

- ORIGINAL ARTICLE -

Exergames: Proposal for a Gamepad to Sense Player Movements.

Exergames: Propuesta de un Gamepad para Sensar los Movimientos del Jugador.

Aldana Del Gener¹ , Cecilia Sanz¹ , and Luciano Iglesias¹

¹*Instituto de Investigación en Informática LIDI (III-LIDI) - CIC. Facultad de Informática, Universidad Nacional de La Plata, La Plata, Buenos Aires, Argentina*

aldana.gamepad@gmail.com, csanz@lidi.info.unlp.edu.ar, li@info.unlp.edu.ar

Abstract

Exergames are a good alternative to perform physical activity while being entertained with a video game. This paper reviews the history of exergames with walk-in-place mechanisms for locomotion, and presents the development of a prototype video game controller (gamepad) with functionalities to sense the player's movements (walk, run, and jump). Then, an exergame that was implemented and integrated with the controller is described. This proposal was evaluated by users considering usability and user experience analysis. The results obtained allow affirming that the gamepad integrated with the video game were positively valued by the participants during the test sessions and allowed the realization of physical activity while maintaining entertainment through the game.

Keywords: Exergames, gamepad, immersive locomotion, videogame controller, walking in place.

Resumen

Los exergames son una buena alternativa para realizar actividad física mientras se disfruta un videojuego. Este artículo revisa la historia de los exergames con mecanismos de caminata en el lugar para la locomoción, y presenta el desarrollo de un prototipo de controlador de videojuegos (gamepad) con funcionalidades para detectar los movimientos del jugador (caminar, correr y saltar). Luego, se describe un exergame que fue implementado e integrado con el controlador. Esta propuesta fue evaluada por usuarios considerando el análisis de usabilidad y experiencia del usuario. Los resultados obtenidos permiten afirmar que el gamepad integrado con el videojuego fue valorado positivamente por los participantes durante las sesiones de prueba y permitió realizar actividad física mientras el jugador se mantenía entretenido a través del juego.

Palabras claves: caminata en el lugar, controlador de videojuego, gamepad, locomoción inmersiva, videojuegos activos

1 Introduction

The use of video games has been associated with sedentary behavior for the last two decades during which technological, industrial, and scientific development has improved the quality and life expectancy, but has also brought an exponential growth of sedentary lifestyle habits, to the detriment of regular physical activity [1]. Sedentary behavior, also known as physical inactivity, is one of the 10 fundamental causes of mortality, morbidity, and disability. It alters endothelial function and favors the appearance of other risk factors such as high blood pressure, diabetes, lipid disorders, overweight, and obesity. However, the need to innovate in traditional exercise practices gave rise to exergames, or exercise video games, which are interactive video games that aim to make physical activity enjoyable by generating motivation and stimulation for individuals while they exercise [2]. Following this, exergames are a versatile alternative to maintain physical activity levels, for example during times of confinement, as their practice allows people to exercise at home or in reduced spaces, leaving behind the prejudice that has associated video games with sedentary lifestyles and inactivity [3]; also offers an improvement in physical, cognitive, and academic conditions [4].

Exergames often use technologies that track body movement and provide a high level of playability, providing a focus for physical activity and helping individuals become more active, improving their quality of life. The origin of exergames dates back to the late 1980s, and their popularity increased in the second half of the 2010s due to technology improvement, better video game graphics and the introduction of new games for mobile and tablet applications. Several companies have launched their gamepads to the market, each with its pros and cons for both users and developers. Also, there are works related to the use of virtual reality and motion sensing [5, 6, 7].

This work presents the design and development of a gamepad prototype that detects user movements, such as walking in place, and interprets them as signals

associated with a conventional gamepad. This is a contribution due to the access limitations of existing commercial proposals, especially in the context of countries such as Argentina, where licensing costs are expensive for small companies or independent developers. A prototype video game that involves the use of the designed gamepad with the detection of the movements of the users was also developed.

From here, this work will be organized as follows: in section 2 the definition and types of gamepad, emphasizing its importance in exergames, and the existing commercial technologies for its implementation are presented. Section 3 provides an analysis of previous work that support the proposal of this article. In section 4, the expected requirements for the gamepad, focus of this paper, are analyzed. These are considered the basis for the production (hardware/software) of the game controller. Section 5 presents a mini-exergame created to test the possibilities and usability of the gamepad described in the previous chapter. Section 6 will report on the tests carried out in conjunction with the gamepad and the proposed exergame in the previous sections. It will delve into the context of the tests, their participants, and the method used to measure the usability of the controller; followed by the results obtained. Finally, section 7 details the conclusions of this work, along with future lines of work.

2 Background

2.1 Gamepad definition

A game controller, or simply controller or gamepad, is an input device used in video games or entertainment systems to typically control an object or character in the game. Its primary function is to facilitate user interaction with computer game software [8]. Usually, a controller is connected to a video game console (game console) or computer, either physically (through some of the console ports or USB) or wirelessly. These input devices that have been classified as game controllers include keyboards, mice, joysticks, as well as those with a specific purpose such as driving wheels, light guns, directional pads, guitars, motion detection, touch screens, etc. A joypad is one of the most used controller, typically consists of several action buttons combined with one or more omnidirectional control buttons or levers. The player must hold it with both hands and operate its buttons and levers using their thumb, index, and middle fingers. The action buttons are usually manipulated with the fingers of the right hand while the directional input is handled with those of the left. A “motion sensing controller” is a type of controller game system that, uses accelerometers or other sensors, to track the player’s movement and provide input to the videogame. These two last technologies will be considered for the proposal, focus of this paper.

2.2 Commercial gamepads

Several commercial technologies focused on exergames can be mentioned, such as:

- Xbox Kinect: Launched in 2010, it is a motion sensor developed by Microsoft that uses RGB cameras, projectors and infrared sensors to track the player’s body movements. It is capable of mapping depth and perform time of flight calculations.
- PlayStation Move: A motion control system developed by Sony Computer Entertainment for its PlayStation 3 console in 2010, which includes a motion wand, a camera type controller and a PlayStation Eye camera. The system assigns a color to the orb and the camera is in charge of detecting it, tracking it and calculating the position with the assistance of inertial sensors.
- Nintendo Switch: A video game console released in 2017 that includes detachable controllers called Joy-Cons, which use motion sensors to detect the player’s movements and can be used individually or together.
- Oculus Rift: A virtual reality system developed by Oculus VR, acquired by Facebook in 2014, which uses virtual reality glasses and head tracking sensors to create immersive gaming experiences. It tracks the position of itself and its controllers in 3D space using a system known as Oculus Insight, which uses the 5 cameras on the HMD (Head-Mounted display) to track points in the environment and infrared LEDs on the controllers, information from accelerometers in both the HMD and controllers, and computer vision to predict what path the HMD and controllers are most likely to take.

These technologies provide innovative concepts to the exergame experience, for example, Kinect presents the concept “without controller”, Augmented Reality (AR) capabilities and provides Open Source development SDK. Move can track three dimensions with high precision, accuracy and a minimum processing latency. Switch’s infrared sensor can distinguish hand gestures; also Nintendo has a strong backing as a video game company that focuses on exergames, an adequate price for programmers. And at last but not least, Oculus and its innovative camera system and motion detection has been widely used for fitness games; it works on Android and no additional development kit is needed for developers.

However, these technologies also present certain limitations for exergame developers such as the expensive price of development kits, tedious acceptance process to publish games on Sony, Microsoft or Nintendo’s platforms; also, some of these technologies

have been discontinued and move on to work with other type of applications or require a significant amount of free space for the cameras to track body movements; some of these technologies are not able to track the lower part of the body; some others produce motion sickness on the player and others are expensive because devices (such as wand controllers and cameras) are sold separately.

2.3 Exergames, immersion and movement-based locomotion

In their work related to cardiac rehabilitation, [9] state that virtual reality technologies can provide an attractive and immersive environment for exergaming techniques. As a technology that depends on the feeling of total immersion, virtual reality fundamentally requires users to move through their environment as if they were physically present within the immersive world, and as such, they may be asked to perform some physical activity according to the mechanics of the game, such as walking. Walking is recommended as an excellent exercise to increase energy expenditure, reduce body mass, and achieve cardiovascular improvement.

In 2020, [10] reviewed the locomotion techniques in virtual reality and classified them into the following categories: Body-centric, Peripheral-centric and mixed. Body-centric techniques has been used to increase the user's sense of self-motion, improve spatial perception, orientation, and user experience. Within body-centric locomotion techniques, the following alternatives can be mentioned: Walking simulation and Inclination-based locomotion. Here will focused on Inclination base locomotion "walking", which is achieved by tilting the whole body or only parts of it in the desired direction. The inclination itself can be detected by standard or special tracking technologies. Depending on the body part involved in this tracking, techniques can be classified as based on the movement tracking of:

- the head,
- the torso,
- the arms (Arm-Swinging),
- the feet (WIP or Walking In Place), and
- combinations of the above techniques

This work will cover the technique based on foot motion tracking called "Walking-in-place" (WIP), which is the closest to simulating walking in the real world. This method tracks the user's foot movement and then translates it into movement in the virtual environment. In this way, it encourages users to engage their whole body in a realistic way of walking as much as possible, but without actually moving forward; it can be performed in a smaller living space and it decreases the likelihood of experiencing motion sickness [11].

3 Related work

In this section some related work will be presented as basis for the gamepad proposal.

3.1 Activate your Gaim: A toolkit for input in active games

GAIM or General Active Input Model is a toolkit developed by [5] that simplifies the programming of exergames by abstracting the details of active input devices through a high-level API that abstracts device details. Basically, all input devices extend the IPower interface and through a simple text file, the user selects the device to use. Depending on the device or devices selected in the file, the toolkit determines which class to use to implement IPower. This allows developers to write code independently of the input device used and players to use the devices they have available without the need to recompile or use special code for different devices.

3.2 VR-Stepper: A Do-It-Yourself Game Interface For Locomotion In Virtual Environments

VR-Stepper is a locomotion interface developed by [12] and it uses a conventional sport stepper and an Arduino. This device enables control in a virtual environment by walking-in-place and without the need for any additional fixation gadgets. This interface allows: forward movement, turn around and crouching. It was also conducted an user study with 10 participants to evaluate the impression on the joy and ease of use, immersion and reliability in comparison to other interfaces used for locomotion, such as the Wii Balance Board and the Wand Joystick.

The VR-Stepper experience, in terms of immersion and joy, was slightly better than the other tested interfaces but the difference was not statistically significant and they could not prove that a physical movement of legs results in a raise of immersion. It addressed the problem of losing balance, when the user was fully focusing on the game and "forgetting about being on a stepper" which lead to some users to fell off the stepper. Most users agreed that using the Wii Balance Board required an extra familiarization phase, which is not needed for the stepper. Overall, all study participants really enjoyed the user test. Furthermore, they found that pressing buttons on a joystick was perceived to be more reliable and significantly easier.

3.3 Challenges in Virtual Reality Exergame Design

The article: "Challenges in Virtual Reality Exergame Design" by [6], discusses and identifies five main challenges associated with the use of immersive technologies in exergaming:

1. Motion sickness caused by the use of virtual reality (VR) headsets
2. The reliability of motion-tracking-based gamepads
3. User safety when using immersive technologies
4. The appropriate selection of the player's perspective in the game
5. Feedback timing regarding the exercise performed.

To address these design challenges, a prototype of an exergame was developed. It comprises a racetrack with obstacles that users must navigate to advance. The goal is to attain the highest score.

For this experience, a stationary bicycle was used as a gamepad, connected to an Arduino microcontroller to regulate the speed. A Microsoft Kinect camera was utilized to detect the user's inclination, a VR headset emulated the first-person camera view, and a monitor represented the third-person camera view.

The stationary bicycle was connected to an Arduino microcontroller, which adjusted the resistance of the bicycle based on the irregularities present in the video game track (e.g., potholes, hills, etc.). This made the bicycle feel heavier or lighter depending on the scenario, enhancing the immersive gaming experience.

The article highlights some considerations for future work in the area. In addition to the challenges already studied, other complications arising from the use of VR headsets and latency were discovered.

3.4 VRun: running-in-place virtual reality exergame

Vrun is a virtual reality exergame prototype developed by [7], which allows players to physically run in place (WIP) to move through a virtual world. The aim of VRun is to engage people, particularly those who cannot visit the gym regularly, allowing them to exercise anywhere.

This study evaluates the effectiveness of the WIP technique for creating immersive environments and compares the immersion and feasibility of the video game presented, VRun, under three different visualization conditions:

1. Desktop display or laptop computer screen, a widely available format;
2. Large display or projector;
3. HMD (head-mounted display).

An usability questionnaire (SUS) was used to gather user feedback, and the results indicated the user experience of participants playing the exergame with each of the aforementioned devices; the limitations they encountered, and their suggestions are interesting for future implementations.

4 A gamepad proposal for sensing user movements

4.1 Design considerations

The gamepad prototype will operate based on user-centered locomotion and will detect the following walking in place events:

- Walking
- Running
- Jumping

And the detection of 6 events that are presented in conventional joypads:

- 5 digital input events through buttons
- 1 analog input event through an analog stick.

Following the results of previous related works and the limitations of commercial devices, some requirements are considered for the gamepad proposed here:

- The proposed gamepad will have economically viable and relatively simple manufacturing elements;
- it will feature a Plug and Play (PnP) controller installation;
- the components will be interconnected wirelessly to reduce the use of cables, which are difficult to install and pose a safety risk to the user;
- the motion detection device will be lightweight and comfortable for the user;
- the system will not demand a substantial amount of free space for its operation, a limitation typically associated with devices like Kinect and PS Move.

4.2 Design and components

Based on the above considerations, we will proceed to describe the controller that was developed. It is designed with 3 parts or components:

- **Ankle brace Component (CT or “Componente Tobillera” in Spanish)** responsible for sensing the user's WIP type movements and send this information to the Central Component (CC).
- **Gamepad Component (CG or “Componente Gamepad” in Spanish):** responsible for sensing digital input events such as “pressing button” and the analog input provided by the movement of the stick, and sending that information to the Central Component (CC).

- **Central Component (CC or “Componente Central” in Spanish):** It’s connected to the computer, works as a game controller, and receives signals from the CT and CG.

The relationship between the components can be seen in Figure 1.

As base hardware, Arduino was chosen because it is open source, easy to use and program, has an active community that provides tutorials and resources, as well as several third-party libraries that solve and facilitates the recognition of sensor modules, transmitters, among others. Also, Arduino boards are easy to obtain. The casing was modeled with Blender and printed with a 3D printer.

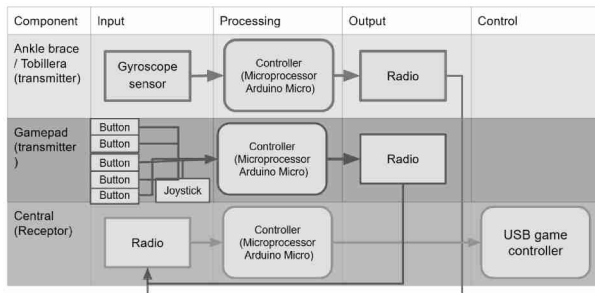


Figure 1: The component relationship diagram shows how the gamepad’s components are related to each other

4.3 Ankle brace Component (CT)

The component CT (Fig. 2) must sense the player’s movements and the power of their walking; an ankle-type controller was used, which is responsible for detecting the walking, running, and jumping events performed by the player. For this, a gyroscope module (MPU9250) was used. In the microcontroller was installed an algorithm trained to detect force and variations on the x, y, and z axes. Force is a measure of the intensity of player activity. The input is continuously captured for a period of time and, based on the values obtained, identifies whether it corresponds to the WIP action of walking, running, or jumping type. Once the state has been defined it sends its data via a radio module (NRF24L01) along with a source flag that indicates which component sends the data. This data will be captured by the CC.

4.4 Gamepad Component (CG)

The component CG (Fig. 3) has 5 buttons and a joystick arranged like the right side of a conventional joystick. It is capable of recognizing these events and sending them through a radio module (NRF24L01) to the CC along with a record indicating the origin of the message, in this case: the CG. It also has an Arduino Pro Micro as processor handling the events from the analogical and digital inputs connected.



Figure 2: Ankle brace Component



Figure 3: Gamepad Component

4.5 Central Component (CC)

The Central Component (Fig. 4) is basically a device that connects to a host computer via USB and runs an application (Arduino Joystick Library) that emulates a Joypad game controller input device. This way, it could be used in any game. This component aims to receive the messages sent by CT and CG; and depending on the content of the message, it is translated as an event coming from a conventional controller connected to the computer running the video game. It contains a radio module NRF24L01 which receives the messages and an Arduino Pro Micro.



Figure 4: Central Component

The events registered by the Central Component can be seen in table 1 along with the respective associated event, which is sent to the host computer.

Table 1: Recognizable events within the Central Component.

Origin	Registry	in CC represents
CG	Button A	Joystick.pressButton(0)
CG	MapX	Joystick.setRxAxis
CG	MapY	Joystick.setRyAxis
CT	walking	Joystick.pressButton(5)
CT	running	Joystick.pressButton(7)
CT	jumping	Joystick.pressButton(4)

5 Development of the exergame *Capitana Aldana* to integrate the developed gamepad

In this section, the design of an exergame that integrates with the previously mentioned controller prototype will be described. The goal of developing this video game was to validate the gamepad proposal through specific tests.

5.1 General description

“Capitana Aldana” is an exploration Role Playing Game (RPG). Also it can be defined as an exergame, because it was designed to promote physical activity. The game takes place on a deserted island called “Hat Island”, and puts the player in the role of “La Capitana”, a super-heroine who survives a plane crash and then must explore the island to find the necessary objects to repair her spacesuit, complete her mission, and return home. Along the way, she must fight against the environment elements like water, fire and mutant worms, climb hills and dodge obstacles. The mutant worms have been designed to attack automatically when an unsuspecting player enters their territory. The game will provide clues to reveal the way to find the lost objects, through a sheet of questions and answers that can be created ad-hoc. In addition, reward points can be achieved based on the number of “steps” and “jumps” performed, the amount of time the player was “running”, and the number of correct answers entered. In the end, a leaderboard will be shown based on the players who scored the highest when completing the adventure. The game aims to be an exergame and RPG, incorporating elements of first-person shooters and open world games. Figure 5 shows some scenarios and areas from the videogame.

5.2 Exergame aspects

The search for objects throughout the island encourages the player to “walk”. The different terrains on the ground influence the power that the player must exert in their walking, and the same applies when the player is being chased by an enemy and must escape by



Figure 5: Screenshots from the videogame Capitana Aldana.

registry	On CC represents	Input Godot	Description
BotonA	Joystick.PressButton(0)	Device 0, Button 0 (DualShock Cross, Xbox A, Nintendo B)	Acept/thold
MapX	Joystick.setRxAxis	Device 0, axis 2 - (Right Stick Left) Device 0, axis 2 + (Right Stick Right)	Rotate camera left Rotate camera right
MapY	Joystick.setRyAxis	Device 0, axis 3 - (Right Stick Up) Device 0, axis 3 + (Right Stick Down)	Rotate camera down Rotate camera up
state = walking	Joystick.PressButton(5)	Device 0, Button 5 (R, R1)	Move forward walking
state = running	Joystick.PressButton(7)	Device 0, Button 7 (R2)	Move forward running
state = jumping	Joystick.PressButton(4)	Device 0, Button 4 (L, L1)	Move forward jumping

Figure 6: Input map: shows how the events from the game input map are associated with the inputs of the gamepad prototype (Device 0 in Godot).

“running”. Similarly, when the player must “jump” to obtain objects that restore their health bar, provide ammunition to defend themselves, or to navigate aquatic environments.

5.3 Technical aspects, input map and relationship with the proposed gamepad.

The game was developed using Godot Engine and initially was compiled for Windows operating system. 3D objects were modeled in Blender. Godot Engine offers the possibility of defining an input map. This determines a set of actions recognized by the video game and that produce an effect on it, actions such as “move forward”, “turn the camera in a certain direction”, “grab an object”, etc. The programmer associates each event with a device and a button (or stick) that is responsible for activating said event.

The following fig. 6 is a detailed list of a set of actions/events that the video game is capable of recognizing, the effect it produces on it, and the associated device (the gamepad prototype is recognized by Godot as Device 0). The table includes the “Registry” field, which was reviewed in section 4, and describes how it relates to the events of the gamepad presented in this work.

It is worth noting that the game is functional even if the events are associated with the appropriate inputs of a conventional controller.

6 Usability evaluation of the proposed gamepad

In this section, the evaluation of the proposed gamepad prototype along with the exergame developed is presented.

6.1 Usability

The usability of a system, (ISO 9241 Part 11 standard), refers to the ability of software to be understood, learned, used and be attractive to the user, under specific conditions of use. Three specific aspects are considered:

1. Effectiveness (can users successfully achieve their objectives)
2. Efficiency (how much effort and resources are spent to achieve those objectives)
3. Satisfaction (was the experience satisfactory)

The System Usability Scale (SUS) was used to evaluate the system's usability. [13] defines SUS as a questionnaire with a Likert scale that generates a number that represents a composite measure of the usability of the system under study. It is a test with a limited number of questions, easy to complete and score, and allows for comparisons between products (e.g., "System A is more usable than System B"). It is an industry standard that is reliable, fast, intuitive, and can be used with a small sample.

6.2 Test's context and participants

The system was tested by beta testers to have a preliminary analysis of the accuracy and response speed of the gamepad. Based on these results, changes and improvements were made to both the gamepad and the video game. Some parts were repaired to fix disconnection issues, the design of the battery bank was changed, the dialogues in the exergame were revised, the 3D models were checked, and a step counter was added, among other things.

Two testing contexts (Fig. 7) were used to evaluate the proposed gamepad prototype along with the exergame developed in the previous section.

The decision to use two test groups with different demographic characteristics, one composed of young individuals experienced with video games and devices, and another consisting of older individuals less familiar with video games, is grounded in the need to comprehensively evaluate device interaction across a wide range of potential users. This choice is justified for several reasons:

- Usability Assessment: Prior experience with video games and devices can influence the perception and usability of the device [8]. By including both groups, the usability of the device can be evaluated for both novices and those with prior knowledge. This provides



Figure 7: Game sessions footage

valuable insights into the accessibility and ease of use of the device for different levels of experience.

- Context of Use: It is a factor that must be considered when studying efficiency, effectiveness and satisfaction. It is important to consider that this refers not only to the physical environment, but also to individual differences and the social environment in which the interaction is taking place [8].

- Detection of Specific Challenges: By comparing the interactions and performance of the two groups, it is possible to identify and address specific challenges that each group may encounter when using the device. This allows for usability and user experience improvements targeted at specific demographic groups.

The first context was carried out at the Facultad de Informática (UNLP) and involved students from Computer Engineering and Informatics degree programs. The group consisted of 4 participants between the ages of 20 and 24, 3 male and 1 female, all with experience in playing video games. This group is referred to as G1.

The second context was a department dedicated to information technology (IT) outside the educational environment and included participants both related to the IT field and not. The group consisted of 6 participants, 3 male and 3 female, between the ages of 40 and 63. Two of them had experience in playing video games, one had experience but was not a regular user, and the others had no experience in playing video games or related to the field of informatics. This group is referred to as G2 in this context.

6.3 Procedure

For the tests with these two groups, the same procedure was applied. The participants were invited and participated on a voluntary basis. The purpose of the test was explained to them. The gamepad and its basic aspects such as the functioning of the buttons, advancing in the field of play using the ankle bracelet, and how vision is handled with the gamepad stick were presented. Once these fundamentals were explained, the gaming session began, which had no time limit, and the objective was to try to complete the level. The tests went smoothly. During the session with G1, the device responded well and everyone managed to complete the level, except for one case where the player entered an “inaccessible area” of the game and could not complete the level. The average duration of the completed gaming sessions was between 13 and 15 minutes, with an average of 1700 steps taken. To end the session, the participants were thanked for their participation and the SUS survey was sent to collect feedback. Several of them responded immediately.

During the session with G2, the proposal worked well, except for one case where the gamepad turned off and had to be repaired. Three participants, who lacked prior experience in video games, successfully completed the game, while the other three participants expressed fatigue and chose to conclude the testing session. The average duration of completed gaming sessions was between 12 and 17 minutes, with an average of 2100 steps (including jumps) counted. It is worth noting that the players who chose not to use the aids took more steps and longer to complete the game, while those who completed it faster used the aids to locate the elements. Once the game was finished, the participants were thanked for their participation and the questionnaire was delivered.

6.4 Results obtained

In group G1, the proposal received positive feedback, averaging 4.5 out of 5 for each item (with a maximum value of 5). The integration of the gamepad with the video game was positively evaluated; it was considered intuitive and a good way to integrate upper and lower body movements into the game, thus fulfilling its immersive role. Additionally, participants expressed interest in using such technology in horror and sports video games. However, it was discovered that the ankle bracelet had some issues in counting steps, especially for taller participants, so a “training” section for the ankle bracelet was suggested. Regarding the participants’ responses to the SUS form, the data presented in table 2 showed good usability, with a score of 84.37, positioning the gamepad above the average SUS score, between “Good” and a minimal distance from “Excellent”, indicating that the gamepad has good usability.

In group G2, despite initial skepticism when describ-

ing the operation of the gamepad orally, enthusiasm was expressed once they tested it and were impressed by its novelty. Regular gamers found it to be a fun alternative to conventional controllers, while non-regular gamers saw it as a good option for physical activity on rainy or windy days. Also, participants from group G2 who didn’t have prior experience in video games were able to successfully complete the exergame. This result could suggest that the exergame design was intuitive and easy to pick up for individuals who were less familiar with traditional video games. The game received a general rating of 4.6/5 on average, and the participants’ responses to the SUS form showed in table 3 good usability, with a score of 83.25, positioning the controller above the average SUS score, between “Good” and a minimal distance from “Excellent”, indicating that the component has good usability, according to this group of participants’ opinion.

Table 2: Table of results of SUS questionnaire in context G1.

Group	Sum	SUS score
G1	33.75	84.37

Table 3: Table of results of SUS questionnaire in context G2.

Group	Sum	SUS score
G2	33.3	83.25

The results of the study showed that the gamepad was easy to use and intuitive, with participants reporting high levels of satisfaction and enjoyment while playing the “Capitana Aldana” exergame. The majority of participants also found the gamepad to be comfortable and ergonomic.

However, some limitations were noted, including the sensitivity of the sensors and the lack of “training” section. Participants also suggested some improvements, such as the inclusion of more buttons, the ability to customize the gamepad settings and add more difficulty levels to the video-game.

In 2023 the gamepad and exergame were used as part of an innovation exposition at “Centro de Innovación y Transferencia Tecnológica (UNLP)”, with around 100 people participating. Many participants approached the space where the proposal was available and positively valued the game and the possibilities of the gamepad. It is important to highlight that in this case the participants had very different ages, from 7 year old children to middle-aged adults (50 years old), in general adults older than this age did not try the game and accompanied only their children and grandchildren.

7 Conclusion and future work

This work contributed to the research in the field of exergames both through the formation of a theoretical study and the proposal and subsequent evaluation of the prototype of gamepad and exergame called “Capitana Aldana”. At the same time, the tests and their results allowed for the identification of opportunities for improvement, which are expected to be carried out in the future.

The results of the usability evaluation were positive, indicating that the gamepad was a viable option for use in exergames. Also, the participants showed and expressed satisfaction and enjoyment when using the gamepad with the exergame. However, further development and improvements may be necessary to address the limitations and suggestions provided during the evaluation sessions. In 2023 some improvements were already made and the proposal was used in an uncontrolled context, within the framework of an exhibition, and was positively evaluated. This encourages moving forward with this type of studies and proposals.

Competing interests

The authors have declared that no competing interests exist.

Authors’ contribution

ADG conceived the original idea, designed and programmed the gamepad and the videogame, developed the theory and took the lead in writing the manuscript with support from CS and LI. CS and LI contributed to the design and implementation of the research, to the analysis of the results, to the writing of the manuscript, carried out the usability tests and verified the analytical methods. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors read and approved the final manuscript.

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