Virtual Reality Games to Promote Healthy Behavior Choices

Alice J. Lin1[#1], Charles B. Chen [*2], Fuhua (Frank) Cheng [#3]

[#1]*University of Central Missouri*
Warrensburg, MO 64093, USA
[*2]*West Virginia University*
Morgantown, WV 26506, USA
[#3]*University of Kentucky*
Lexington, KY 40506, USA

Abstract *— Poor dietary choices and sedentary lifestyles are common in today's society. These choices can cause low self-esteem as well as significant social, psychological, and other health problems. Video games provide extensive player involvement for a large number of children and adults, and thereby provide a channel to deliver health behavior changing experiences and messages in an engaging and entertaining format. Virtual reality (VR) is an artificial environment that is created with software and presented to the player in such a way that the player suspends disbelief and accepts it as the real environment. In this paper, we propose a new design of a VR game. The goal of this game is to encourage young people to make healthy behavior choices by reinforcing specific messages through the VR game experience. The players will enjoy the thrill of the VR world as they navigate their way through different levels and missions while learning about healthy behavior choices.*

Keywords *— virtual reality, game, education, healthy behavior.*

I. INTRODUCTION

Today, the number of children in the United States is at an all-time high of 86 million. Among the millions of children in our communities, poor dietary choices and sedentary lifestyles cause serious health problems, low self-esteem, and social and psychological problems that contribute to poor quality of life and long-term outcomes. If this pattern continues into adulthood, it will lead to an unprecedented rate of premature death and disability, diminished workplace productivity, and serious financial repercussions for those individuals and healthcare providers [1].

Ordinary school health curricula and other behavior changing interventions targeted at children sometimes have only had limited effectiveness [2, 3]. New channels are needed to reach children that offer the promise of promoting substantial health-related behavior changes [4]. One such new channel is the video game, since many children spend numerous hours playing them. Using video games to promote behavior change could capitalize on children's pre-existing attention to and enjoyment of them [5]. "Serious video games" are designed to entertain players as they educate, train, or change behavior [6].

Video games provide extensive player involvement for a large number of children and adults, and thereby provide a channel to deliver health behavior changing experiences and messages in an engaging and entertaining format [5]. Video games appeal to a wide range of individuals, regardless of age, gender, and cultural background. Not surprisingly, they have both broad reach and appeal, making them a potentially powerful channel for reaching large numbers of both youths and adults with health promoting messages [7].

People of all ages and backgrounds play electronic games enthusiastically for entertainment and fun, as well as for motivation and learning. According to surveys, 155 million Americans play video games regularly. More than 40 percent of all gamers are female [8]. A recent study shows that around 99% of American boys play video games, along with 94% of girls [9]. Considerable literature reveals video games to be a powerful teaching tool [10-12].

Serious video games attempt to entertain while encouraging some kind of change, such as change in the player's attitudes, beliefs, risk perceptions, knowledge, or skills. The aim is to ultimately change behavior. Thus, serious video games have dual, and seemingly disparate, goals of "fun-ness" and "seriousness" [5]. Serious video games for health are more likely to be effective if they target factors that are closely and causally related to the behavior of interest [13]. Behavioral science offers insight into how to design serious video games for health that achieve the dual goals of entertaining (i.e., "fun-

ness") while promoting health behavior changes (i.e., "seriousness") [14, 15]. Video games in health care provide ample examples of innovative ways to use existing commercial games for health improvement or surgical training [16, 17].

Serious video games for health are a special type of serious video game that is specifically designed to entertain while changing health behavior [14]. Changing health behaviors, such as improving diet or increasing physical activity, can be a daunting task. Health behaviors are typically influenced by multiple competing factors, and are oftentimes resistant to change [7].

II. RELATED WORK

There are many genres of games in today's market, and serious games for health education account for only for a small percentage of these games. With the recent technological advancements, young children and adolescents live in a media-rich environment, with unprecedented exposure to content - including television, movies, music, games, advertising, and the Internet [18]. Traditional video games are no longer as attractive to young children and adolescents as they were in the past. Mobile devices and Virtual Reality (VR) are reshaping those digital fantasies.

The use of virtual reality and commercial gaming systems has received attention for enabling physical activity and engagement in healthy individuals and for rehabilitation in disabled individuals [19]. Particularly when coupled with popular, commercially available gaming systems, the engaging nature of these activities can provide a motivating and enjoyable means of adhering to exercise and increasing physical activity [20, 21] in the comfort and convenience of one's own home. The application of VR gaming systems to promote physical activity has been termed exergaming or activity-promoting gaming [21]. The gameplay has the following attributes: voluntary, intrinsically motivating, active (perhaps physical) involvement, and a make-believe quality [22], all of which may help improve psychosocial functioning.

Given the importance and high costs of healthcare for affected individuals, application of this technology can improve health maintenance and healthcare and reduce associated costs [23]. Moreover, the technology needs to be introduced into everyday life well before sensory, sensorimotor, and cognitive impairments have occurred [24]. Such technology should not be centered only on disability and pathology, but should also be geared toward improving quality of life at all ages [25].

III. OUR APPROACHES

Although there are plenty of games on the market, only a small percentage of these games are for educational purposes. VR is mainly used for game development to entertain people. Our goal is to develop serious games with VR as its game environment and encourage children to live healthier lives by promoting healthy behaviors through the game.

We propose to develop a VR based serious game for children to promote healthy behaviors. This challenging and engaging VR game system will be affordable and appeal to children who don't normally play video games. VR is an artificial environment that is created with software and presented to the player in such a way that the player suspends disbelief and accepts it as a real environment. Players feel like they are really there, opening up unimagined ways to interact and communicate. The VR of our system primarily experiences through three senses: sight, sound and haptic. If the environment incorporates 3-D sound, the sound's orientation shifts in a natural way as the player maneuvers through the environment. The system will have full 6-freedom-degree of rotational and positional tracking. It will allow players to sit, stand, or walk around. In addition to providing players with an immersive audiovisual experience, we also have other sensory output from the virtual environment (VE) system which can adjust in real time as a player explores the environment. Sensory stimulation will be consistent if a player is to feel immersed within a VE. If the VE shows a perfectly still scene, the player wouldn't expect to feel gale-force winds. Likewise, if the VE puts a player in the middle of a hurricane, the player wouldn't expect to feel a gentle breeze.

Our aim is to develop serious games with VR technology. The goal of VR is to convince the player that he or she is somewhere else. It achieves this by tricking the human brain - in particular the visual cortex and parts of the brain that perceive motion. In our game, there will be a variety of technologies to create this illusion, including stereoscopic displays and motion tracking hardware.

Motion Tracking Hardware including gyroscopes, accelerometers and other low-cost components are used in VR to sense when our bodies move and our heads turn, so that the application can update our view into the 3D scene. The second essential trick for making the brain believe it is in another place is to track movements of the head and update the rendered scene in real time. This mimics what happens when we look around in the real world. We will develop our serious game utilizing Oculus Rift for its rapid head motion tracking using a high speed inertial measurement unit (IMU). Head-tracking

IMUs combine gyroscope, accelerometer and/or magnetometer hardware. The development of our VE game system is guided by various generation VE development systems [26-32].

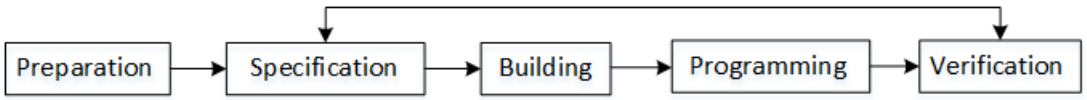

Fig 1: A framework of the main stages of a VR game.

Figure 1 shows a framework of the main stages. (1) Preparation: We will assess what tasks must be completed in the VE and in the real world via a task or function analysis; we will define the end-user characteristics and design the interface. (2) Specification: We will assess the application goals and prioritization, concept design, persons, scenarios, story boarding, and virtual task analysis. (3) Building: In this stage, the process is that concepts established in the storyboard can be realized using the tools available. The different parts such as objects and appearance, layout and the user interface will work together when assembled. In order for users to interact successfully, we provide cues and feedback to the participant. (4) Programming: 3D models and 3D scenes have to be created and be given dynamics and behaviors and associated sounds where appropriate. Viewpoints, on-screen buttons, and text boxes can be added at any time. There are many toolkits and some domain-specific languages that will be used for the actual scripting. (5) Verification: This process is to ensure that the product is internally consistent and that it meets the specification and behaviors as expected or specified. To find out whether the components of the entire VE have the specified interactivity, navigation, and fidelity, this process has feedback loops; the iteration will be to correct problems found during verification, but the majority takes place as each object is designed in detail, built, and tested before moving on to the next object.

A virtual environment can look more realistic if the objects in the environment follow the physical laws we are used to in the real world. Real-world objects have mass, may be rigid or flexible and solid or fluid, will fall at a constant acceleration when not supported, and will move and twist when pushed by an external force. Although the capability of computers at simulating the real world continues to improve, with some computation being off-loaded onto the GPU, there are still limits to how many potential interactions between objects and parts of objects can be handled at interactive rates. More complex polyhedral may be supported, but fewer in number and with some limitations [33]. We propose to design and develop some physics simulation methods to make our game truly immersive.

Our game will utilize Oculus Rift for VR displaying and Atlas for positioning. By placing down markers in a room and using an app and an iPhone (mounted on a player's chest) to track where the player is within that environment, we convert a real-world space into a virtual space.

We will develop a variety of levels for the game based on age related considerations. Each level or section of the game will have a new narrative. The lessons about healthy behavior choices will be incorporated into the game and will influence the children while they are playing. In our game, the beginner level will be similar to a tutorial and will be easy to control. We will design an inexpensive "walk-around" VR system that uses markers on the ground to track a player's movements as they use an Oculus Rift headset. These markers may be used as the boundaries for the game area or as the land markers inside the game area. A large open space will be optimal for gameplay. A large single room may work, but several connected rooms will be better (Figure 2). The play booth (Figure 4) can be placed in one part of a room. We will map the real world into a virtual world to set the boundaries of the game space. What this allows is for an Oculus Rift wearer to move around freely. Additionally, the accelerometer and gyroscopes will pinpoint a player's exact location.

More advanced levels of the game will allow the player to face greater challenges in the game. Figure 3 shows our overall system which combines VR and gaming fields. We will use Unity as the game engine. Atlas will be used for players to walk, run, jump, crouch, bend and move around as they would in real life. In the VR game interface, there will be a health index meter, main menu, map, level, and score, to indicate the game progress and the player's virtual health status. One aspect of the game that could help in educating players is to allow them to choose items that will improve their health status. For example, a player may be presented with foods to choose to increase his health score. The player's action will be statistically analyzed according to the food that the player consumed in the game [34]. The player's health index can be subsequently determined based on the proportion of healthy/unhealthy food that he takes throughout the entire game.

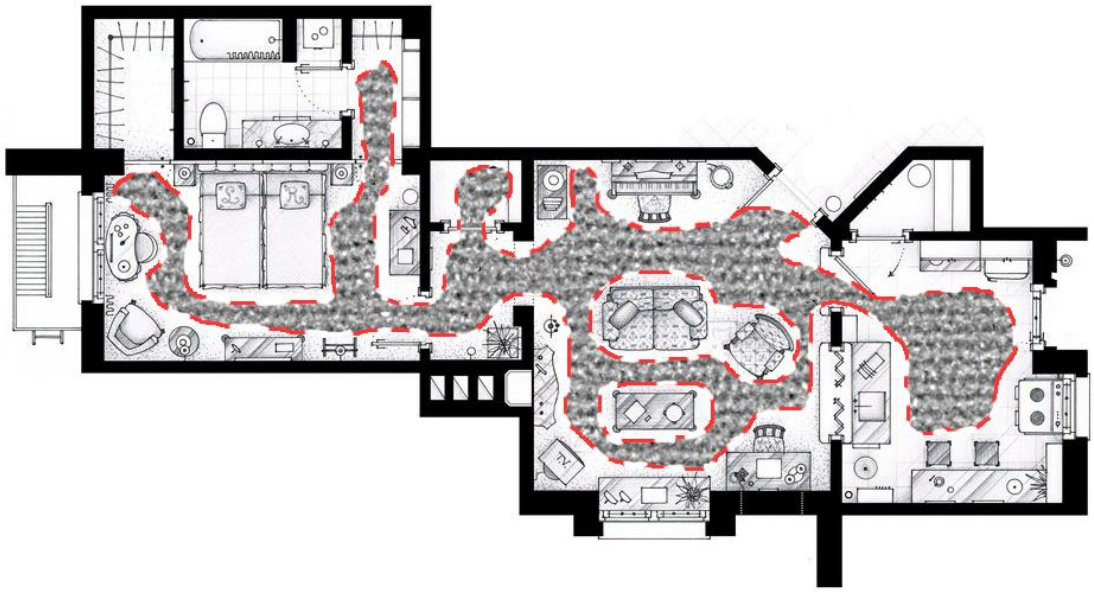

Fig 2: Real space can be mapped into virtual space. This floor map shows connected rooms. The red broken lines indicate the boundaries in virtual space. The carpeted area is the virtual space that the player can freely play on.

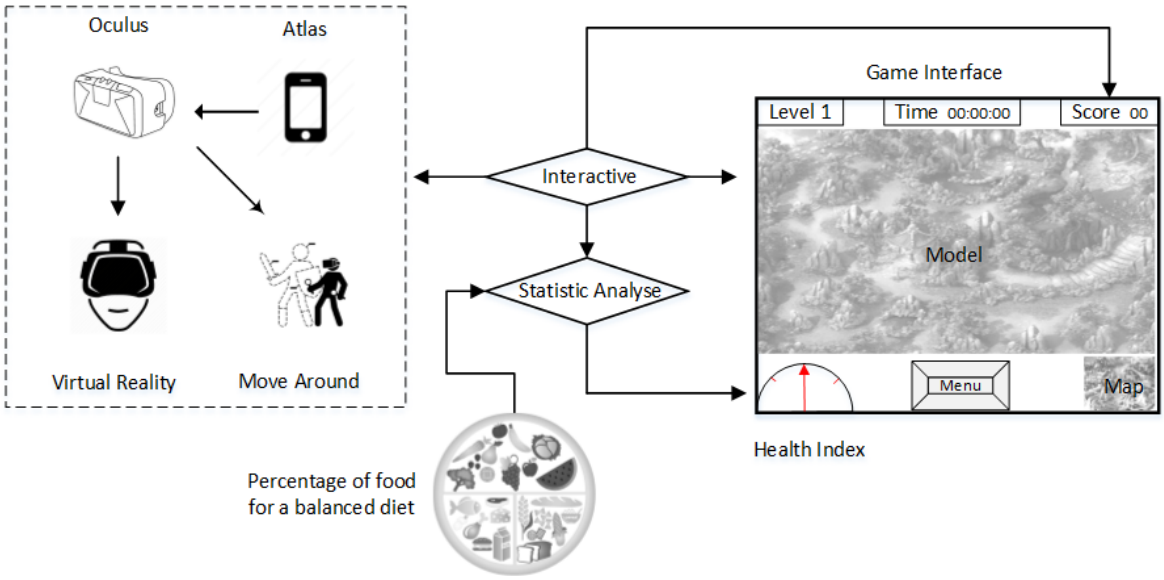

Fig 3: The overall structure of the game.

To enhance the VR experience, the play booth will be equipped with a set of sand bags, an air-conditioner, and vibration equipment. Sand bags are used to create weight on the player's shoulder and legs to make the player feel that he is gaining weight. The air-conditioner is used to blow air of different temperatures to simulate different environments and scenes. The vibrating equipment will shake the players when they are in an unstable place such as a pedestrian-only suspension bridge.

A variety of levels will be built within the game, allowing players of different levels to participate. The player will be able to navigate each sub-system. In each level, there will be a tutorial which will be a VR movie suitable for the difficulty level and specific age group. Each new level will provide

additional challenges. Whether the players are stepping into the game, watching an immersive VR movie, or jumping to a destination on the other side of the world, they will feel as if they are really there.

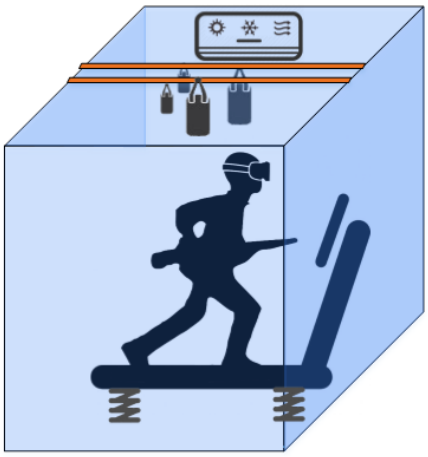

Fig 4: Setting of the play booth: treadmill, air-conditioner, sand bags, and springs under the treadmill for generating vibration.

Another aspect of the game that we hope to develop is the creation of a Hulk-like character in the game. The Hulk is a non-player character (NPC) in the game. The enemy NPCs are populated at a given level. Enemy NPCs are controlled by the computer and are the main source of conflict during gameplay. NPCs are one of the elements we will develop to craft the pacing, challenge, and tension of a level. We can control not only where the NPC is placed but also the NPC's scripted behavior, how they are equipped, their level of health, their armor, and other variables [35]. We will develop artificial intelligence to give nonhuman entities algorithmic and mathematical solutions for problem solving and simulating human thought and decision making. In our video games, it is the heart and soul of the NPCs controlling enemies. Figure 5 is an artificial neural network for our game characters (Hulk and its followers).

The artificial neural network computes a function F, where F is from R^n into R^m with R being the set of real numbers. The $x_1, x_2, \ldots x_n$ represent the inputs, such as the Hulk's health index, the visibility of the player and the distance between the Hulk and the player. When the Hulk's health index becomes low, it will have a lower ability to approach. The $y_1, y_2, \ldots y_n$ represent the outputs, such as hide, flee or approach. The neural network can be trained to consider two or more different alternatives.

The player's health index is controlled by the intake of different kinds of food. When the food is balanced and the total amount is not above the limit, the player is healthy. Otherwise the player's health index will be decreased by a certain amount (Figure 6). In the figure, W, X, Y and Z represent the percentages of health index changes.

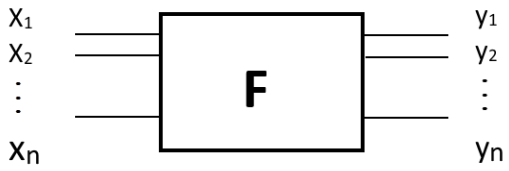

Fig 5: Neural network

Each level contains sessions. In each session in our VR game, the player can play a selected category or a combination of categories. The categories include balancing your diet, fighting against alcohol/cigarettes/drugs, seeking opportunities for exercise, protecting your teeth, and preventing injuries. These categories can be played individually for younger children or played with a combination of two or more categories for higher level players. To balance the diet, for example, the player will be surrounded with various kinds of food in the game. The player needs to get the desired kind of food, such as vegetables and fruits, and avoid certain kinds of food to maintain or improve his health. The Hulk will try all it can to do to sabotage the player's work to balance his diet.

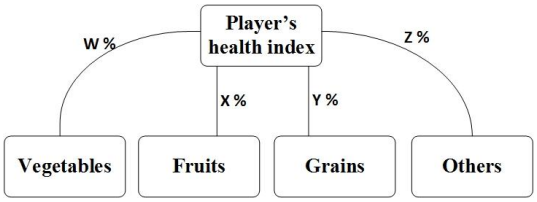

Fig 6: The player's health index is controlled by the intake of different foods.

The player's actions will be incorporated into the computer model and reflected in a way that the player can perceive. We will employ passive haptics to augment interaction and perception in the game to enhance the VE. Passive haptics are real objects in a physical space that are mapped to virtual objects in a virtual space. Players wear a HMD (head-mounted display) while in the physical space. When they look toward the physical object, they will see the virtual representation of it in their display. When they approach the object and try to touch it, they encounter the real object in the physical space. Anything a player does with that object in real space appears as a reflected action upon the virtual object in virtual space.

Our game will be suitable for children of all ages, since the promotion of healthy behavior will influence their entire lives. For very young children, parental guidance may be needed to properly using the VR equipment. For different age groups, there will be different materials in the game.

The system will also provide adjusting mechanisms. These items control the difficulty level of the game. For instance, when the Hulk throws harmful items at a player at a faster speed, there will be a greater chance that the player will be hit. Other factors include the amount of healthy food that the player can get each time, the Hulk's moving/turning speed, and the number of Hulk followers.

The game pits the children against the Hulk and encourages them to make healthy behavior choices. The players will enjoy the thrill of the VR world as they battle their way through missions while learning about healthy and unhealthy behaviors of the real world.

The interaction between the technology and the individual is paramount. Therefore, it is important to assess children's perceptions or actions to determine whether the VR game has been well designed and employed and whether it provides meaningful feedback and knowledge of results to individual children. We will develop a VR assessment game. It has the capability to precisely recreate situations or environments across different sessions at different times or places. It has the power to record behavior with detail and precision. This allows expert raters and automated scoring systems to create meaningful performance profiles for children.

IV. CONCLUSION

We have presented a design for a compelling, challenging and engaging VR game system. The immersive nature of VR and the unique design of our game will attract young people and educate them to make healthy behavior choices while they have fun playing the game. The games coupled with physical exercise equipment will also provide the additional benefit for young people to get some real exercise to improve their health.

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