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Virtual Rival: Driving to Win, Motivation, Effort and Performance

Master's Thesis

to achieve the university degree of

Master of Science

Master's degree programme: Computer Science

submitted to

Graz University of Technology

Supervisor

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Institute for Softwaretechnology
Head: Univ.-Prof. Dipl-Ing. Dr.techn. Some One

Graz, November 2013

This document is set in Palatino, compiled with pdfLaTeX2e and Biber.

The LaTeX template from Karl Voit is based on KOMA script and can be found online: https://github.com/novoid/LaTeX-KOMA-template

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Abstract

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1 Introduction

1.1 Introduce the general topic

Racing is about mastering the race track, perfect car control, high-speed decision making and risk taking. Race drivers are constantly working to improve their physical and mental strength. The challenge for video game developers is to transfer the emotional and physical roller coaster of piloting a vehicle over the racetrack and competing against the best drivers of the world into the living room. Because testing is limited, the simulator work is crucial for the team's success and winning titles. Driver simulators are elaborated tools, vital to the development of the car as well as the drivers. Motorsport teams and car manufactures are constantly pushing their boundaries which leave a lot of room for innovations in the simulation and video game market. In that respect, race games made a big leap forward in terms of realism, but there is a massive amount of work still needed to deliver the entire racing experience. Compared to other genres, racing games are different. Most of the players drive or at least have a basic understanding how driving works. The challenge is to transfer the driving experience into the game. With virtual rivals we have the possibility to teach and guide while entertain and challenge. You learn the basic principles and car control in the first laps and then improve your driving skills in every lap after that.

1.2 Motivate the research and explain why people should care

The tools we use to perform better in racing games may be implemented in future cars. Car Manufactures already develop virtual assists, like racing lines with braking guidance and ghost cars.

The barriers between driving simulation and motorsports are blurring. There are a lot of different simulation games currently on the market e.g. Forza, Project Cars and Gran Turismo. Gran Turismo Sport offers a FIA race license.

E-sport is a huge business factor. Prize money and Viewership is comparable to traditional sport. Collages offer well-funded programs. True gaming skills are becoming very valuable.

With F1 E-sports and the GT Academy the dream of starting real-life professional racing career can start on the PlayStation.

Boost competitive motivation using rivals will also boost the effectiveness of other games like exercise games.

Driver safety and fuel efficiency go hand in hand. Efficient safe driving can reduce your fuel consumption and carbon dioxide emissions by 25 percent.

1.3 What is your research question?

- Are virtual rivals positive effecting driver skills development?
- What is the effect of virtual rivals on risk taking, motivation and performance?

1.4 Study Design

1.5 Result of the study

quantitative?

2 Related Work

A core task in game design is creating a positive player experience. Games and simulations are very complex applications. The developers have to model extensive functionality, while maintaining usability and optimizing player experience. Despite the complexity, the users should be able to learn the game as they play it. Learning curves come in different shapes, but must match the skills of the target audience in order to avoid frustration (Nacke, 2011). There are already design principles to make games faster and efficient. R. J. Pagulayan et al. (2003) introduced design methodologies to make them more enjoyable. There are three major factors in game developing, testing and evaluation. Game genres provide very different experiences, but there are some common fundamental design features. A central factor for basically all software applications is the ease of use. This includes controls and interface for video games. Challenge is a critical factor to the enjoyment of a game. It must be adapted to every individual player for the best results. Pacing is another important metric. It is the rate in which players go through new challenges. Designers at Microsoft have their own version of the documentary "Powers of Ten" (C. Eames and R. Eames, 1977). The game must keep the user's attention at 10 seconds, 10 minutes, 10 hours and 100 hours. The first hour is of special importance (P. Davis, Steury, and R. Pagulayan, 2005). It is the entry point into the main experience of the game and vital time in the learning process. Cheung, Zimmermann, and Nagappan (2014) found that momentary enjoyment is less valuable than intriguing and engagement. It is important that designers transmit their vision and the central purpose of the game. Entertainment is secondary.

To provide the best player experience, it's important to understand the preferences of the players. To reach a brought audience it's beneficial to allow a vast number of different playstyles. One of the best practical implementations of this principle is the action role-playing game "Deus Ex"[1]. It offered unprecedented freedom of action at that time and was an important milestone for video games. Other games like the "The Elder Scrolls"[2] series persuade the players with big open worlds and stimulate the creativity with diversified narratives. Canossa and Drachen (2009) found the game mechanics and the main character already defines the audience and expected behaviours. To understand the player base in "Forca Motorsports 5", Harpstead et al. (2015) analysed log data to create engagement profiles. This method visualises the player behaviour on a high abstraction level. It also is used to analyse the effectiveness of reward systems. The next step is to translate the user needs to the game. Researches in Human-Computer Interaction (HCI) have created guidelines to develop applications for specific user groups. In the book "The Inmates are Running the Asylum", Cooper (1999) introduces the Goal-Directed Design (GDD). In GDD developers define personas based on the target group. The personas have to be defined very specific and detailed. The whole development process is based around these fictional users. This strategy is very simple and incredible powerful. The alternative is Task-Centred System Design (TCSD). In TCSD the developers think of tasks which are presented and tested with real users(Lewis and Rieman, 1993). Both methodologies present efficient strategies to ensure user requirements are fulfilled.

[1] Ion-Storm-Austin, 2000.
[2] Bethesda-Game-Studios and Zenimax-Online-Studios, 1994-2016.

Game developers are looking at the psychological side of enjoyment and happiness, to extract features that generate entertainment for the player. Csikszentmihalyi (1991) describes the most important features of motivating activities. The feeling of pleasure is essentially a feeling of contentment when a personal or social expectation has been met. Enjoyment goes beyond the feeling of pleasure. It is characterised by achieving something unexpected and special. In games we want to create enjoyment, the deep involvement that removes the frustrations of everyday life and make hours pass like minutes. Csikszentmihalyi (1991) defines the major building blocks for enjoyment. Some important components are:

- clear goals
- reasonable chance of completion
- immediate feedback
- control over the actions

Malone (1980) analysed the theoretical principles of challenging environment. For an environment to be challenging it needs uncertain goal attainment. There are at least four ways to create uncertain goals in video games: variable difficulty level, multiple level goals, hidden information and randomness. G. Yannakakis and Hallam (2005) follow the principles to make predator/prey games more interesting. The criteria for the best predator/prey opponents are:

- balanced (neither too hard nor too easy)
- diverse behaviour (strategy is not predictable)
- aggressive behaviour (rather than static)

To balance skill level and progression, game developers often provide an option for the players to specify the level of difficulty. Most racing games provide several customizable assist like trajectory lines, braking assist, traction control or automatic gear. Debeauvais et al. (2014) found that players don't always know what level of difficulty will work. The players are often not confident enough to disable an assist or turn them on again after a bad experience. Race games should have models to predicting when a player is ready to disable an assist and encourage him to do so. Furthermore, some games provide several levels of AI difficulty, but don't progressively recommend increase the degree of difficulty. Hullett et al. (2012) analysed games modes, vehicles and race tracks in Project Gotham Racing 4. They found that players use only a small amount of race tracks and vehicles. This means reducing the number of options can improve the game experience for the players and decrease development cost. Also, developers have to encourage players to switch vehicles.

For level design it's important to match skill to difficulty. Recently, Procedural Content Generation attracted the attention of researchers. For platform games Mourato, Santos, and Birra (2011) introduced framework for automatic level creation with personalised content. Furthermore, Jennings-Teats, G. Smith, and Wardrip-Fruin (2010) utilized machine learning to automatically construct platform levels with continually-appropriate difficulty and understand player skill. To make race tracks more interesting, Togelius, Nardi, and Lucas (2007) developed an evolutionary algorithm to procedurally generate race tracks. The generation strategy is based on player driving styles to maximum entertainment value. Their previous paper (Togelius, Nardi, and Lucas, 2006) dealt with player modelling approaches and provided a definition of fun race tracks. The main factors to make race tracks fun are speed, versatile composition and the right amount of challenge for the player.

Not only the level design, also the enemies should challenge the player. Artificial Intelligence research found multiple ways to model intelligent agents. They are used to cover complex problems in computer science e.g. autonomous cars, speech recognition. An often used method to creating human like opponents in games is evolutionary learning. Evolutionary learning approaches can be applied to all kinds of games. A lot of research on learning in games has been done on board and card games. Fogel (1993) created a simple AI able to play tic-tac-toe. Richards, Moriarty, and Miikkulainen (1998) showed that Neuronal Networks can be used to model an opponent for GO. It's one of the most complex board games and very difficult to master, even for computers. With the increased computational power in recent years, the generated opponents are capable of beating even expert humans in a multitude of games. Today's best Computer GO program AlphaGo[3] uses a Monte Carlo algorithm based on learned knowledge. It was the first algorithm to consistently beating the world No.1 ranked player

[3]DeepMind-Technologies, 2017.

at the time. Modern computer game AI research focuses mainly on real time strategy (RTS) and first-person shooter (FPS) games due to their popularity. Khoo and Zubek (2002) developed simple and computationally inexpensive AI mechanism to produce engaging character behaviour. Cole, Louis, and Miles (2004) used a generic algorithm to balance parameters for bots. Ponsen and Spronck (2004) is using RTS games to propose adaptive game AI with dynamical scripting. Towards the development of more human-like computer game bots, Thurau, Bauckhage, and Sagerer (2004) learned strategies by observing human players. The investigated movement patterns resulted in a wide range of situation dependent human-like strategic movements. Despite all these complex algorithms, there is little research done how these behaviours contribute to the player experience(G. N. Yannakakis and Hallam, 2007). There is no evidence that by generating human-like opponents we can create more satisfaction. It exists research in general board games. For chess Iida, Takeshita, and Yoshimura (2003) defined a metric of entertainment. The metric is based on average game length and the number of possible moves per turn.

To improve and measure the performance of a player we have to understand emotions first. Emotions have an important role in the determination of behaviour (Ravaja et al., 2006). Most theories agree on three major aspects of emotion: subjective experience, expressive behaviour and the physiological component (Scherer, 1993). The subjective experience is the "feeling" part of the emotion. Expressive behaviour covers the body signals which are related to the experienced emotion. The physiological component is the response of the body to an emotion e.g. releasing hormones. Effective methods to measure emotional arousal are heart rate monitors and electrodermal activity sensors. Scherer (2005) introduced the Geneva Emotion Wheel (GEW) to measure emotions. It's a simple method realised with paper and pencil or a computer program. The GEW is an instrument that evaluates emotion qualities and intensity of the feeling. C. A. Smith and Ellsworth (1985) measured the properties of emotions. I state only the relevant emotions for gamers. Happiness and pride are extremely pleasant states. Persons are filled with pride when receiving personal achievements, awards or winning in general. In disparity personal achievements are not associated with happiness. Most persons relate happiness with spending time with friends or relatives. Other positive emotions are interest, challenge and surprise. Interest is supported by desire and little control over the situation. Challenge is similar to interest but with total control over the situation. The most challenging experience is when the desired goal takes a lot effort, but is still reachable. Surprises on the other hand are unexpected situations gotten with little effort. Negative emotions in games are very unpleasant. The experience of boredom comes with low effort and low attention. It appears when the mind is not challenged. Anger and frustration are very unpleasant emotions where persons expect a lot of effort. Anger comes in unfair situations. When success is expected, failure is often accompanied with frustration. The most impactful variables are challenge and certainty in both positive and negative experiences. When designing a game we have to control the challenge and the certainty of the situation to control the emotion of the player.

A widespread social phenomenon is rivalry. It is closely connected to competition. Rivalry is a broader culture pattern going beyond our hunting instinct, aggression and the need to excel in sports (Sipes, 1973). In traditional sports, excellence is the quality of being outstanding in relation to others. Many people believe that doing well means doing better than others (Stanne, D. W. Johnson, and R. T. Johnson, 1999). It's the essence, which drives elite persons in sport, science and economy. Proponents argue that competition brings out the best in a person. According to one of the all-time greatest coaches Vince Lombardi, "Winning is not everything, but wanting to win is". The downside is that people with no chance of winning can experience a lack of motivation. A rivalry is the combination of a relationship and history between competitors. Kilduff (2014) showed that rivalry motivates and boosts the performance independent of the stakes. He also defined three important factors which can cause rivalry. First, similar competitors increase social comparison. People are naturally driven towards self-evaluation and the comparison with other persons (Festinger, 1954). Second, the level of competitiveness can increase when facing the same opponent multiple times. Finally, evenly matched games, when narrowly decided, result in greater emotional responses. Kilduff (2014) evaluated that rivalry can improve motivation and performance. The results indicate that the odds of victory are more important than previous results. In some situations the motivation can transform to a desire to win. In this state the person maximizes relative pay-outs at all costs. Bazerman et al. (1992) evaluated that people display more apprehension for personal profit than overall profit. The desire to win has a high impact on the decision making process. It diminishes concerns and increases the aggregation with the focus on beating the opponent (Malhotra, 2010). The desire to win is a powerful motivation boost. The effect is hard to measure. Good indicators are the presence of rivalry and time pressure. Both are presents in real-life racing competitions and racing games.

Race games are different to other games. People drive in their day-to-day life. Driving is a safety critical task. According to the U.S. Census Bureau (McKenzie, 2015), 86 percent of all workers commuted to work by private vehicle. Given the amount of time spend with driving, it's important to consider all the risks. Traffic injuries have become a major health problem. To protect all road users we need to design safer vehicles, roads and infrastructure (WHO, n.d.). Great efforts have already been made to improve vehicles and safety equipment. Crash analysis data shows a reduction of traffic accidents in recent years (Statistics-Austria, 2016). Driving assistance systems focus on the major causes of crashes. Unintentional lane departure is responsible for about 40% of crashes in Europe. Navarro, Mars, and Young (2011) showed that Lateral Control Assistance reduces the number of loss of control accidents by 25%. Advanced driver assistance systems (ADAS) reduce the risks and improve the driving experience. They are a vital part of modern cars, motorcycles and trucks. German-Insurers-Accident-Research (2016) found that the theoretical safety potential ranges from 2% for simple blind spot detection systems up to 45% for Emergency Break Assistance Systems. ADAS is a fast growing sector. In order to realise an intelligent transportation system researchers focus on inter-vehicle communication and smart roads (Nadeem et al., 2004). Trending research questions are safe driving, dynamic route scheduling, emergency message dissemination and traffic condition monitoring. Despite all efforts in assistance systems, statistics indicate two high risk groups in young, inexperienced drivers and elderly drivers above 65 years. Young driver have little experience in complicated situations. Clarke, Ward, and Truman (2005) found that young driver have a tendency to take higher risks. Driving is a fun and exciting way of testing limits. It is important that young drivers are confronted with high risk situations in a safe way. Tada et al. (2014) investigated elderly driver behaviour. They demonstrated a lack in scanning behaviour to identify possible threads. Safe driving skill can be identified by the drivers head motion and pedal operation. It's important to provide personal training programs based on the shortcomings of a driver. Fischer et al. (2007) showed that playing violence encouraging race games increases risk-taking behaviour in critical road traffic situations. Playing and watching reckless driver causes risk-related symptoms including blood pressure, risk-related cognitions and emotions (Fischer et al., 2007). The study found that nonviolent race games (e.g. F1, Gran Turismo, Project Cars) arouse greater self-perception and a more positive driver attitude.

Rating systems are vital in different application domains. The most common application is to calculate the competitive strength of sport teams. The provided ratings can be used to make power rankings and predict the outcome of future matches. The Elo system is a rating system original proposed to rate chess players. Nowadays, variations of the algorithm are used in sports, economy, and science. The Elo system gives every player a rating which represents the strength. The outcome of a match can be predicted by comparing the player ratings. Hvattum and Arntzen (2010) showed that the Elo-System is a reasonable method to predict match result in football. It's a useful tool to encode information of past results. Lehmann and Wohlrabe (2017) measured the quality of scientific paper based on the Elo rating system. The impact of a paper is encoded in his Elo number. The Elo ranking is very easy to compute and a promising alternative to existing paper ranking approaches. A competition on the website kaggle.com, 2015 was arranged to find an approach that predicts the outcomes of chess games more accurately than the Elo rating system. Most teams used machine learning to improve the rating system (Pennington, 2010). The drawback of this method is that it needs large datasets to give optimal predictions. Timmaraju, Palnitkar, and Khanna (2013) used pseudo-likelihood statistics to predict the outcome of English Premier League matches. They took the number of goals for each team in a match to train a machine learning algorithm. The model predicted the matches with up to 66% accuracy. It outperformed experts and the betting market.

Appendix

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