

# *Designing a Digital Fitness Game System for Older Adults in Community Settings*

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**Abstract**— Exergames is one of the new innovative approaches used in primary healthcare programmes. The current study introduces a fitness game system, HOCAMOSE-VETS, which includes digital rehabilitation exercises and exergames designed with a particular focus on older adults. Besides the new exergames, the system also allows care staff to actively schedule, monitor and assess the progress of older adults' exercise activities. A survey-based study was conducted to investigate the overall user acceptance of the digital fitness game system. We found that users' perceived ease of use and usefulness have a significant impact on their actual intention of using the game system. However, the output quality of the system is not significantly associated with users' perception of the usefulness and ease of use of the system. The findings from this research have provided new insights into designing elderly fitness games.

**Keywords**—*exergame; ageing; active living; physical health; gaming system*

## I. INTRODUCTION

The phenomenon of an ageing society is emerging worldwide. There has been an increasing public concern regarding the well-being of older adults. Many community programmes and interventions have been developed to improve the physical and mental health of older adults. Exergames is one of the new innovative approaches recently used in primary healthcare programmes [1, 2]. Exergames is a combination of video games and exercises, in which users achieve higher motivation and enjoyment while performing exercises [3]. Many studies have supported the positive effects of exergames on both physical and psychosocial well-being among older adults [2].

However, most of the exergames in the current market are designed for the young generation. They are not customised for the ageing population [4, 5]. Older adults generally suffer from age-related changes, including decline in motor abilities, sensory-perceptual and cognitive processes [6, 7]. These problems may negatively affect their experiences and performances in playing exergames. There is a high demand to develop exergames taking into consideration older adults' conditions and preferences. The current study introduces a fitness game system, named 'HOCAMOSE-VETS', which includes digital rehabilitation exercises and exergames designed with a particular focus on older adults. Besides the exergames, the system also allows care staff to actively schedule, monitor and assess the progress of older adults' exercise activities.

## II. RELATED WORKS

Currently, there are very few exergaming systems designed for older adults. Chao et al. [8] is one of the exceptions that introduced improved Wii Fit exergames that incorporated self-efficacy theory for assisted-living older adults. Their findings confirmed that the improved Wii Fit exergames had positive physical and psychosocial effects on older adults when compared to a health education program. SilverBalance from Gerling et al. [9] is another digital fitness game prototype aimed for elderly users. The implementation of different ways to use the Wii Fit Balance Board (e.g., either standing or sitting) in SilverBalance offered a more accessible design for elderly players. Additionally, the creation of the interface design followed the guidelines for when designing digital games for elderly [9]. Keyani et al. [10] designed an augmented dancing environment called "DanceAlong", which allows elders to select dance sequences from well-known movies and encourages them to dance along. DanceAlong can also promote social engagement within the elderly group when exercising [10].

## III. SYSTEM DESIGN

The HOCAMOSE-VETS system comprises of the HOCAMOSE administration application (including database and data collector), and the VETS game station with Kinect sensors at the elderly homecare centers. The VETS game stations have the Unity Application installed.

The VETS game station provides motion-based gameplay with controlled movement/activities using Microsoft Kinect sensors [11]. It provides access to self-guided exercises and exergames for the elderly with the use of motion-based technology to track body movement. All movements within the gameplay are controlled and can be modified by the game designer. It provides facilities for doctors, therapists or caregivers to track the physical performances/conditions of the elderly via the fitness Gameplay Interface for the Elderly analytics module. The HOCAMOSE-VETS system architecture is presented in Figure 1.

HOCAMOSE-VETS system aims to be implemented at senior activity centres, which provide eldercare services and social activities for older adults living nearby. The centre manager or care provider at the senior activity centre will create exercise plans for the elderly clients. Depending on the condition of the elderly clients, physicians may be involved in the exercise planning for the elderly clients. An exercise or exergame is offered in the system for different difficulty levels (i.e., beginner, intermediary, or advanced). Several exercises

and exergames have been specifically conceived and designed for elderly exercise and movements. Table I describes the examples of exercises and exergames and highlights the benefits for the elderly.

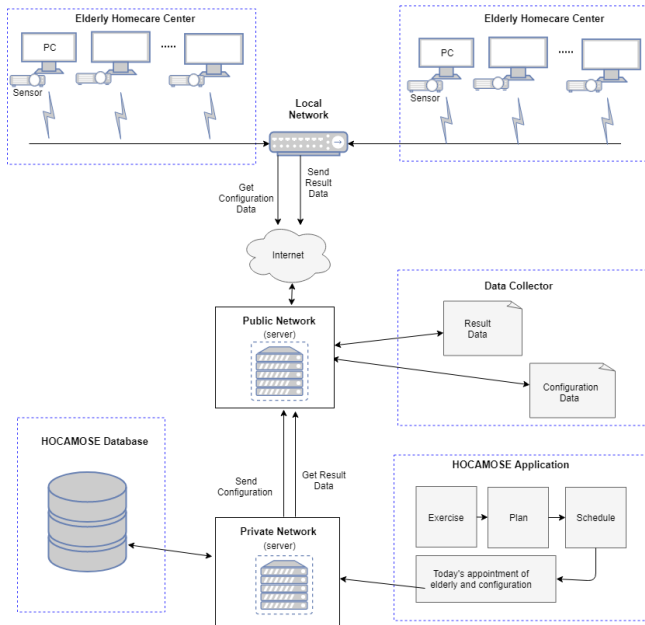


Fig. 1. HOCAMOSE - VETS System Architecture.

TABLE I. EXAMPLES OF EXERCISES AND EXERGAMES

Examples	Health Benefits to Elderly	How to Play
<b>Exercises</b>		
Single Leg Stand	<ul style="list-style-type: none"> <li>Trains balance</li> </ul>	Stand in a comfortable position. Keep hips level and slightly bend knee backwards, holding it there. Repeat. Follow the avatar on screen.
Hip Extension In Standing	<ul style="list-style-type: none"> <li>Strengthens hip flexor muscles</li> <li>Improve trunk stability when lifting the thigh muscles</li> </ul>	From a standing position, move your legs back as far as possible while keeping legs straight. Do not lean to the front. Follow the avatar on screen.
<b>Exergames</b>		
Chinatown Race	<ul style="list-style-type: none"> <li>Builds balance</li> <li>Provides aerobic exercise</li> </ul>	From a standing position, lean the body left or right to move in that direction. Marching on spot will increase the speed that character moves. Use hands to collect coins and lantern by moving them to the items. Avoid the fences and people walking by moving them out of the way.
New Apple	<ul style="list-style-type: none"> <li>Helps user with hand-eye coordination</li> <li>Allows stretching of arm muscles</li> </ul>	Use hands and hover over the fruits that appear on the tree, once hand/cursor is over the fruit close your hand to hold the fruit and put it in the corresponding basket.

An 'exergame plan' comprises of a combination of exercises and exergames and can be configured as needed, see Figure 2 for the screen for creating an exergame plan. An exergame plan is assigned to an elderly client in an 'exergame session' that includes the dates and exact time slots when the plan will be executed, and the clients involved if it is a group session. The centre manager schedules appointments for the exergame sessions where volunteers are assigned to assist the elderly clients in performing the exergames. When the appointment commences, the session data (date, time, client name, plan, PC station, QR code) is sent to the VETS game station.

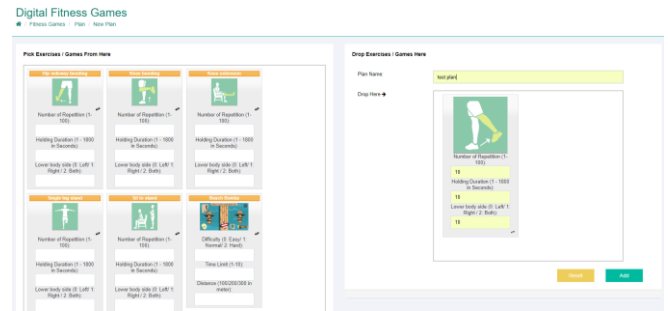


Fig. 2. Screen for creating a HOCAMOSE Exercise/ Exergame Plan Units

An elderly client's exergame session data from the HOCAMOSE administration application will be tagged to one particular QR code dynamically. Elderly clients with the help of volunteers can collect the QR code assigned to them from the center manager or care provider. The elderly client will then hold up the QR code to be scanned by the Kinect sensor. Once the detection is completed, a list of the configured exergames for that session will be shown and the elderly client can start playing the exergames as shown in Figure 3. The configuration data needed to perform the exergames for the elderly client is pulled by the VETS station terminals at the elderly homecare center from the HOCAMOSE administration application.

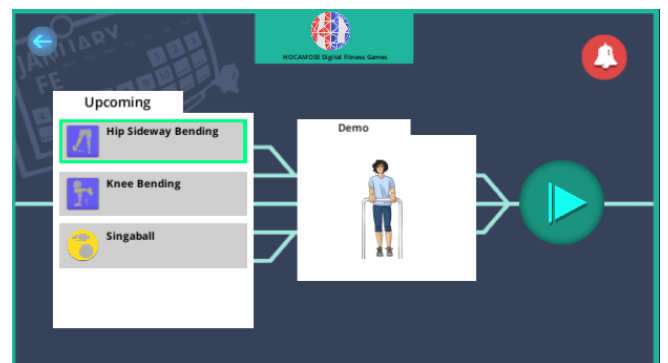


Fig. 3. Unity Application Showing an Elderly Client's Exercise/ Exergame Plan

While the elderly client performs the exergames, the scores and body movements will be monitored and captured by the VETS game station. After the exergame session is completed, the VETS game station will send the session results (including scores, points, and general fitness performance data) to

HOCAMOSE administration application. The output from each exercise/game at the elderly homecare center is sent to the Data Collector and the results are pulled to the HOCAMOSE database. In the HOCAMOSE administration application, the session results will be analysed and visualized for the center manager to track the progress of the elderly client. Based on the analysis of the elderly client's performance, if required, a physician may wish to modify the elderly client's exergame plan.

#### IV. USER ACCEPTANCE STUDY

A user acceptance study was conducted to investigate the overall user acceptance of the HOCAMOSE-VETS system. This study employs the Technology Acceptance Model (TAM) [12-15] (shown in Figure 4) as a conceptual framework for exploring users' beliefs of the HOCAMOSE-VETS system. Additionally, the influence of a task-technology fit was also examined.

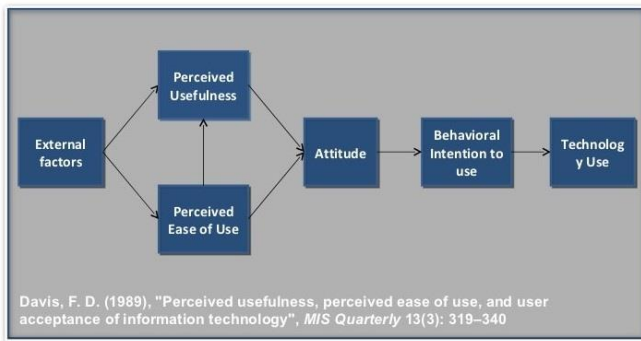


Fig. 4. Technology Acceptance Model from Davis (1989).

A survey-based study was conducted to measure the user perceptions on the HOCAMOSE-VETS system. The study involved 8 participants (including centre managers, and elderly clients) who used the HOCAMOSE-VETS prototype to test the games system. Following which, they were asked to take part in a survey to give their feedback on the usability of the system. The TAM survey includes a 7-point Likert scale adapted from Davis et al. [12-15], measuring several subscales of system quality, perceived usefulness, perceived ease of use, intention to use, output quality and task-technology fit of the system.

Firstly, we conducted a reliability analysis among the items for each of variables as per Table II. Thereafter, bivariate correlation analyses and moderation regression analysis were conducted to help explain some of the hypotheses.

We conducted bivariate correlation analyses for the various variables and hypotheses as per Table III. Two significant relationships were found: (1) *Perceived usefulness* is shown to have a significant positive correlation with *users' intention to use*, with  $r=.88$ ,  $p<.01$ . (2) *Perceived ease of use* is shown to have a significant positive correlation with *users' intention to use*, with  $r=.84$ ,  $p<.01$ .

TABLE II. MEAN AND STANDARD DEVIATION OF VARIABLES

Variables	Mean (SD)	Reliability (Cronbach's $\alpha$ )
Perceived Usefulness (PU)	5.85 (.83)	.92
Perceived Ease of Use (PEU)	6.16 (1.04)	.95
Intention to Use (IU)	5.75 (1.37)	.96
System Quality (SQ)	5.00 (.79)	.67
Output Quality (OQ)	5.50 (1.22)	.86
Task-tech-fit (TTF)	5.75 (.85)	.33
System Quality*Task-tech-fit	32.4 (11.1)	-

TABLE III. FINDINGS IN USER ACCEPTANCE TEST

Hypothesis	N	Correlation (r)	Significance level (p)	Hypothesis supported?
H1a: System quality has a positive relationship with perceived usefulness.	8	.36	.39	No
H1b: System quality has a positive relationship with perceived ease of use.	8	.26	.53	No
H1c: System quality has a positive relationship with intention to use	8	.18	.67	No
H2a: Output quality has a positive relationship with perceived usefulness.	8	.60	.11	No
H2b: Output quality has a positive relationship with perceived ease of use.	8	.69	.06	No
H2c: Output quality has a positive relationship with intention to use.	8	.45	.26	No
H3: Perceived usefulness has a positive relationship with users' intention to use the system.	8	.88	<.01	Yes
H4: Perceived ease of use has a positive relationship with users' intention to use the system.	8	.84	<.01	Yes
H5: Task technology fit has a moderating effect on the relationship between output quality and perceived usefulness.	8	$F$ -ratio, $R^2$ $F(1,5)=1.49$ $R^2=.51$	<.28	No

Note: \* represents 1 missing data in N.

#### V. DISCUSSION AND CONCLUSION

The present study aims to present the HOCAMOSE-VETS system and evaluate its overall acceptance. The HOCAMOSE-VETS system integrates both HOCAMOSE administration application and the VETS game station to facilitate the administration of exergames for the elderly. It allows elder care administrators to create and schedule exercise plans, and monitor performance data of the elderly that is captured by the system.

To evaluate the overall acceptance of the HOCAMOSE-VETS system, we conducted a user acceptance study with the

TAM methodology. Our findings show that the overall acceptance of the system was relatively good, as users generally reported the HOCAMOSE-VETS system to be useful, easy to use, has relatively high system and output quality and task-tech-fit, and participants had relatively high intention to use the system. The *system quality* was found not to be related to *perceived usefulness*, *perceived ease-of-use*, and *intention to use*. Similarly, the *output quality* of the system was not significantly related to *perceived usefulness*, *perceived ease-of-use*, and *intention to use* the system. Despite users reporting relatively high levels of *system quality*, *output quality*, and *intention to use* the system, it is interesting to note that both system and output quality were not associated with the intention to use the system. Thus, regardless of the quality of the system, users would still intend to use the system. The relatively high acceptance and intention to use the system could reflect the novelty and importance of the HOCAMOSE-VETS system as an information system that could cater to the elderly population in the context of Exergames.

Higher ratings for *perceived usefulness* and *perceived ease-of-use* were associated with higher levels of *intention to use* the HOCAMOSE-VETS system. In other words, when users perceive the system as useful and easy to use, they would be more likely to use it. Furthermore, *task-tech-fit* was found to exert a non-significant moderating effect on the relationship between the *output quality* and *perceived usefulness* of the system. This result implies that the system's output quality is important in determining the users' perceived usefulness of the system. Although task-tech-fit explains a small-moderate variance of the relationship between output quality and perceived usefulness, the users perceived that the output quality of the system to be more important. . Lastly, higher reports of *perceived usefulness* and *perceived ease-of-use* were related to higher levels of *intention to use* the system. Both *perceived usefulness* and *perceived ease-of-use* are important factors that influence the intention to use a system. Our findings are supported by previous studies whereby Davis (1993) reported that perceived usefulness was found to be the most important predictor of usage of a particular information system.

As aforementioned, the purpose of the study was to evaluate the overall acceptance of the HOCAMOSE-VETS system and we found that users reported relatively high acceptance and intention to use the system. Nonetheless, our findings presented must be taken with caution as the present study has several limitations for consideration. For example, it is important for us to ensure that self-reports of intention to use translates to actual usage of the system. Our study has surveyed users from different roles (i.e., centre managers, volunteers, and elderly clients), and the nature of their intention to use the system might be different. Future studies that employ qualitative analyses can therefore go beyond our findings to better understand how the system can be improved and increase its actual usage. It could also help explain the discrepancies found between system quality and output quality and their differential relationship with perceived usefulness and perceived ease-of-use.

All in all, exergames designed and catered for the silver generation is less understood and practised. Our research seeks to provide new direction and guidance for research in exergames in the context of the elderly population. The design, development, and evaluation of such systems for the elderly are important areas for future research, as it doing so might revolutionise the way we cater elder care and promote physical and mental well-being in older adults.

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