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Fixed Bicycle System Gamification in order to Improve Student's Physical Condition and Generate Energy (Action research)

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Original Article

Abstract

Introduction: Today, with the advancement of technology and the expansion of the use of computers and mobile phones, mobility and health care through gamification has reached a special place. Despite increasing people health, gamification can create a small step towards a green city and create new job opportunities.

Materials and Methods: In this study, a motor was attached to the pedal or rotary axis of a stationary bicycle as a generator to convert the produced mechanical energy into the electrical form. Some buttons were also mounted on the bicycle handlebar so that the user could control the game character in the Android application. All required hardware and circuits were also initially selected and designed to provide the power needed to charge the mobile and send the sensor information to the software via a Bluetooth module.

Results: Referring to the latest achievements in health care, the complete design and manufacturing process of the control hardware required to read the information of the sensors connected to the bicycle and send them by a microcontroller to a mobile application as well as the design of a related android game with its software challenges, were provided. Two IoT-based Android developing tools, Flutter and Flame, were also briefly introduced.

Conclusion: The output of this study was a full version of a small-scale stationary bicycle attached to the sensor, which was a comprehensive example of a set of interconnected bicycles. It can be widely used at sports clubs, parks, and gardens to enhance sport culture through gamification.

Keywords: Gamification; Smart stationary bikes; Energy production; Sports and health

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Introduction

Early humans had to perform a lot of hard physical activities to meet their needs, and hence they were very physically fit and rarely had diseases such as obesity and hyperlipidemia, the source of which is the lack of mobility. Over the years, as tools and instruments were invented to help humans and make things easier, physical activity gradually declined, and humans became more overweight and, as a result, developed various diseases.

Thus, the subject of gamification emerged to meet this human need and to act as a stimulus for him in every field, including exercise and physical activity. This technique can be used in education, marketing and advertising, Internet-based businesses, internet marketing, health, employment, slimming, fitness, and the like (1).

The idea behind the use of entertainment in software is not only to simplify the user interface, but also to include fun in using it. Gamification can lead to positive emotions in the user through items such as sound, images, and challenges, thereby improving the user experience of using the software (2). Improving the application experience in the medium term will increase system referral and greater adherence. In 2008, a book was published entitled "The Gameful World: Approaches, Issues, Applications", which first referred to the term "Gamification", but was not

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welcomed until 2010 (3). In 2010, an article entitled "Play to Win: The Game-Based Economy" was published, which strengthened the use of the word "gamification", and since then this approach has attracted the attention of investment companies and many academic studies began at the same time (4). Numerous companies are now trying to invest in this field and provide gamification services by understanding the opportunity created by this new perspective. For example, companies such as Bunchball and Badgeville have developed platforms to use the concept of game on websites. Moreover, many sites, such as winepic, started up using this concept, or, for example, a US health center used a video game called "Zombies, Run Away" to train personal hygiene and first aid; so that the person actually enters this virtual world and using the Global Positioning System (GPS) of the phone, the position of each person is determined and he is informed by the headphones of the phone that the zombies are approaching. Then, on the way, he gets acquainted with health issues and first aid.

In 2011, a French advertisement for a cycling campaign was released in cyberspace, which received a lot of positive feedback. In this advertisement, people accidentally saw some stationary (exercise) bikes on the sidewalk of their city that did not exist before. Everyone wondered who put these bikes there. So they got on the bikes and saw that by pedaling, music was playing for them, and a series of neon lights began to light up, and after a short while, a large neon sign mounted on the building in front of them was activated and showed the moving image of a man dancing. Everyone was eager to see the following of the image, and so a large crowd gathered and took turns to ride bicycles and exercise and were happy.

Thus, the idea arose in the minds of the authors of the study that the culture of sport could be expanded by the gamification approach. In this context, there is a powerful and complete software called Zwift (Zwift Inc., California, USA) (5) that only considers the gamification aspect of the stationary bike. Among the most important differences in the work is the possibility of generating electricity by the bicycle, so that with the least facilities and costs, the person riding the bicycle, while exercising and being entertained by the game software, can also charge his mobile phone by the energy produced. In this regard, there is a sports club in New York that supplies electricity to the entire of a building by its bicycles (6).

Materials and Methods

In this study, a motor was attached to the pedal or rotating axis of a stationary bicycle as a generator to convert the mechanical energy produced into the electrical energy. There were also buttons mounted on the bike's handlebar that allowed the user to control the character in the Android-based game. The required hardware circuits and equipment were also initially selected and designed to provide the power required to charge the mobile phone and send the sensor information to the software via a Bluetooth module.

Results

The main finding of the present study was the electromechanical system by which exercise on the mechanical system of the stationary bicycle attached to the sensor connected to a mobile phone became a game. The Android game designed online red the data related to the sensors mounted on the bike and created an interactive game environment for the user, in which the user was encouraged to control the speed and power of his stationary bike along with various scenarios.

Design and manufacture of hardware required: The hardware appropriate for this design was along with a variety of requirements, including the ability to connect the generator to the wheel axis or to connect it to an armature in a smaller simulation environment. The two motors work in such a way that the first motor rotates the outer shaft of the second motor, and the generator uses the appropriate circuits and connections to generate the required electricity. Obtaining the speed of rotation of the wheels in order to adjust the pedaling speed of the game character were other requirements of this plan. The pushbuttons on the bicycle handle bar were also used to control the movement line of the game character.

An optical counter (Opto Counter) was employed to measure the rotational speed. There are several types of this part on the market with different designs, of which the H22A1 type (Semiconductor Components Industries, LLC, Phoenix, Arizona, USA) was chosen as the desired model that was suitable for the study in terms of dimensions. There is an infrared transmitter on the one side and an infrared receiver on the other side of this counter. As long as there is no external object or other obstacle between these two layers, the counter output is high, but when an object prevents the light exchange between these two layers, the output of the counter is low. It should be noted that this piece is sensitive to the rising edge and sends a positive pulse with each object

passing through it. Therefore, if an object is fixed inside it, it is counted only once.

The Arduino Uno board [Arduino Uno R3, Arduino.cc., Interaction Design Institute Ivrea (IDII) in Ivrea, Italy] and the HC-05 Bluetooth module were used to manage and send data to the mobile phone. This board was an ATmega328-based microcontroller with 14 digital input and output pins [6 of which were used as Pulse Width Modulation (PWM) output], six analog inputs, a 16 MHz ceramic resonator, a USB port, a Power Jack (power supply input), an ICSP header, and a Reset button. The Arduino Uno board included all the features needed to use the microcontroller on the board. The Bluetooth module, along with an auxiliary board with support for the Serial Port Protocol, was designed for wireless serial communication. The schematic of the printed circuit board designed and the map of the occupied space are presented in figure 1.

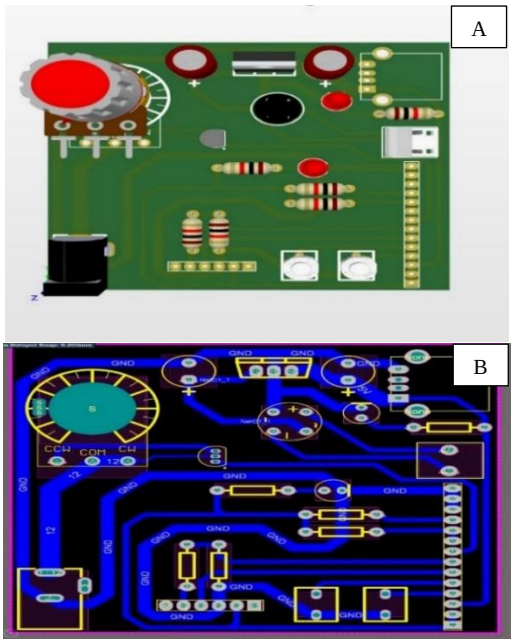

Figure 1. (A) Schematic of the designed circuit board printed and (B) map of the space occupied by the printed circuit

Game graphics design and Arduino programming: To design the game software, various factors such as asphalt road with its marking, trees for roadside, road obstacles (game challenge), cycling character with the possibility of changing the leg position while moving, and coins as rewards to earn points in the game were necessary. To distinguish between the road and the roadside, yellow lines were placed between them. In order to design the game character, a cycling character was needed from the top view to show the movement of his legs in the game. To design the game coins, the ready-made three-dimensional coin was inserted from the Paint 3D software, and after changing its size, color, and other specifications, it was rotated eight times as 45 degrees and photographed. Then in the game, switches were made quickly among these 8 photos to form an animation.

For the output of the optical counter and in order to analyze its output pulses, it was necessary to use a hardware interrupt to perform counting with the obstacle rotating through the groove of the optical counter with each turn, and in this way the rotation speed of the motor per unit time was obtained. There were two functions for measuring the engine speed. The first function was performed by the Arduino each time the interrupt signal was sent (sending pulses by the optical counter). Each time the external object passed through the groove of the optical counter (optical counter was connected to pin 2, which was equipped with interrupt), a signal was sent, and receiving this interruption according to the programming performed for it, Arduino executed the Counting function as the procedure of this interrupt. Therefore, a global variable called Counter was defined and a unit was added each time the interrupt signal was sent in the Counting function.

Game design and development: There are numerous gamification engines in order to develop games, some of which have a long history, including Unity (7), Construct 3 (8), Game Maker Studio 2 (9), Phaser (10), and Flutter (with a film). Each of these gamification engines is accompanied by some advantages and disadvantages. Using Flutter makes it easier to develop relatively simple games that lack much graphic complexity. The Flutter open source framework was first used by Google in 2017 (11). Programs developed by Flutter can be run on a variety of platforms (12). This framework allows programmers and developers to consistently get Android and IOS output for their application by writing the code once. Flutter currently has the ability to design applications for all mobile, web, and desktop platforms (13), but the application programming interfaces (APIs) for Windows and Web are still in the Beta stage (14).

The main reason for choosing the Flutter framework (Flame film gamification engine) was that it was the latest open source tool for developing cross platform applications, especially Android and iOS,

developed directly under the Google Company supervision. In fact, the positive point of Flutter over the cross-platform frameworks such as Xamarin (15) and Phonegap (16) is the native output of the application. In other words, there is no difference between Java and Android apps developed by Flutter. The language used in the Flutter framework is the language developed by Google called Dart, which is an object-oriented, high-level language similar to Java. Google has also announced that Dart and Flutter will be used as the main development platform for the Fuchsia operating system in the future (17). Therefore, this framework also benefits from the main environment for the Google's next operating system, Fushia. As a result, its future can be hoped for (18).

Flame is a much simpler gamification engine than Unity, but it also has features required for developing a game, including game loops, input APIs, animations, simple images, text rendering, and moving images. Additionally, film documentation is sufficient to start programming the game and follows a logical coding structure (19).

Game loop is the most important part of starting and understanding the performance of a gamification engine. This is actually the main part of the game, which simply includes a set of instructions that are run by the computer repeatedly. Games often have a specific measurement criterion called frame per second (FPS), in which a frame means running the game loop once. The Flutter framework runs the programs written by it at 60 frames per second, which is close to native programs, and since game fluency depends on it, it is an important game development indicator.

The Update part processes the logic of motion (LOM) of objects (for example, in this project, the left and right motion of the bike, obstacles, road movement, coin movement, etc.) and other things that need to be updated (for example, checking the coin being eaten by the player or checking the player's impact to the obstacles. Most of the activities take place in this part. The rendering part is responsible for drawing objects on the screen, and the separation process is considered relative to the update, and as a result, the entire game loop is synchronized. The Flutter framework has not officially implemented the Bluetooth programming interface, but it can be connected to the Arduino board using the flutter_bluetooth_serial library. Figure 2 demonstrates an overview of the Android game designed.

Figure 2. An image of the Android game screen

Discussion

Currently, there are numerous virtual reality (VR) games for cycling simulation in the global market, but in the current field of research, namely stationary bike gamification, there is only one similar case, i.e. the Zwift Company, where building a separate and of course costly module, the personal bike can be turned into a stationary one, and the module can be connected to the game developed specifically for this purpose. One of the advantages of the project examined in this study compared to the product of the Zwift Company is the production of electric energy by the mechanical energy produced by the cyclist, which can be a big step towards the production of clean energy by expanding this project in the real world. The second advantage of this project is its much cheaper cost of production and installation compared to the Zwift's product, and ordinary people, sports clubs, and government agencies can provide the stationary bike system connected to the game at the lowest possible cost. Of course, the Zwift module also has advantages over the current design, including the apparent beauty of the module, the three-dimensionality, and advancedness of the game, as well as the possibility of easy installation on a personal bicycle.

To advance this project in the future, the software is able to display a collection of online bicycles on a screen (in the game) so that everyone can beat their competitors in the game with more effort and set a better record. Furthermore, to create more desire to play, this system can be implemented in collaboration with organizations and universities, and reward the winner or the person who sets the best record. At the university, for example, the highest record each week is awarded with the reward which is attractive to students.

Larger touch or push sensors can be used instead of simple pushbuttons to improve the appearance of bicycles. Additionally, the generator system can be delivered to the organs as a closed kit with a more beautiful appearance, and instead of using the mobile phone as a screen, it can be displayed on a larger screen that is connected to the bicycles. In this case, by upgrading the hardware and software, the "gamification" approach can be better presented and more welcomed by users.

With the goal of improving the use of this product and increasing the motivation for people to continue using this system, it is possible to create a telecommunication via Internet among bicycles by launching a server, in addition to saving the records of each individual in a database so they can compete with each other in this style.

Limitations

The major limitation of this study was the lack of funding and facilities. Therefore, the laboratory and miniature version of this bike was implemented. If there is financial support for the construction of this system, and also, the necessary facilities (such as stationary bicycles in sports clubs and laboratory equipment related to the construction and testing of hardware, etc.) are provided to researchers, more progress can be made in this field and the real and better version of this project can be implemented.

Recommendations

With the support of government agencies and universities, a great deal of culture and health can be created in educational and administrative settings. In addition, by doing this, clean energy can be produced at no cost. For example, by installing and deploying several bicycles at a faculty, it is possible to produce part or all of the building's electricity needs through exercise and free of charge, while providing physical health for the students. Moreover, this system can be employed in physiotherapy and rehabilitation centers for related purposes. To read more about this, the following can be mentioned:

1- Building a game specific to this system for virtual glasses instead of using a mobile phone and even a larger screen

2- Recording, tracking, and analyzing medical information of the cyclist by the relevant sensors

3- Changing the sensors and hardware of this design so that it can be installed on personal bicycles.

4- Implementing this project on the random statistical population and collecting and analyzing the information obtained and using this data

Conclusion

In the present study, a simulated but complete version of a stationary bike attached to a sensor was presented, which alone is a comprehensive sample of a series of interconnected bicycles and can be produced at a higher level and communicating with each other, fulfill the main goal of the project, namely promoting sports culture using the gamification approach.

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Authors' Contribution

Pouya Khani: Implementation of hardware and its energy production circuits, pursuit of administrative affairs and correspondence, specialized evaluation of manuscript in scientific concepts, confirmation of the final manuscript for submission to the journal and conference office, responsibility to maintain the study integrity from the beginning to the publication, and responding to the referees' comments; Salman Goli-Bidgoli: Basic study ideation, providing study equipment, manuscript preparation, specialized evaluation of manuscript in scientific concepts, confirmation of the final manuscript for submission to the journal and conference office, responsibility to

maintain the study integrity from the beginning to the publication, and responding to the referees' comments; Mostafa Heshmat: Design and development of Android game, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, confirmation of the final manuscript for submission to the journal and conference office, responsibility to maintain the study integrity from the beginning to the publication, and responding to the referees' comments; Marjan Moazzam-Sedeh: Android game graphic design and microcontroller programming, setting and preparing the electrical content of the study, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, confirmation of the final manuscript for submission to the journal and conference office, responsibility to maintain the study integrity from the beginning to the publication, and responding to the referees' comments.

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Conflict of Interest

The authors declare no conflict of interest.

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