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A SYSTEM FRAMEWORK DESIGN FOR VIRTUAL REALITY GAME USING GAMEPLAY BIG DATA TECHNOLOGY

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Abstract

Game big data analysis has gained a large amount of attention in game business and game research in recent years. The adoption of data-driven business intelligence at game operation combines with the integration of quantitative measures in user- oriented game research. The objective of this research is to develop a novel system framework using Unity3D game engine and virtual reality game case for game big data analytics based on player behaviors. Within our VR game design model, we collected the level design data and game map information during user game play data. We proposed the design game variables, extract game features and also develop game play behaviors models. The research results could be useful for VR/AR game level design and game balance decision in the game business and industry.

Keywords: Virtual Reality Game Design, Big Data Technology, Gameplay Analysis, Game Business Management

Introduction

Game big data analytics has gained a large amount of attention in game business and game research in recent years. The adoption of data-driven business intelligence at game operation and business strategic in the game industry, combined with the integration of quantitative measures in user-oriented game

research. The objective of this research is to develop a novel framework using of Unity3D game engine and big data technology for game data analytics based on user behaviors. This huge need has been emphasized with rapid emergence of social network online games and Free-to-Play APP game in Internet-based game business. It is necessary for game designers to get an understanding of users and experiences they obtain from interacting with games.

Anton (2018) reported on a study that examined tele-collaboration scenario with three different modalities: 2D video-conferencing, 3D stereoscopic interface, and 3D stereoscopic interface with augmented visual feedback. Matsas (2017) investigated users' enhanced experience and behavior inside the virtual world while cooperating with the robot and positive pertinent.

In player-oriented game analytics, there are major related researches in game design, including game level design, player preferences research, gameplay data analysis, player behavior cluster, and monetization strategy. The goal of game analytics is to support decision making, at design and strategic level and within all levels of an organization – design, art, programming, marketing, player data research in C. Jennett (2008) research. Ruiz-Ariza (2018) concluded that Pokémon GO AR game increases, in a playful way, the amount of daily exercise in adolescents, could positively affect their cognitive performance, and improve the social relationships.

In recent years, many game design studios – from indie to AAA class studio – have started to collect game telemetry in B. Weber (2009) research. Telemetry is data obtained over Internet. This data could be quantitative data about how user plays a game, tracked from game client and transmitted to a game server. A common source of game metrics is telemetry data of player behavior. This raw data can be transformed into metrics, such as "total playtime" or "daily active users" in Hullett (2012) research. Si. Chen (2017) investigated the gameplay behaviors of 25 players across three types of exploration games by collecting in-game data, think-aloud data, questionnaire responses and post-game interview data. They used thematic analysis to analyze the data and map out four player exploration archetypes.

Mellon (2009) categorized game metrics into three types, based on an expansion and definition of which the following categories of game metrics, as shown in Figure1.

User metrics.

These are metrics related to game players, from dual perspective of them being either player, who act in a particular way when interacting with games. The first perspective is used when calculating metrics related to revenue, average revenue per user (ARPU), daily active users (DAU) or when performing analyses related to revenue. The second perspective is used for investigating how people interact with the actual game system and the components of it and with other players, i.e. focusing on in-game behavior.

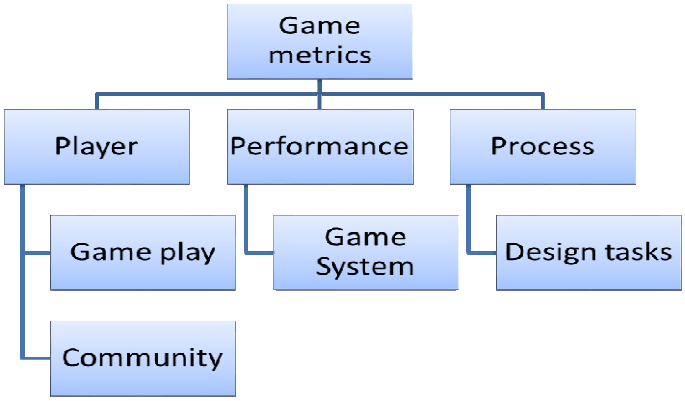

Figure 1. Hierarchical diagram of game metrics (Mellon 2009)

Performance metrics.

These are metrics related to performance of technical and software-based infrastructure behind a game, notably relevant for online games. Common performance metrics include frame rate at which a game executes on a client hardware platform, or in case of a game server. Performance metrics are also used when monitoring changing features or impact of patches and updates on how well the client executes. A simple performance metrics known since game was programmed is the number of bugs found – per hour and day. Performance metrics are mainly used in QA to monitor the health of a game. It is also one of the most mature areas of game analytics.

Process metrics.

These are metrics related to actual process of developing games. Game development is to a smaller or greater degree a creative process, similar to other creative areas in multimedia design. For example, by combining design task size estimation with burn down charts, or measuring the average turnaround time of new game content being delivered, type and effect of blocks to game development pipeline.

Background and Related Researches

In game play metrics, four types of game play information can be logged whenever a player does something – or is exposed to something in a game:

(1) What is happening?
(2) Where is it happening?
(3) At what time is it happening?
(4) When multiple objects or players interact?

Gameplay metrics are particularly useful to game user research for informing game design. These game data provide opportunity to address key questions, whether any game map areas are over- or underused, if players utilize game features as intended, or whether there are any barriers hindering player progression. This kind of game metrics can be recorded during all phases of game development of Si. Chen (2017), Matsas (2017), Drachen (2011), Lameman (2010), Isbister and Schaffer (2008).

The major goal of game design is to create games that provide a good user experience. However, the fundamental

need of running a game development company is to make money. Recently, in F2P (Free-to-play) game where there is no investment from players. In this situation, the underlying drivers for game analytics are twofold: (1) ensuring user experience, in order to acquire and retain players; (2) ensuring that monetization cycle generates revenue in Fields and Cotton (2011).

The need of data mining player behavior in game industry has been driven by the rise of social online game and F2P game. With the evolution of Web 2.0 technologies, notably social networking platforms like Facebook, F2P App game also increased in popularity. While many Key Performance Indicators are common used, the level of sophistication in analytics software and processes vary across the game industry in Fields (2011).

Lewis and Wardrip-Fruin (2010) presented a case study of large-scale data collection and interpretation of World of Warcraft repositories for better understanding of player behavior. They analyzed how long it took players from each class to reach level 80 (the highest level) in order to empirically evaluate whether the game design is balanced, and confirm or refute common folklore surrounding the game. Weber and Mateas (2009) used data mining techniques on large amounts of collected data to understand player strategies in the game StarCraft. Over 5000 replays of expert matches were used as training data for a machine learning algorithm that predicted player strategies. This predictor became a component of an AI bot that played StarCraft better than most other available techniques, thus helping to improve game AI technology.

According the research background, an introduction of gameplay metric data, game data mining and its application in game development is given. A number of important research results with game telemetry datasets have been discussed. Virtual reality game telemetry presents some challenges that are uncommon or maybe even unique in large-scale player-oriented datasets:

1. The VR gameplay data can have a high dimensionality, with lots of features (or variables) being tracked for each player.

2. The data can be of substantial size, an average virtual reality or augmented reality game generating datasets on the terabyte scale.

3. It is necessary to compile datasets for analysis from disparate sources. From game telemetry and account systems, with associated challenges in merging data and avoiding redundancies.

The system framework for virtual reality game design

1: Collect virtual reality game design data

1-1 Internal game data: Level design and game map information

One of the earliest sources of data for virtual reality game development studio is from their internal testing. This includes game testing by the developers and more testing by the QA test. In early game development, designers create small prototypes to test and explore new ideas. While these prototypes are generally modified when main development cycle begins, the lessons learned are an

important source of data about what works in the game.

Once the game is fully developed, team will continuously be testing the game. Of particular interest to designers is play balance. Level designers will play levels to ensure that they have correct difficulty level for where they appear in the game.

In this research, we design a virtual reality game prototype using Unity 3D game engine. Within this VR adventure game, we collect level design data and game map information, as both shown in Figure 2.

Figure 2. The virtual reality adventure game design case in this research

The main objective of the QA team is to find bugs and report them to development team. Statistics from reported bugs are used to make production decisions in much the same way as they are used in traditional software development. Many bugs are straightforward problems that programmers, designers, and artists can easily address, but QA team will often find problems with the playability of the game, including play balance issues. QA testers are often highly skilled game players, and continuously evaluate aspects of game for difficulty, play time, and balance.

1-2 Beta Tests game data

A beta test is a release of a nearly-complete version of a game to a limited set of players. In this research, Beta testers are carefully selected from I-Shou University students. With the increasing ubiquity of internet connected game platform, beta version can be downloaded directly to the tester's mobile phone and play data can be reported directly to the development team. Beta tests can also be contribute to the marketing of a game by giving players a preview of the game and building excitement about the release.

1-3 Long-term virtual reality player data

Long-term play data gathered from players after a game's release can be an important source of data. Due to the increasing ubiquity of virtual reality game, development teams can easily collect player data indefinitely after release. If

problems are found, teams can make changes and deliver a new version to players even after release online.

Examples of useful VR player data that can be obtained from long-term data are what achievements are earned, how quickly players progress, or favorite levels or VR game play modes.

Data from long-term VR play is particularly useful for maintaining play balance. A lack of balance may not have been appeared in earlier testing, but only becomes apparent after many months of play. An example would be an unanticipated dominant strategy. If, by observing VR play data, a team sees that a particular game item has become favored, then they may want to adjust the balance to counter this.

3-2 : Design of VR Game Variables, Game Features and User-behavior models

In our research project, the virtual reality game variables consist of potentially any change in the game systems resulted from a player interaction within the VR game. In the virtual reality adventure game, these include: navigating VR menus, starting a player session, choosing a VR character, VR game scene teleport, collecting game items, and navigating game levels. These variables are mainly derived from the possible changes in the VR game state that result from the interaction of players within the game.

Defining how to measure variables may produce VR game features if the data structure is conceptually distant from the raw code that the variables are based upon. For example, in our virtual reality game, analysts want to monitor the location of players, it is simple enough to sample the x, y coordinates of the avatar every 10th of a second, so the variable "location" becomes a metric in the form of a stream of x, y coordinates lasting as long as the play session lasts.

In our VR adventure game scenes, the data collection format is defined as Table 1.

Table 1. The virtual reality game data collection format

Location: Map1 Entrypoint: 13,40,32	Time: 120	Items: tool1	Log:1
Location: Map1 Entrypoint: 15,23,17	Time: 350	Items: tool2	Log:1
Location: Map2 Entrypoint: 21,50,04	Time: 420	Items: tool2	Log:2
Location: Map3 Entrypoint: 22,06,48	Time: 280	Items: tool3	Log:3

The VR game variables are measured and turned into metrics data, it would be necessary to extract game features. The VR game features are the concrete values entered in complex data mining operations and used as input for different algorithms. They can represent heuristic perspectives on the metrics gathered; they form points of view, interpretations, on the raw data. For example, we record the variable "initial menu selection" for the VR adventure game.

At this process we extract VR game features, like "player favorite selection" which in this case would be "solo play", or a feature like "most common sequence of selections" which in this case would be first "solo play" and then

"multiplayer", a feature like "least favorite VR selections" which in this dataset would return "deleted VR scene", "what's hot VR game scene" and "downloadable VR content".

After several VR game features are extracted, we start selecting these game features that are sufficient to define groups of players with similar behaviors. In our VR game, players with "player favorite VR selection" equal to category 1 and "most common sequence of selections" equal to category 1 and category 2 can be clustered together in the "competitive" player group.

Models can be extracted by classifying data and describing important classes or by predicting discrete and unordered labels. Models can be both descriptive interpretations under which a particular statement is true and also can be predictions of future data trends in continuous-valued functions.

In this process, we create a model to describe player behavior for the VR game variable "Initial VR Menu Selection". Realizing that Solo Play and Social Play are exclusive options helps considerably: Solo Play and Social Play are the two opposite polarities of a single dimension describing one aspect of player behavior relative to "initial menu selection". A second dimension is individuated by the feature 'Extra Info' that describes how much players tend to seek additional information and content. This second dimension is independent and perpendicular to the previous dimension as shown in Figure 3.

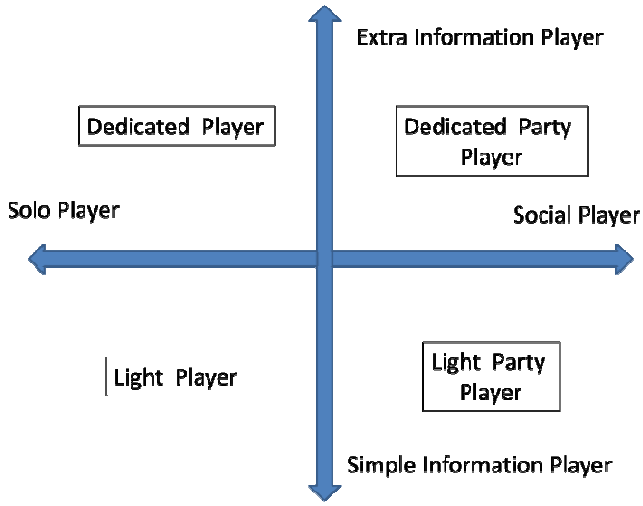

Figure 3. The proposed design model for VR game player behavior

This is one case example of a descriptive game user model created by classification. A predictive model could state that if certain conditions are met, players will tend to maintain a certain behavior. This proposed model was created through a manual process of extracting and selecting game features based on game designers' expert knowledge.

In this research, we capture the VR game player process in VR game, seen as a collection of systems, is analyzed to

abstract those VR variables that more likely will provide answers to questions about VR adventure game design. These variables are then measured and features extracted from these measures, finally generating high-level information. From this raw data, several VR features can be extracted, including "average health" during a whole play session or "minimum amount of health" reached in a specific location. Some of these features can be utilized to compare many players, and to look for similarities and differences and eventually create clusters or models of behavior.

In our VR adventure game prototype, we design several VR control methods to navigate the VR game environments. Each control method is identified as a variable. These variables are defined as Table 2:

Table 2. The definition of VR adventure gameplay variables

1. Walk
2. Teleport
3. Jump
4. Pickup

Our VR game offers a number of event variables for players to interact with VR game objects, characters and other players. The VR event variables are defined as Table 3:

Table 3. The definition of VR game event variables

6. Attack
7. Use
8. Open
9. Close
10. Speech
11. Save
12. Load

When defining the possible variables to create models of VR player behavior it is important to ascertain whether these models should try to capture the most common traits encountered. In this process, we consider practice of speed running: it consists of playing a

VR game, with intention of completing it as fast as possible. There are statistically few players completing games in such a way, but creating a model also encompassing this behavior can be extremely informative for VR game developers. And we answer questions such as "what is the fastest time a certain level can be completed in?", "what is the minimum set of actions necessary to finish the VR game?"

Conclusion

Game big data analytics has gained a large amount of attention in game business and game research in recent years. The objective of this research is to develop a framework system using of Unity3D game engine for virtual reality game data analytics based on user behaviors. This research could present our VR gameplay data study by explaining VR game analysis research domain for the adventure game. The research results would be summarized as below: (1)We developed the virtual reality gameplay data analysis framework for VR adventure game. (2) The research defines and develops VR game variables, VR game features and user-behavior models. (3) We provided virtual reality level design and game balance decisions using our gameplay analysis results.

Our research results could be applied generally to a wide variety of virtual reality games in different sections. The VR game developers who are inclined to add many options to their games should consider the result that players tended to focus mainly on the game's core features. Also we provide a gentle game player curve can help new players into a VR game and keep them playing.

References

Anton. David, Kurillo. Gregorij, Bajcsy. Ruzena (2018), User experience and interaction performance in 2D/3D telecollaboration, Future Generation Computer Systems, v 82, p 77-88.

B. Weber and M. Mateas (2009), A data mining approach to strategy prediction, IEEE Symposium on Computational Intelligence and Games.

C. Jennett, A. L. Cox, P. Cairns, S. Dhoparee, A. Epps, T. Tijs and A. Walton (2008) Measuring and defining the experience of immersion in games , International Journal of Human-Computer Studies , vol. 66 , pp.641 -661.

Drachen, A., & Canossa, A., (2011), Evaluating motion: Spatial user behavior in virtual environments, International Journal of Arts and Technology, 4 (3), 294–314.

Fields, T., & Cotton, B.(2011), Social game design: Monetization methods and mechanics, Burlington: Morgan Kauffman Publishers.

Gagné, A., Seif El-Nasr, M., & Shaw, C.(2012), Analysis of telemetry data from a real time strategy game: A case study. Computers in Entertainment (CIE) - Theoretical and

Practical Computer Applications in Entertainment, 10 (3).

Hullett, K.,Nagappan, N.,Schuh, E., Hopson, J.(2012), Empirical analysis of user data in game software development, Empirical Software Engineering and Measurement (ESEM), 2012 ACM-IEEE International Symposium.

Isbister, K., & Schaffer, N.(2008), Game usability: Advancing the player experience, Burlington: Morgan Kaufman Publishers.

Lameman, B. A., Seif El-Nasr, M., Drachen, A., Foster, W., Moura, D., & Aghabeigi, B.,User studies (2010)– A strategy towards a successful industry-academic relationship. In Proceedings of future play (pp. 1–9) . Vancouver: ACM Publishers.

Lewis, C. and Wardrip-Fruin, N (2010), Mining game statistics from web services: a World of Warcraft armory case study. In Proceedings of the Fifth International Conference on the Foundations of Digital Games.

Matsas. Elias, Vosniakos. George-Christopher (2017), Design of a virtual reality training system for human–robot collaboration in manufacturing tasks, International Journal on Interactive Design and Manufacturing, v 11, n 2, p 139-153.

Mellon, L.(2009), Applying metrics driven development to MMO costs and risks. Versant Corporation, Tech. Rep.

Ruiz-Ariza. Alberto, Casuso. Rafael Antonio, Suarez-Manzano. Sara (2018), Effect of augmented reality game Pokémon GO on cognitive performance and emotional intelligence in adolescent young, Computers and Education, v 116, p 49-63.

Si. Chen, Pisan. Yusuf, Tan. Chek Tien, Shen. Songjia (2017), An initial understanding of how game users explore virtual environments, Entertainment Computing, v 19, p 13-27.

Weber, B., Mateas, M (2009). A data mining approach to strategy prediction. In IEEE Symposium on Computational Intelligence and Games.