Hand controlled 3D minesweeper

Nicolás Mendoza R.
Systems and computer engineering
Universidad de los Andes
Bogotá, Colombia
n.mendoza26@uniandes.edu.co

Pablo Figueroa F.
Systems and computer engineering
Universidad de los Andes
Bogotá, Colombia
pfiguero@uniandes.edu.co

***Abstract*—During the last six years, the gaming industry has introduced nontraditional interfaces to play videogames. These efforts had been done before but without reaching the success these new interfaces are experiencing in the last years. These new interfaces use player movement rather than buttons or joysticks, creating a more immersive environment for the player. These results open up a universe of new possibilities for developers to create new ways to interact with games. In this article, a 3D minesweeper game is presented, using hand movement to interact with the game. A user study was conducted to validate the results of the implementation.**

***Keywords*—Minesweeper, virtual hand, PhaseSpace, 3D interaction, videogames.**

I. INTRODUCTION

Console gaming is a complex and changing market. It is not easy to predict how the industry will behave at a given timeframe. With each generation of new consoles, better and cheaper technology is available for consumers to enjoy increasingly complex games that create more immersive experiences. But it's not only the graphic or sound quality that can be achieved with each generation of consoles that make these games more complex and immersive, changing traditional human interaction interfaces like controllers with buttons and joysticks make new challenges arise for game developers.

Recent examples demonstrate how console gaming industry changes. In the so called sixth generation of consoles, the PlayStation 2 took the leadership in terms of sold units worldwide, becoming the best-selling videogame console of all time with more than 152 million units sold [1]. Sony was leading the market by the time the sixth generation of consoles was the current generation, but with the coming of the seventh generation of consoles, Nintendo took over the first place in sales for the seventh generation of videogame consoles [2]. Why did this happen? Certainly the fact that the Nintendo Wii is cheaper than the PlayStation 3and the Xbox 360 has helped to boost its sales, but what I think that really made the difference was the interface that the Wii uses. The motion controllers that the Wii uses enabled consumers to experience a different way of playing videogames and made the Wii a very attractive option at the time of its launch. Microsoft and Sony later caught up with the release of Microsoft Kinect and PlayStation Move.

Although, several nontraditional gaming interfaces have been introduced in the past, like the Nintendo PowerGlove [3], the interfaces introduced in the seventh generation of gaming consoles actually have been successful unlike the previous ones. Successful and popular games like Wii sports have been created with the new controllers in mind [4], showing a new trend towards game development using nontraditional control schemes. This trend opens new gameplay possibilities that can be exploited to create new entertainment experiences.

In this article a game that attempts to use a nontraditional interface is presented. The game is a 3D minesweeper controlled using a glove. First, the motivation for creating this kind of game is presented. Then the game rules are described and an explanation of how these rules are derived from the 2D version of the game is presented. After that, a high-level technical description about the game is developed, including the hardware disposition. Finally a user study is presented with some conclusions about the work done and the future work that the project would follow.

II. MOTIVATION

Creating an entertaining game is not an easy or straightforward task. During the process of creating a videogame several gameplay options may arise, and managing to create the right gameplay can become a daunting task. Although it's not a simple process, it doesn't always have to be such a difficult task to find and create a good and entertaining gameplay. A strategy that can aid in the process of designing and developing a videogame is the enhancement of existing and well known gameplay schemes to provide a different yet entertaining experience that doesn't feel repetitive.

An example of this strategy is a game called Jetpack Joyride, which is an iOS game from Halfbrick studios [5]. In this game, the developers took a classic helicopter obstacle avoiding gameplay seen in various web based games and added a number of gameplay elements like collectable coins, random power-ups, achievements and added a recognizable context for the game (a main character and a laboratory environment where the game develops). With this formula Jetpack Joyride has achieved more than 13 million downloads in the app store [6] which is a number that can't be ignored.

Following this strategy, the idea of a 3D minesweeper game directly controlled by the user hand, came out. Minesweeper gameplay is very popular due to the version that comes with Microsoft Windows operating system. Given the fact that this version has a 2D gameplay, a 3D version of the game is already an addition to a simple gameplay. A 3D version proposes various challenges. The player should be able to see all the

boxes at a given time, so a method to rotate the environment in an appropriate way should be provided. The same actions available in a normal 2D minesweeper game should be available in the 3D version, which are expanding a given box and marking a box as having a mine in it.

Apart from taking the game to the 3D realm, the use of an interface different from standard mouse and keyboard or standard controllers that only use joysticks and buttons is desired. Natural hand movement was chosen as the medium to control the game so the user would need only one hand without any controller to interact with the game. Some power-ups and power-downs could be added to the game in order to provide elements that change the core game rules.

III. PREVIOUS WORK

There are several 3D minesweeper implementations and for different platforms. Some are web based; some are desktop applications for Linux, Windows or Mac; some are games for smartphones; even there is a Nintendo DS game. Below, some examples are mentioned.

Mine3D[1] is a good example of a web implementation of a 3D minesweeper. The game has all the actions one would expect from a 3D minesweeper game which are expanding a box and marking the box as having a flag. It also lets customize the gameplay as the player wants by selecting 3 difficulty levels; letting the user set the dimensions of the mine cube; turning animations on or off; and letting the player decide if the camera should auto center or not. It also features a new gameplay mode called sweep, which can also be implemented in a 2D minesweeper version. In this mode when the left click is used (button which is normally used to mark a box as having a flag) the box is deleted if it contains a mine, but if it doesn't the player loses. The game doesn't add a context to the game (with characters and an environment) like Jetpack Joyride does, but offers a new experience out of an existing concept and adds a new game mode.

Different approaches can be seen in 3D minesweeper games, in Mine3D the mines were inside the 3D boxes like a sphere inside a cube, but another web based game takes a different approach. Minesweeper 3D: Universe[2] places the mines on the sides of the cubes conforming the levels, it means that a given cube could have 6 mines. This game places the levels in an "outer space" context by changing the background where the game is played. Each level features a shape formed by cubes, "pyramid" and "sun" are some of the level names, featuring a pyramid formed by cubes and a sphere formed by cubes.

Picross 3D is a Nintendo DS game where the player has to solve puzzles in order to reveal a hidden object within the puzzle [7]. What is relevant about the game is that the puzzle that has to be solved is a 3D minesweeper in the mode presented by Minesweeper 3D: Universe. The game also combines Sudoku, crossword and paint-by-numbers elements combined together. When the player solves a puzzle, an object formed by cubes is revealed. Objects featured in the game include animals, machines and some other shapes. In this game a combination of different gameplay styles can be seen together within a context, which is the discovery of the shape revealed at the end of each level. The object revealed acts as a reward for completing the level, adding a new element that normal minesweeper games do not have. Common minesweeper games usually place mines in a random way, on the contrary the mine equivalent in this game has to be placed carefully to form the hidden object and to give the level a desired difficulty grade.

These examples show implementations of a 3D minesweeper, showing different adaptations of the core gameplay. Although these implementations offer a full 3D visual environment, they were made to be manipulated with a 2D input device. Sometimes, changing the camera perspective with a 2D input device can be a difficult task. The work presented here, tries to use a 3D input device to interact with the game.

IV. DESCRIPTION

The gameplay implemented in this work, resembles the gameplay seen in Mine3D, where the mines are put inside each box instead of using the sides of the cube.

In the 2D version of minesweeper a grid of covered boxes is displayed. The goal of the game is to uncover or expand all the boxes in the grid with the exception of the boxes that contain mines. When the player expands a box containing a mine, the game is over and the player loses. The mechanism used to indicate the player where the mines are is the number of adjacent boxes that contain mines. That is to say, when a box that doesn't contain a mine is expanded, a number inside the box is displayed. This number indicates how many adjacent boxes to that box contain a mine. The maximum number that could be shown is 8. If no adjacent box contains a mine, all the adjacent boxes are expanded recursively, implying that if any of the adjacent boxes that were expanded has no adjacent boxes containing mines, then the adjacent boxes would be expanded and so on. Each box can be marked by the player to indicate that a mine is in a specific box.

The 3D minesweeper concept, takes this mechanic to the 3D world. Instead of a 2D grid, a cube subdivided into smaller cubes (the boxes) is displayed. Mines are put inside of each cube and the maximum number of adjacent boxes with mines that could be shown is 14. The gameplay rules are extracted directly from the 2D version, so all the actions are possible in this environment.

A. *Prototype*

The implemented prototype was done using Blender as a modeling tool and game engine. The Impulse motion capture system from PhaseSpace was used to capture user input. A glove with markers used by the motion capture system is used to track the hand movement of the user. VRPN is used to communicate the motion capture system with the game.

A virtual hand is shown to the player in order to represent the hand movements done by the player. The virtual hand tries to recreate all the movements that player's hand does in real life, including finger movements. This information is captured by the PhaseSpace system and mapped into the virtual hand.

[1] http://egraether.com/mine3d/
[2] http://www.minijuegos.com/Minesweeper-3D/11131

The hand on the screen is used as a cursor for the player to interact with the mines. Whenever the hand is inside a given box, a visual feedback is shown to indicate the player which mine will be manipulated. Actions performed on a given mine could be expanding the box, or marking the box as having a mine.

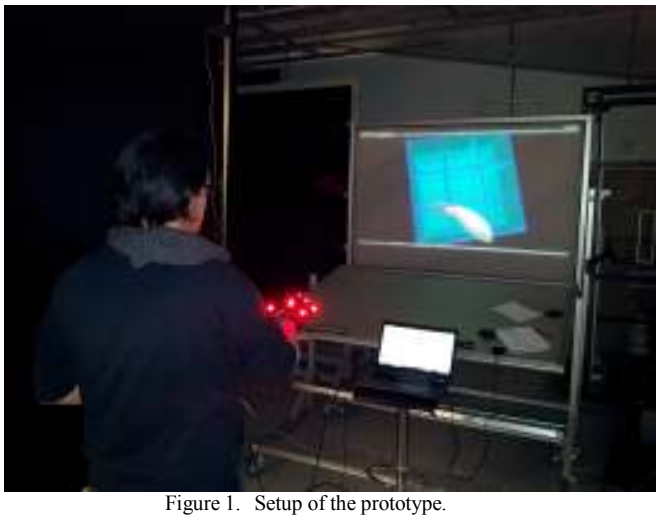

Figure 1. Setup of the prototype.

Hand gestures are used to interact with the game. Three gestures were designed to perform the required actions in the game. The first gesture is used to rotate the cube of boxes that conforms the level. When the player joins the index finger with the thumb while keeping the other fingers straight, the gesture is recognized and the virtual hand turns green in order to indicate the player that rotating mode is turned on and a hand movement will result in a rotation of the cube.

The gesture used to expand a box is done by closing the player's hand in order to form a fist. When this gesture is done, the current highlighted box will be expanded.

The third gesture is used to mark a box as having a mine inside. It is accomplished by closing the player's hand as in the previous gesture but keeping the index finger straight.

With these three gestures the set of actions that can be performed is complete. Each box in the level is presented with a transparency level to enable the player to see boxes that are being occluded by other boxes. This is done because the interface being used is a 3D input device, and as such the user can reach all the boxes with his hand. Using a 2D input device, the user can only interact with the boxes that are directly in from of him.

A context, power-ups and power-downs, are desirable features for the game, but were not added due to a lack of time.

V. EVALUATION

A user study was conducted in order to evaluate the work done. A total of 6 subjects, all students, completed the user study that was conducted. The test scenario was a 3x3x3 cube which contained e mines in total. The number of mines was told to the user. Due to lack of implementation quality, the use of two gestures was avoided, and a button proxy was used, these were the expand box gesture and the box marking gesture. Although the existence of these gestures would have been desirable, there were not that important because they didn't do any task that needed 3D information. The test had 6 steps which are described as follows:

1) Previous questions: To get an idea of the people's knowledge and familiarity with minesweeper games, two simple questions were asked. They were answered textually.

2) Game rules explanation: Despite the popularity that 2D minsweper games can have, a 3D minesweeper is not very common, so the game rules were explained to users in order to avoid confusions. The explanation was verbal.

3) Control scheme explanation: An explanation of how to rotate the cube, how to mark and how to expand a box was given to the users. The explanation was also verbal.

4) Rotate gesture familiarization: As the rotate gesture was not easy to acomplish, a 1 minute gameplay session was done in order to get the user used to the rotating gesture. During this time, the player only rotated the cube.

5) Gameplay sessions: After the familiarization process, the user played the game for 5 minutes. A total of 3 attempts were done by each player.

6) Final questions: After the gameplay experience, the player was asked to complete a cuestionary was question about the experience thay had.

Time and final result of the game was captured for each attempt.

A. Results

There were 4 possible outcomes out of each gameplay attempt. The player could lose, could win, time could run out or the virtual hand got lost out of sight or in a very awkward position. The latter could happen because the PhaseSpace system doesn't track the position of all markers all the time, sometimes the position is lost for a certain amount of time and the game isn't that robust to handle all the problems that this fact can arise.

Out of the 18 gameplay attempts that were made with the 6 subjects, 8 lost the game, 6 lost track of the hand, 3 ran out of time and only 1 won the game. These results show us that a lot of work needs to be done in order to make the hand movement as seamless as possible.

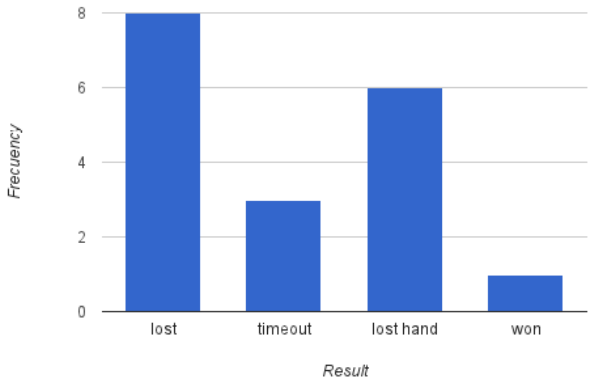

Figure 2. Game results of the user tests.

The average time for the first attempt was 1:59, for the second attempt was 2:16 and for the third attempt was 2:18. An initial observation about this result is that the players tend to be more careful when they have played the game at least once and don't rush to expand boxes. Anyway this is a preliminary result that cannot be treated as a fact and a deeper study would be needed to verify this statement.

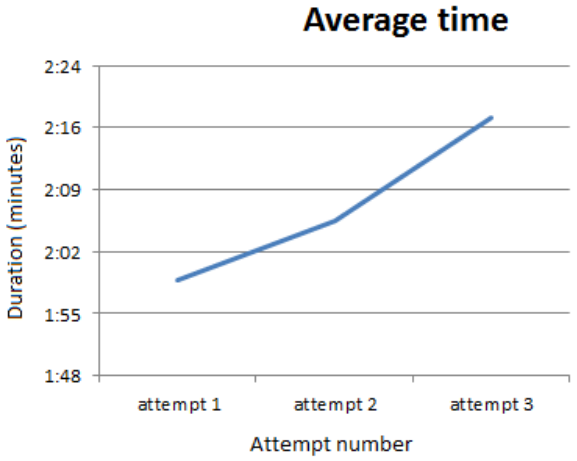

Figure 3. Average time between gameplay attempts.

Results regarding some qualitative questions asked to the participants are shown next. Each question had to be responded with a number with 7 as totally agree and 1 as totally disagree. Only the most relevant questions are shown. The questions are: the game is fun? (#1), controls are easy to use? (#2), the way of rotating the mines is adequate? (#3), all the boxes are easy to reach with the glove? (#4), the game camera is adequate? (#5), the box information (number inside each box) is visible for all boxes? (#6), the color of the boxes id adequate according to the state they represent? (#7). Answers to the questions are shown in figure 4.

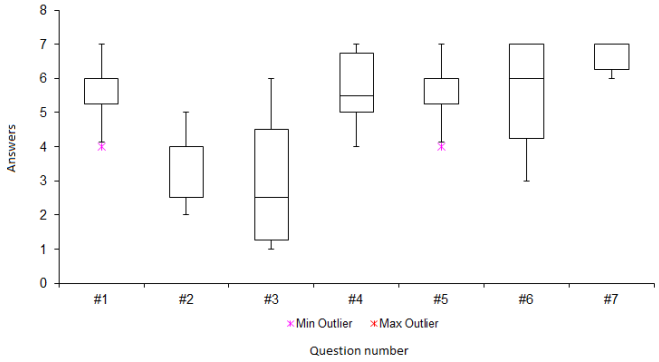

Figure 4. Boxplot of the answers given by the users.

The first question suggests that the users liked the game in general terms but it wasn't a superb experience. Questions #2 and #3 make clear that great improvements should be made in the hand movement as the general opinion was that the controls don't offer the expected experience. Questions #4 thru #7 show that small but important details such as the colors representing the state of each box are adequate but still there is room for improvement in these areas, like the visibility of the information associated with each box.

VI. Conclusion and Future Work

Successful games such as Jetpack Joyride demonstrate us that simple generic gameplay mechanics can be converted into commercially successful games by adding a number of elements. The game presented here makes an attempt in this direction by implementing new control mechanics that change the way of interacting with an existing gameplay.

Results show that a good potential exists in the game developed, as people found the game quite entertaining but wasn't totally amazed by the game. Taking into account that the implementation wasn't totally satisfactory due to a number of technical reasons, people still enjoyed the game. This means that an improvement over the current implementation would boost greatly the entertaining quality of the game and would be an example of a game that takes simple or generic mechanics, and transforms it into a different entertaining experience.

To make it a truly entertaining experience, integration of solutions like the one presented in [8] would make a big difference to the actual gameplay, and the fact that is using Microsoft Kinect makes it a better choice as it doesn't require markers or gloves to be used by the player. Finally game context should be added to seek a better connection with the audience.

References

[1] Sony Computer Entertainment Inc. "PLAYSTATION®2 SALES REACH 150 MILLION UNITS WORLDWIDE". Internet: http://www.scei.co.jp/corporate/release/110214_e.html, Feb. 14, 2011 [May 16, 2012].

[2] Mariko Sanchanta. "Nintendo's Wii takes console lead". Internet: http://www.ft.com/intl/cms/s/51df0c84-6154-11dc-bf25-0000779fd2ac,Authorised=false.html?_i_location=http%3A%2F%2Fwww.ft.com%2Fcms%2Fs%2F0%2F51df0c84-6154-11dc-bf25-0000779fd2ac.html&_i_referer=http%3A%2F%2Fen.wikipedia.org%2Fwiki%2FWii#axzz1v2w5WM4Z, Sept. 12, 2007 [May 16, 2012].

[3] "PowerGlove". Internet: http://www.ageinc.com/tech/index.html, [May 16, 2012].

[4] Mr. Marbles. "Wii Sports". Internet: http://web.archive.org/web/20080917044537/http://www.gamepro.com/article/reviews/86628/wii-sports/, Nov. 16, 2006 [May 16, 2012].

[5] Halfbrick. "Jetpack Joyride". Internet: http://www.halfbrick.com/our-games/jetpack-joyride/, [May 16, 2012].

[6] Matt Sakuraoka-Gilman. "Halfbrick's Jetpack Joyride ascends to 13 million downloads since going free-to-play". Internet: http://www.pocketgamer.biz/r/PG.Biz/Jetpack+Joyride+(previously+Machine+Gun+Jetpack)/news.asp?c=37689, Feb. 9, 2012 [May 16, 2012].

[7] Nathan Meunier. "Picross 3D Review". Internet: http://www.gamespot.com/picross-3d/reviews/picross-3d-review-6261327/, May 5, 2010 [May 16, 2012].

[8] Antonis Argyros. "Efficient model-based 3D tracking of hand articulations using Kinect". Internet: http://www.ics.forth.gr/~argyros/research/kinecthandtracking.htm, Mar. 3, 2012 [May 16, 2012].