The Potential of Exergame: A Review

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Abstract - This review paper examines the potential of game-based training programs, or exergames, to address the rising prevalence of sedentary behavior among older adults, focusing on the need to motivate this demographic to exercise regularly while considering the importance of maintaining engagement and motivation for long-term adherence to physical activity programs. Evaluating various criteria for developing motivating exergames, including considerations specific to the target group and the integration of emotion theories into game design, the paper highlights attributes such as personalization and sensor technology as essential components for creating successful and engaging interventions. Drawing from our own project experience, which focuses on introducing exergaming to combat sedentary behavior among gamers, we recommend further exploration of technology, game design, and psychology intersections to develop tailored interventions promoting physical activity and well-being among diverse age groups. Collaboration between researchers, game developers, and healthcare professionals is crucial for ensuring accessibility and usability of exergames for older adults, contributing to improved health outcomes and quality of life in this population.

Key Words: Exergames, Older adults, Physical activity, Emotion theories, Personalization and Sensor technology

1. INTRODUCTION

Due to the serious health concerns associated with the sedentary lifestyle that many older persons lead, creative strategies for promoting regular physical activity are required. Exergames, or game-based training regimens, have become a viable remedy in response. This study explores how exergames could help combat older individuals' inactive lifestyles, highlighting the critical role that motivation and engagement play in maintaining long-term commitment to physical exercise regimens. By creating engaging exergames that include individualized experiences and emotion theories into game design, this article highlights how important it is to customize interventions to the particular requirements and preferences of older persons.

One of the most important takeaways is the importance of sensor technology and personalization in developing effective and captivating exercise games. Exergames can effectively drive older persons to engage in physical activity while meeting their different demands by tailoring gameplay experiences to match individual skills and preferences. Moreover, the use of sensor technology amplifies the interactive aspect of exergames, furnishing instantaneous feedback and cultivating a feeling of successful completion, both of which are crucial for maintaining motivation in the long run.

In light of our own project experience, which aims to counteract gamers' sedentary behavior through the introduction of exergaming, this study promotes more research into the relationships between technology, game design, and psychology. Through the use of knowledge from these domains, customized interventions for a range of age groups can be created to encourage physical exercise and general well-being. Furthermore, it is believed that cooperation between researchers, game developers, and medical experts is essential to guaranteeing the usefulness and accessibility of exergames for senior citizens.

Exergames are a dynamic and entertaining way to encourage physical activity and enhance health outcomes, and they have great potential to counteract sedentary behavior in older individuals. Through the prioritization of personalization, sensor technology, and interdisciplinary collaboration, stakeholders can collaborate to create efficacious exercise games that improve the quality of life and general well-being of older persons.

2. RELATED WORK

Fenja T. Bruns and Frank Wallhoff [1] introduces a conceptual framework that uses affective computing to modify exergames for older people with the goal of raising motivation and engagement levels for physical activity. The framework incorporates personalization techniques and constant feedback to provide valuable insights into improving motivation and engagement, especially among older adults. Techniques include the use of non-invasive sensors to record physiological data, such as wristbands or smartwatches, and machine learning algorithms to infer emotional states from the data gathered.

Alhagbani and Williams [2] conduct a systematic evaluation of how well home-based exercise games help older individuals' balance and lower their risk of falling. The review highlights the potential advantages of exergames in improving balance outcomes and lowering the risk of falls through careful study selection and data synthesis, underscoring the significance of scientific rigor in assessing exergame interventions. A systematic search approach and the use of approved tools, including JBI tools for quality assessment, are part of the methodologies.

Alberto Isaac Perez Sanpablo and team [3] present a novel method for creating exergame systems for pediatric gait therapy using Persuasive System Design (PSD). The authors create a system that is suited to children's psychomotor performance through observational studies and scenario-based design, with a strong emphasis on individualized therapy sessions. The human-centered design process for game development and observational studies to determine system requirements are examples of methodologies.

Ari Kusumaningsih and their team [4] conduct a randomized controlled trial assesses the benefits of personalized exergames combined with traditional exercise for older adults' motor performance and quality of life. Results indicate significant improvements in strength and mental health outcomes among participants in the exergames group compared to controls. Methodologies involve a 12-week exercise intervention with outcome measures at various intervals, including strength assessments and quality of life evaluations.

Afonso G, John Munoz and team [5] randomized investigates the benefits of custom exergames for fitness, balance, and health-related quality of life in community-dwelling older adults. Through a randomized controlled trial, the study demonstrates the effectiveness of integrating personalized exergames into traditional exercise interventions, leading to improvements in motor performance and mental well-being. Methodologies include the development of custom exergames using a human-centered design process and the use of controlled trial methodology for evaluation.

Together, these studies' outcomes demonstrate the promise of exergames as a workable intervention for raising motor skills, encouraging physical activity, and benefiting quality of life in a range of demographics. Exergames present a promising strategy for enhancing health and well-being across the lifespan because of its emphasis on personalized design, stringent evaluation procedures, and incorporation of persuasive features. The potential of exergames to improve health outcomes and general quality of life may yet be unlocked with more study and innovation in this field.

3. DESIGN AND ANALYSIS

3.1. AFFECTIVE COMPUTING EXERGAMES FOR ELDERLY

Requirements for Emotion Recognition and Requirements for the Elderly are the two key elements that need to be taken into account while creating an effective exergame. Senior users frequently experience issues with hearing, vision, and mobility; therefore, inclusive design and flexible fitness programmes are necessary. Furthermore, the requirement for psychosocial involvement through features like skill-adjusted competitions and multiplayer activities is highlighted by the social isolation that older people experience. Retaining player motivation is mostly dependent on emotion detection, which prioritises learning-centered feelings above basic ones. Individualised modifications are facilitated by user profiles, and real-time data collecting for personalised experiences is made possible by non-invasive sensors. The whole game experience is improved by usability factors including cable-free installations and pleasant sensor use. The players' physiological states will be recorded by sensors throughout the game. The data collected will be subjected to machine learning to identify the players' emotional states[1]. This will enable the gaming environment to dynamically adjust to the players' emotional reactions. Sustained engagement is ensured via constant customisation based on user conditions, underscoring the significance of accessible and flexible design concepts. Fig 1 shows the proposed framework for an affective exergame.

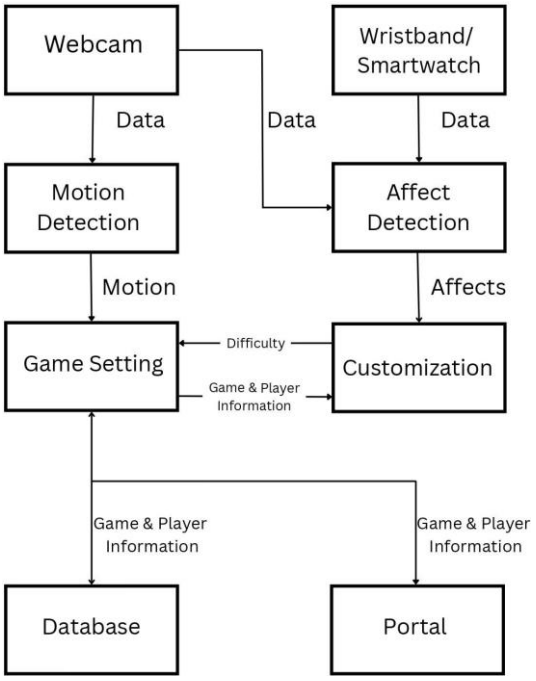

Fig -1: Affective exergame framework

3.2. HOME- BASED EXERGAMES FOR OLDER ADULTS

Creating exergames that may be adjusted for different degrees of physical ability requires changing the parameters and difficulty levels [2]. By including safety measures like fall detection and emergency alarms, users' safety during unattended sessions is guaranteed. Furthermore, adding social components to exergames helps older persons feel supported and part of a group, which increases motivation and adherence. We develop a comprehensive strategy for easily accessible and captivating exergaming experiences by integrating these elements. Players can adjust the games to their skill level and still feel comfortable because assistance is always available. Furthermore, having a feeling of community improves motivation and enjoyment, which in turn promotes involvement and, in the end, leads to better physical and mental health.

3.3. PERSUASIVE SYSTEM DESIGN FOR PEDIATRIC GAIT REHABILITATION

A unique treatment for young patients undergoing gait rehabilitation through the creation of exergame systems using the Persuasive System Design (PSD) paradigm. For treadmill gait rehabilitation, the therapy uses a virtual reality (VG/VR) biofeedback device with configurable settings to meet each patient's demands. Based on their clinical expertise throughout sessions, physiotherapists can adjust treadmill speed, auditory feedback, and gaming challenges. The system was created with input from rehabilitation specialists using a scenario-based design approach. It is thought to be useful for tailoring therapy to children's abilities and including them in treatment through visual and audio stimulation. Fig.2 illustrates the process of interaction between the child, system, and physiotherapist [3].

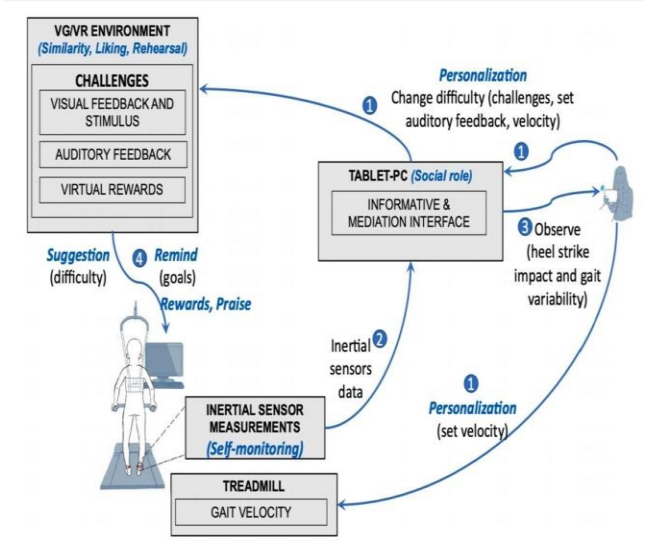

Fig -2: Bio-Gait's interaction process facilitates the evolution of settings. Grey boxes depict the VG/VR properties of Bio-Gait. The PSD model's guiding principles are shown in blue. The order of the child, system, and physiotherapist's interaction is shown by blue circles.

3.4. SERIOUS EXERGAMES FOR CHILDREN WITH SPECIAL NEEDS

Children with special needs can benefit from specialised learning through serious games like our Kinect-based workout game, which improves cognitive and motor skills through interactive encounters[4]. Children can stay involved and motivated while improving their name, shape, and colour recognition skills in a virtual classroom. The results of the experiment show a greater interest in and curiosity about learning, which is supported by the User Experience Questionnaire(UEQ). With high ratings for attractiveness, this method provides a gratifying user experience and supports improved results for kids with special needs. The illustration of exergame using Kinect is shown in Fig. 3.

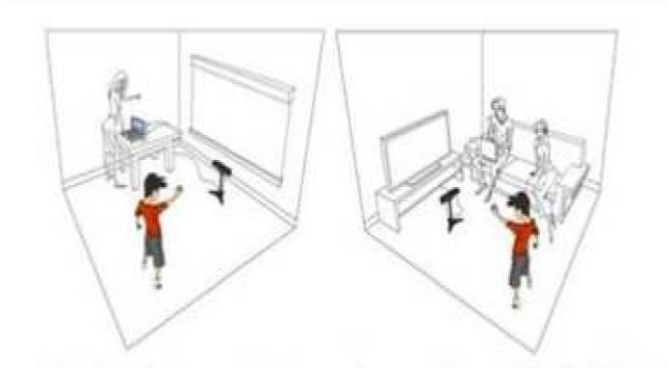

Fig- 3: With the assistance of parents or teachers, special needs children use the Kinect exercise game to control their hand and body movements.

The created programme is a desktop application that was created using Blender 3D, Photoshop, and the Unity 3D game engine. It uses the Microsoft Kinect input device as a controller. Microsoft Kinect is positioned between the player and the monitor to interpret the user's movements while controlling the game with his body. The game interprets, processes, and reacts to the user's body movement input as well as the distance between the user and the Microsoft Kinect input device.
It is anticipated that the participants in this encounter, who are kids with special needs, will receive therapy.

An in-game creation that packages learning to make it more pleasurable is called a serious game. The application's learning concept is to identify games that involve finding objects inside the confines of the classroom, word stacking, object colouring, and objects in the school environment. Users will be allowed to play the game with this learning concept freely, and it will be tested on a number of users, particularly youngsters with special needs. Instructors and researchers guide students through the process of installing the gadget and demonstrate how to finish the game. The game's scene is displayed in Fig. 4.

a. Main menu scene

b. Finding object scene. c. Word game scene.

Fig -4: Game scenes

In this study, we evaluated user experience using UEQ. With regard to both traditional usability and user experience, the UEQ offers a full impression of the user experience. It also comes with an analytical tool for quick and easy result interpretation. Table 1 displays the results of the UESQ from the Kinect exergame for kids with special needs who had help from teachers.

Child	Attr	Pers	Eff	Dep	Stim	Nov
Ch1	2,00	1,75	1,5	2	2,25	2
Ch2	0,67	-1,75	0,5	0,5	0,75	1,25
Ch3	0,67	-1,5	0,25	0,5	0,5	1,5
Ch4	1,83	0,75	1,25	1,25	1,25	1,5
Ch5	1,50	0,5	0,75	0,5	1,25	1
Ch6	2,00	1,25	1,5	1,75	1,5	1,75
Ch7	2,50	2,5	3	2,5	2	2,25
Ch8	2,00	0,75	1,25	1,75	1,5	1
Ch9	2,83	2,75	3	2,75	3	2,5
Ch10	1,67	0,75	1	1,25	1,25	0,75

Table 1: User experience scale per child

Figure 5 display the average value of the five UEQ scales: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty.

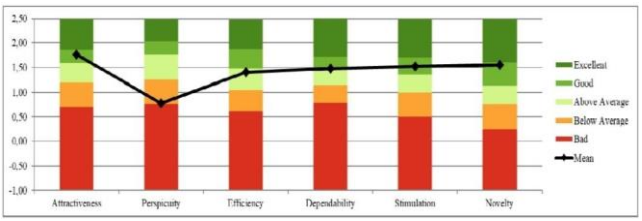

Fig -5: User experience graph

3.5. CUSTOM EXERGAMES FOR OLDER ADULTS

Designing exergames for older adults involves integrating multidimensional training to address various aspects of physical fitness, encompassing strength, balance, flexibility, and coordination. Personalized feedback mechanisms and progress tracking features are embedded within the games to empower individuals by providing tailored guidance on their fitness journey. To ensure sustained engagement over time, strategies such as goal-setting, fostering social support networks, and incorporating gamification elements are employed. These elements collectively aim to create a holistic exercise experience that not only enhances physical fitness but also fosters long-term adherence to exergame routines by continually motivating and challenging older adults in their pursuit of improved health and well-being. Fig 6 shows diagram system setup in this study.

Fig -6: System setup

The study utilized five custom-made exergames developed through a human-centered design process and playtests (Fig 7). Each game focused on different aspects of fitness and incorporated traditional Portuguese themes:

- Grape Stomping: Aerobic training with some upper-body strength and cognitive elements.
- Rabelos: Upper-body strength training through rowing gestures and side-stepping.
- Exermusic: Lower-limb strength and flexibility training with a minor upper-body strength component.
- Toboggan Ride: Balance, postural stability, and trunk muscular strength training through trunk movements and side-stepping.
- Exerpong: A fast-paced game targeting aerobic endurance, agility, and dynamic balance through side-step motion control.

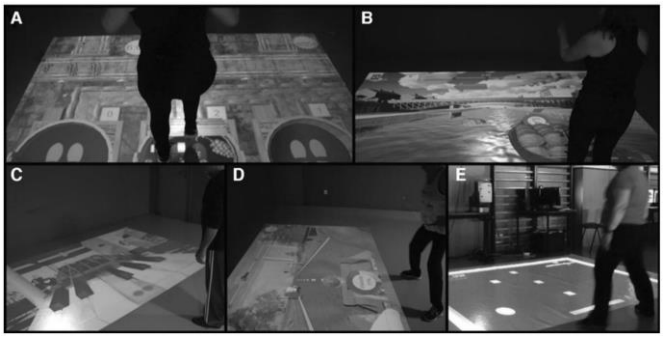

Fig -7: Tthe collection of exercise games that the exercise group uses. A and E, grape stomping and Exerpong, are aerobic fitness exercises. While the Toboggan Ride (D) and Exermusic (C) train motor abilities, Rabelos (B) trains upper and lower limb strength.

4. DISCUSSION

Exergames or game-based exercise programs, provide great potential in the fight against sedentary lifestyles among the elderly, highlighting the significance of consistent exercise and prolonged participation. Customisation and sensor technology become essential for successful treatments when older persons' needs and emotion theories are incorporated into game design. To guarantee usability and accessibility, cooperation between researchers, game developers, and healthcare professionals is essential. The study supports multidisciplinary efforts to develop customised interventions that enhance wellbeing and physical activity for people of all ages. The ultimate objective is to improve older people's health and quality of life by meeting their unique needs and preferences through exergaming.

Exergaming research has potential for the future in a variety of situations and populations. Incorporating affective computing into senior citizen exergames can boost motivation and engagement, and investigating long-term impacts and comparative research can yield important information about their effectiveness. Additionally, the therapeutic potential of

exercise games can be maximized by creating ones that are specifically designed to meet the needs of kids with special needs, including usability testing and clinical application. Incorporating educational material and language assistance into serious exergames can improve their usability and accessibility for a range of user demographics. Additionally, customized exergames for senior citizens present chances to enhance wellbeing and physical activity by addressing multifaceted fitness and including adjustable elements. In general, to optimize the effects of exercise gaming across age groups and health problems, future research should give priority to customisation, long-term assessments, and usability testing.

The articles draw attention to important problems that must be resolved before exercise gaming can go further, such as sample size restrictions, time constraints for study, and potential bias. There are issues with the findings' generalizability to different populations and the requirement for comprehensive evaluation methods. The emphasis is on practical issues such as reliably identifying emotions in affective computing activities and analysing "unsupervised" home-based sessions. In addition, the need for inclusive exergame design and assessment is highlighted by constraints in user experience evaluation and the concentration on particular demographics. In order to optimise the advantages of exercise gaming for mental and physical health in a variety of demographics, it is necessary to address these limitations by rigorous research design, varied participant recruitment, and thorough assessment techniques.

5. CONCLUSIONS

The study's conclusion makes a strong case for the use of exergames, or game-based fitness programmes, to help older people break their habit of being inactive. In order to encourage seniors to exercise consistently and maintain their commitment to physical activity regimens, it emphasizes the significance of creating entertaining and customized exercise activities. In order to guarantee the usability and efficacy of exergames for older persons, the study emphasizes the incorporation of emotion theories into game design and sensor technologies and advocates for cooperation between scientists, game designers, and health professionals. It emphasizes the necessity for more investigation into the relationship between sedentary behavior and exergaming in order to improve this population's general health and quality of life.

SOME OF ADVANTAGES

a) Increased motivation for regular exercise.
b) Consistently engaging in physical exercise.
c) Customisation to meet specific requirements.
d) Game design that elicits emotional response.
e) Using sensor technology, to ensure precise observation.
f) Effectiveness and accessibility are guaranteed
by interdisciplinary collaboration.

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