

Nadine Humanoid Social Robotics Platform

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Abstract. Developing a social robot architecture is very difficult as there are countless possibilities and scenarios. In this paper, we introduce the design of a generic social robotics architecture deployed in Nadine social robot, that can be customized to handle any scenario or application, and allows her to express human-like emotions, personality, behaviors, dialog. Our design comprises of three layers, namely, perception, processing and interaction layer and allows modularity (add/ remove sub-modules), task or environment based customizations (for example, change in knowledge database, gestures, emotions). We noticed that it is difficult to do a precise state of the art for robots as each of them might be developed for different tasks, different work environment. The robots could have different hardware that also makes comparison challenging. In this paper, we compare Nadine social robot with state of art robots on the basis of social robot characteristics such as speech recognition and synthesis, gaze, face, object recognition, affective system, dialog interaction capabilities, memory.

Keywords: Social Robotics · Generic Robotics Architecture · Nadine-Social Robot · Human-Robot Interaction.

1 Introduction

Social robots are designed as autonomous systems with AI that allow them to interact with humans, other robots and their environment. Their design is based on cognitive computing, which includes data mining, pattern recognition, natural language processing, so as to mimic a human brain, which allows social robots to interact in socially acceptable and sophisticated manner. For example, they can work as consumer guides [20], teachers[7], companions for the elderly [15].

Building a generic social robot platform that can be used for any workplace is very difficult. Such a platform would need to be reusable and retrained easily for different context and environment. This also makes it inherently difficult to compare two social robots as their applications, hardware can be completely different. In this paper, we develop a generic social robot platform that is modular and allows retraining according to our requirements (context, environment). Also, we provide a comparison between social robots based on social interaction

cues, characteristics to understand and provide an overview of the available social robots. As shown in Figure 1, she has a realistic human-like appearance with very natural skin, hair. Nadine has a total of 27 degrees of freedom for facial expressions and upper body movements. With the proposed platform, Nadine is able to adapt and work at different workplaces.

The rest of the paper is organized as follows: In section II, we provide previous related work in the field of social robots and architecture proposed. In section III, we introduce our proposed generic social robot architecture that follows perception - processing - interaction layer framework. In section IV, we discuss about essential social robot characteristics and compare Nadine with other state of art social robots based on these characteristics to the best of our knowledge. We provide conclusions in section V.

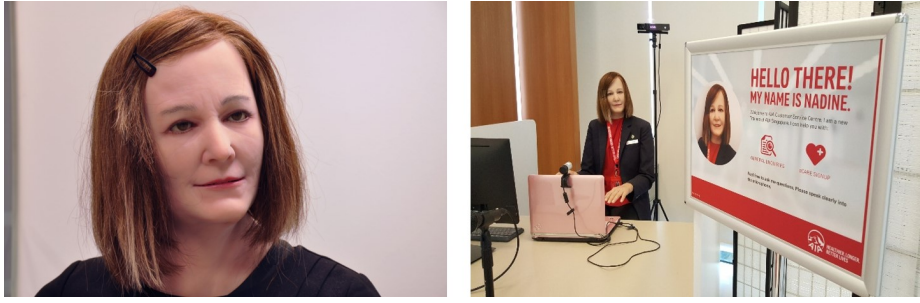


Fig. 1. Nadine Social Robot

2 Related Work

Humanoid robots are an essential part of robotics, which have a body shape built to resemble the human body. The design may be for functional purposes, such as interacting with human tools and environments, for experimental purposes, such as the study of locomotion, or for other purposes [1]. Designing humanoid robots for specific tasks like playing ping pong [24], chess [16], health care social robot [5] is considerably easy. But developing a generic social robot architecture to consider all possible social situations, context, workplace and hardware available is very challenging. Especially understanding social context and social interaction cues is difficult. KISMET robot [4] can process visual, auditory and proprioceptive sensory inputs to understand social context and behave appropriately.

iCub[13], Nao [18] are general purpose robots that are widely used for several applications. Metta et.al [13] introduced an open platform for cognition studies for iCub humanoid robot, based on YARP libraries, where modules can be

added/ removed. Similarly, Nao [18] designed by Softbank robotics for playing soccer allows modularity to include modules such as speech recognition, multi lingual speech synthesis, facial and shape recognition. SURENA [2] is a humanoid social robot capable of reading sensory inputs, recognize objects and detect human face/motion, distinguish Persian commands, navigation, imitate human actions.

The appearance of robot is a deciding factor in people’s perception. The realistic appearance of a humanoid robot increases expectations of people in its functionality and behavior. HRP-4C [11] introduced a biped humanoid robot that has a Japanese female face and skin. It can closely mimic human movements and can respond to voice commands by using speech recognition. Robots like Nadine, Sophia [23], Erica [9] have realistic human appearance compared to other previously mentioned humanoid robots. In these cases, the behavior, cognitive abilities, personalities have to be carefully designed to look and behave human-like to avoid uncanny valley effects. Goertzel et.al [6] published a pilot study on Sophia robot’s social interaction. Zhang et.al [25, 26] shows studies on Nadine social robot’s memory, emotion and personality in a social interaction.

3 Social Robotics Architecture

An essential requirement for any social robot would be interactions with humans, environmental awareness, dynamically understanding social cues. The social robot needs to maintain a natural human-like tone and flow to any conversation with any user. Therefore, the design of generic social robot platform is a complex task that takes into account several factors like maintaining naturalness of conversation, generalization to any field, multi-lingual support. In this section, we briefly explain about our social robot, Nadine’s architecture.

Figure 2 shows our proposed architecture. From the figure 2, we can see that our architecture consists of 3 layers, namely, perception, processing and interaction. Firstly, our platform perceives various stimuli which helps the robot understand user and its operating environment. 3D cameras, web cameras, and microphone are used as input devices to recognize the user identity, position, facial emotion, actions, speech, gender and objects in the environment. Then each of these stimuli are processed to decide upon an appropriate verbal or non-verbal response. The processing layer includes various sub-modules such as dialog processing (chatbot), affective system (emotions, personality, mood), Nadine’s memory of previous encounters with users. Finally, the verbal or non-verbal responses have to be shown on the robot using the interaction layer. This layer is specific to Nadine’s hardware but can be changed easily to fit other robots. The responses from the processing layer can be head movement to maintain eye gaze, gestures and facial expressions, dialog and tone (to show different emotions, personality). The main objectives of our design is to maintain human-like natural behavior even in complex situations and be generic to handle any kind of data. Each layer consists of several sub-modules for specific tasks. These sub-modules are connected using an independent platform framework [3] to facilitate module

connections and development. Sub-modules can be added/ removed into each layer based on our requirement. Currently, Nadine can support six languages including English, German, French, Chinese, Hindi and Japanese. See Wikipedia [22].

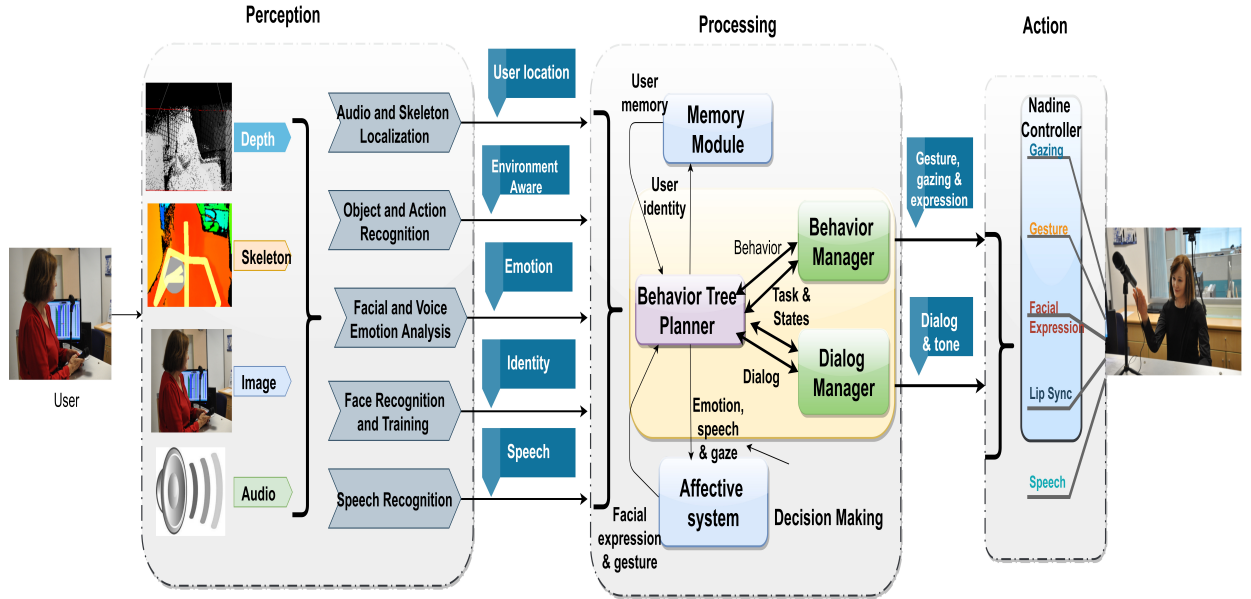


Fig. 2. Proposed social robots architecture of Nadine with perception-processing-interaction layers

4 Nadine Social Robot Characteristics - Discussion

In any setting, a social robot would require to gauge both verbal and non-verbal cues of people it meets and be able to change its own verbal and non-verbal behavior accordingly. Another requirement would be understanding its environment that would allow it perform different tasks and navigate if needed. Therefore, for robust functioning, Nadine has been equipped dedicated modules for face recognition, gaze behavior, speech recognition and synthesis, action recognition, object recognition, memory of users, affective system (to model her personality, emotion, mood), data processing or dialog system. Due to the generic nature of the platform, other modules can be added based on any requirement. Also each of the modules can be customized, modified and retrained according to the requirement.

Table 1. Classification of Social Robots based on essential social robot characteristics

Robot	Face Recognition	Speech Recognition	Speech Synthesis	Gesture Recognition	Object Recognition	Memory	Affective System	Human appearance
Nadine	√	√	√	√	√	√	√	√
[5]	√	√	√	√	√	×	√	×
[8]	√	√	√	×	×	×	×	×
[17]	√	√	√	NA	NA	×	NA	×
[23]	√	√	√	×	×	×	×	√
[9]	×	√	√	×	×	×	NA	√
[12]	×	√	√	×	NA	×	×	×
[21]	√	√	√	√	√	×	×	×
[10]	×	×	√	×	√	×	×	×
[14]	×	√	√	×	√	×	√	√ (Only head)
[13]	×	√	×	×	√	×	×	×
[19]	√	√	√	×	√	×	√	×

Recently, several robots have been developed with different capabilities based on their work place, requirements, tasks and hardware itself. Due to this, there exists no fixed benchmark to compare the robots as well. But using the above-mentioned essential characteristics as a basis of comparison, in table 1, we classify the available state of the art robots. To make this classification, it is necessary to know if a robotic platform can support these characteristics. But collection of such data is very difficult for commercial robots as they do not share proprietary data. Here, we have collected information based on the data sheets and online videos. In table 1, √ indicates presence and × indicates absence of those characteristic in the robot. We have recorded ‘NA’ for entries were these characteristics could have been included by others or when we are not sure if such capabilities are present in the robot.

Another important factor considered is the human-like appearance of the robot including artificial skin. If a robot has more human-like appearance, the realism expected from it will be more. It also means the robot is expected to perform human-like tasks and behaviours in all scenarios. This can be attributed to the uncanny valley effect that users would experience. For this reason, realistic looking robots such as Nadine, Sophia [23], Erica [9] have to be designed to avoid uncanny valley effect. Due to this, Nadine has dedicated modules for the above-mentioned characteristics that allows her to behave in human-like manner.

5 Conclusion

Social robotics is a rapidly developing field with several applications in the real world. Each robot is required to operate in different work places, to perform different tasks making it difficult to develop a generic social robotics framework. In this paper, we provide a overview of the overall Nadine social robot platform. We also provide a comparison between Nadine social robot and state of the art robots based on social robot characteristics.

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