Design Algorithms in Games for the Visually Impaired

Introduction

Most modern games are built using game design techniques that involve skill, risk and strategy to improve user engagement [1]. Games that are meant to be educational, follow additional paradigms that fulfil the learning aspect of the game [2]. However, most games are inaccessible to those with a learning disability; to build accessible games, the developer needs to factor in constraints such as limited working memory as well as strengths such as improved hearing capabilities in the case of visually impaired groups [3], [4]. This paper reviews game design algorithms followed in educational games for the visually impaired, and software and hardware considerations for building them.

Commercial applications

Currently, accessible games in the market run on a variety of platforms such as PCs, mobile phones, gaming consoles as well as custom hardware. The price of the game ranges from free to over $2500 depending on the platform and the extent of interactions provided [5].

Many accessible PC games are free or available for less than $30. Developers such as 7-128 develop word games and puzzles for the PC, that improve the vocabulary, memory, and critical thinking of visually impaired children [6]. They employ a variety of game design paradigms such as storytelling, level ups, and strategy building to keep the player engaged. Incus games and GMA are other companies that build accessible PC video games, relying on avatars and first person narratives as well as some level of random improvisation in the game so that the game is replayable [7]. Some games make existing consoles accessible such as those created by VI Fit which can run on the Wii console with an additional $20 controller [8]. The games provided by VI Fit are free and encourage participants to improve their fitness and physical education through sports which rely on skill-building and teamwork. Games running on custom hardware are generally more expensive, one game called Blind Hero, which is an accessible version of Guitar Hero, costs $2500 and has a hardware setup different from that of Guitar Hero. The game relies on foreshadowing, increasing difficulty and a points based system to engage the player [8].

Underlying technologies

The game design techniques discussed in this paper can be summarized into the following - storytelling, skill building, and strategy. The algorithms that can be used to implement each of these have been described below:

Storytelling

Most storytelling aspects of games involve allowing the player to navigate a virtual space as themselves or in the form of an avatar. One algorithm that is very popular in navigation is the A* algorithm that helps map the path that a player can take in a game to reach the goal [9]. Other algorithms that are often used include breadth-first search and Djikstra's to determine the path that a character in the game should take [].

Skill-building and reward

To be able to account for the experience gained by the player, the difficulty in the game needs to increase to keep the user engaged. The improved skill can come with rewards in the form of points or level ups that motivate the player to keep going. The experience gain is often modeled as a logarithmic curve which means that the gain slows down with time and it becomes harder to gain experience [10]. A common algorithm for improving the player's skill while playing is by changing difficulty of the game through a process known as dynamic difficulty adjustment, where the difficulty increases if the player is consistently doing well so that player is sufficiently challenged [11].

Strategy and Improvisation

Games can quickly get boring if the player is asked to perform the same task repeatedly. Additionally, once the game is over, repeating the game would mean that the player has to go through the exact same process. To build games that are replayable, randomization algorithms are often used to improvise during the course of the game. One of the common algorithms employed is the Monte Carlo Approach that is used in sequential games to generate a set of random moves that can be made [12]. The minimax algorithm is also often used in such games to determine the best strategy to use to defeat the player and can be adjusted to find moves that match the difficulty level of the game [13].

Building blocks

While the complexity of the algorithms to be developed is a major software challenge in itself, it also brings additional hardware challenges. Due to the complexity, the hardware supporting the game needs to have sufficient processing power to do improvisation and strategy implementation at each level of the game. There also needs to be sufficient memory to save the game state including associated values for each algorithm. Additionally, since these algorithms require high processing power, the energy consumption will also be high.

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