hold for an extended period of time.
414	I spent a couple hours wandering around the zoo yesterday pretty much holding it in my hand the whole time without getting tired.
415	Try that with a DSLR. It doesn't matter how good and expensive your camera is if it's so big that you don't bother to take it with you.
416	It's extremely fast and responsive.
417	Pre-focused shots are virtually instantaneous and even with focus you'll almost always get the shot as it's very quick.
418	This is a huge improvement over older cameras I've used.
419	The camera has Sweep Panorama mode.
420	Spin the dial to the panorama mode, hold the shutter and move the camera around to create a The camera has 270 degree panorama shot.
421	The camera takes a whole bunch of pictures and then stitches them all together in a couple seconds, and the results are amazing.
422	This gives you a very interesting and different way to photograph a location, and the camera is worth the price for this alone.
423	The camera has 10-shot burst mode.
424	Touch the still/bracket button on the top of the camera and you enable burst mode by default.
425	This will take 10 pictures over a one second period, and is perfect for capturing animals, kids, or any other moving/uncooperative subject.
426	It does take about 20 seconds or so to process and save all ten shots to the memory card before it's ready to shoot again.
427	The camera has HDR backlight mode.
428	This is one of numerous modes the camera has that involve it taking multiple exposures and then merging them together.
429	In HDR mode it takes two shots in quick succession to expose both highlights and shadows, and then merges the two together to create a result that has the appearance of having much more dynamic range than you could get from a single exposure.
430	The camera really works well with backlit subjects.
431	Hand Held Twilight (HHT) mode.
432	This snaps a series of images and then syncs/merges them together to produce a sharp lower-noise image than you could get from a single long-exposure shot.
433	The camera Works great in low light situations.
434	The camera has HD Video.
435	The HX5V can capture great looking 1080i High-Definition video.
436	You don't even have to switch into "movie mode" as there's a dedicated record button that will start recording video while in any mode.

437	So if your subject starts doing something interesting, just hit the button and it's quickly recording full definition video. The results are really quite impressive.
438	The camera has GPS.
439	The camera contains both a digital compass and a GPS receiver, and will "geotag" pictures with their location and the direction you were facing.
440	It's great to be browsing your photo collection and be able to click a link in the metadata (I'm using Adobe Lightroom) and have a Google maps satellite image come up showing you exactly where the picture was taken.
441	So far it is amazingly accurate, at least when shooting outdoors where it can get a good view of the sky.
442	If the camera has boon off for a long while then it takes about 30s to get a lock on the position, but if you've had it on recently then it only takes a few seconds to re-establish the position when you turn the camera back on.
443	There's a bunch more useful and fun stuff it can do, but those are the most interesting features for me so far.
444	This camera just does so much that it adds new dimensions of fun to taking pictures, and its advanced features are made easier to use than you might expect.
445	There's even an "easy mode" that increases the size of the text on the display and simplifies the information shown for your less-technology-savvy user.
446	The camera is a great fun overall.
447	The camera is happy overall.
448	The camera has great photos, HD videos (both AVCHD 1080i and MP4).
449	Look fantastic on my 50" plasma TV -FINALLY, SD card compatibility.
450	The camera works well when photos are zoomed in but for family viewing.
451	It's fine.
452	I'm not photographing for a magazine or anything.
453	The camera has Proprietary mini-HDMI adapter.
454	The camera chooses 16:9 format reduces to 7meg photos.
455	I have 3 Canon Powershots (A540, SD700IS, SX10IS) from reading past recommendations and I'm not overly happy with them.
456	The camera works in low light.
457	I also looked at this HX5V's main competitor, the Pana TZ10/ZS7 and looks like it takes better photos and video.
458	But the Pana causes annoying light streaks on videos (see Youtube), which I would find irritating and unacceptable.
459	Also, I owned 2 Pana camcorders that broke so reliability was in question.
460	Therefore, I chose Sony this time around.
461	Especially since they decided to incorporate SD card usage.
462	My 8GB card can hold 1500 photos or approx.
463	1 hour of 1080i video.Perfect! No need to take my video camera on trips anymore.
464	I've had it for 1.5 days and so far, am quite happy with the quality.
465	I viewed photos and videos on my plasma TV and it's amazing.
466	The AVCHD video format needs to be converted before you can edit them on your computer.
467	I have both a Mac and PC so I'm still playing around on both and looking for an easy method.
468	The original MTS file format is not recognized by iMovie 08. You can shoot in a lower quality MP4 which iMovie will recognize.
469	Also, if you have the Sony DVDirect VRD6, there's a firmware download on Sony's website to accommodate burning AVCHD from a digital camera video such as this HX5V.

470	I recommend ordering an extra battery and 1-hour quick charger from eBay.
471	The camera has Standard charger takes 4+ hours.
472	If you don't need the GPS, turn it off to save battery power.
473	Some say the build quality is cheap but I don't find that to be the case.
474	There is a metal band that wraps around from the top to the bottom to protect it.
475	The battery cover may need a little softer touch but there are other camera that sells itself as waterproof, shock-proof, etc so go buy them instead if you're clumsy and tend to drop things.
476	Rating the camera with a 4.5 stars.
477	Video format is still difficult to edit.
478	Updated on Jun 1, 2010 I got a Blu-ray player with a network DLNA feature (Samsung 5500).
479	I copy the original mts file to my desktop computer and stream the file over my network to my bluray and TV.
480	The camera is Neat.
481	My rating has not changed since, on the Mac, I need to get iMovie '09 to transfer, but must use iMovie '08 to edit.
482	The camera has best picture quality I've Ever Seen.
483	The camera has medium Price, picture quality, improved sensor, and very fast autofocus in the viewfinder, navigation key arrangement, video quality and kit lens.
484	The camera has auto Focus in Live View (Monitor), Battery Price and battery grip.
485	Overall, I see the camera for me personally as a big win and great start into the realm of photography.
486	Already have the first pictures of friends known to inspire strong and I am still very much indeed to learn, but also much joy in it.
487	One or the other shortcoming (10min video, equipment incomplete: BDA, USB cable, a relatively high price) must put up with it.
488	Only the swivelling display of the camera in conjunction with the HD video would have been the icing on the cake, but you cannot have it all.
489	For beginners like me certainly a great device and it makes me not care that I'm probably gone the Nikon PR campaign for the trap with the easiest-to-use DSLR.
490	If you ask me that where is cheap price for the camera.
491	The camera is great for Cinematic looking with HD video.
492	The camera has Manual Control of ISO, F-stop, Shutter speed, White balance in video mode (by using AE-Lock).
493	The camera has Manual Focus Subject Tracking Auto Focus (useful for steadicam) 21mbps (so far, might be able to push it higher) Improved ISO, less noise in lower light.
494	The camera has Good Video Effect.
495	The camera has microphone input.
496	I produce independent television and short films utilizing the camera.
497	I decided to move into DSLR video production specifically due to this camera.
498	I've shot still photography for years on Nikon with beautiful results.
499	With this camera I can now get those looks on video without buying overly expensive 35mm adapters for video cameras.
500	I don't see any more than you'd get on normal CMOS sensors as long as you aren't a moron and know how to operate video/film cameras.