A Deeper Look at the use of Telemetry for Analysis of Player Behavior in RTS Games

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ABSTRACT: This paper describes the analysis of a simple, free-to-play Real Time Strategy game called *Pixel Legions*. In developing this analysis, we worked with the developer to instrument, collect, and analyze telemetry data. Due to the specifics of the designers' inquiries, we developed a visualization system that enables us to answer specific micro-level questions in a way that is easy for the designer to understand how players learned and played the game. Our contribution constitutes the system we built and the analysis we developed to answer the questions imposed by the designer.

Keywords: Video Game, Visualization, Telemetry

1. INTRODUCTION

AAA franchises have massive budgets of tens of millions of dollars but offer large rewards; the most recent published sales figures of Call of Duty reported was hitting the $1 billion dollars [1]. To strengthen the sales and the design of games, user research is often conducted. While different methods for user research and player behavior analysis have been used, recently telemetry (records of events in the game) analysis has been widely adopted [2]. Telemetry data allows designers to investigate play behavior from a large (and sometimes all the) playing population. Thus, it has two advantages; it is: (a) representative of the player population since it is not a small artificially sampled population, and (b) an ecologically valid record of the play sessions, i.e. not a time slice played under lab conditions.

For at least a decade, telemetry has been used and shown to have an instrumental role in developing and refining the design of Virtual worlds and MMOs [3]. This is important due to MMOs' and virtual worlds' nature as they rely on players retention to stay in business. As the industry shifts to franchises and MMO type games, an understanding of how to use telemetry data to analyze and understand player behavior for refining design becomes essential.

Research on user behavior analysis using telemetry has been underway for sometime; Drachen and Canossa have used GIS to visualize death behavior in Tomb Raider [4] and machine learning to organize that behavior into groups [5]. Also, companies have instrumented their games and discussed the value of analyzing telemetry in terms of finding bugs [6] and maintaining the market [7]. While such endeavors investigated telemetry analysis of First Person Shooter (FPS) games [8] and Role Playing Games (RPGs) [9] games, none of the previous work discussed analysis of Real Time Strategy (RTS) games. RTS games have some similarities to FPS, but their gameplay mechanics are different, relying more on strategy in management and control of resources. Methods for analyzing an RTS game thus rely on analysis of strategies of action over time. Additionally, most RTSs are composed of a series of independent matches that do not impact each other and contain tens to hundreds of units controlled by a player, and thus are also different from an FPS and RPG, where the game is inherently connected through the multiple levels. This makes RTS telemetry analysis unique, as players can jump in an out of matches with no real guiding narrative to their actions, which makes questions around player motivation and behavior prediction rather challenging.

Due to these differences, studying the use of telemetry in RTS game analysis is an important endeavor. This paper discusses a case study highlighting the use of telemetry to study user behaviors. The paper approaches this analysis through collaboration with the designer of the game called *Pixel Legions* [10]. The goal is to uncover techniques and analysis methods that are valid to the RTS domain and are adaptable within a game production pipeline. During this process, we also found that current visualization methods provided by off the shelf tools were not suitable. This is due to two reasons: the tools are often (a) too generic and thus need much work and effort in part of the designers or producers to fit the RTS analysis needed, e.g. GIS, and (b) static and do not show temporal spatial relationships, e.g. tableau or heatmpas. In our research, we were inspired by several previous research on visualization systems, e.g. VU-flow [11]. Building on these research projects, we developed our own system, called *Pathways*, which is similar to previous visualization research work (specifically VU-Flow), but adapted to the RTS game domain by adding several features allowing designers to see outcome in addition to interactively displaying player behavior in both the spatial an temporal dimensions, as will be discussed later.

Therefore, this paper presents two main contributions: (a) a case study analyzing telemetry of an RTS game, and (b) a system that allows designers to analyze player behavior within a match outlining several important factors, including how players played the match and the strategies they used to win. In the next section we will review the related work, then discuss the RTS game we used for this case study. In section 4, we describe the telemetry recorded followed by the analysis we conducted on the game. Then we close by discussing the limitations and future work.

2. RELATED WORK

Understanding players' gameplay behaviors is currently an important research direction for the industry and academia. Researchers explored several methods including focus groups [12], think aloud protocols [13], surveys [13], and psycho-physiological sensors to study emotions and affect [14]. While these methods show great promise, they are often constrained by small samples and short play session times [15]. As a result, there has been a move towards using telemetry data as a method of player behavior analysis [3]. In earlier stages, the main goals were to use telemetry to find outliers for further investigation (i.e. finding cheaters), balance the economy or look at what assets players are using [3]. Initially, gameplay telemetry was only collected on MMOs with a centralized server due to the ease of collection and the necessity to balance the game to keep players playing [3]. As more personal computers and consoles became connected to the internet, the ability to use telemetry to find and prioritize bugs and improve games in development became more common [16] [17]. Telemetry is still primarily analyzed using either off the shelf tools like Tableau (Tableau 2011) or custom made visualizations using a variety of programming languages. More recently, Drachen and Cannosssa proposed the use of machine learning methods to classify players [5] for the game Tomb Raider Underworld (Crystal Dynamics, 2008).

A common problem with working with telemetry is how to analyze the results. How and what to visualize has been looked at in some detail. For Halo 3, researchers used simple heatmaps showing death frequency superimposed on the game level; thus investigating underutilized locations [8]. In addition, Hoobler et al. used heatmaps to give spectators watching players playing *Return to Castle Wolfenstein: Enemy Territory* a comprehensive understanding of where players were on the map, their general status, and statistics about the different teams [18]. For RPGs, the time spent in combat, inventory management, and conversations are important, and thus visualization and analysis for these behaviors are as well [19].

Current visualization techniques could visualize parts of the data collected from a game; a heatmap, for example, will show intensity, but is typically non-interactive and only visualizes one or two events. Most visualizations showing movement in space, such as geotime [20], are either designed for a small number of events (at most 100) or cost prohibitive to most video game designers. For example, GIS was mentioned earlier as a tool for creating elaborate static visualizations; a single license of GIS costs roughly $20,000 with plugins costing around $5,000 each, a single license of GIS will hire a good artist for half a year and is a more definite ROI for the studio than a single tool for analysis. VU-flow is one of the closest visualization tools to Pathways, like GIS it is designed to visualize large number of paths in 2-dimensional space in an aggregate manner but is focused on visualizing player movement (flow) [11]. VU-flow is focused exclusively on the visualization of movement, and thus would not be applicable to the analysis of RTS games that often require multiple types of events (movement, death, unit creation, etc.) to be visualized at once to give a good understanding of what happened within a match. Also as mentioned earlier, an RTS game has different mechanics from other games rendering such visualization techniques unsuitable or impractical. Therefore, for this problem, we adapted some of the previous work found in the visualization literature to the domain of RTS games by developing a system called *Pathways* discussed below.

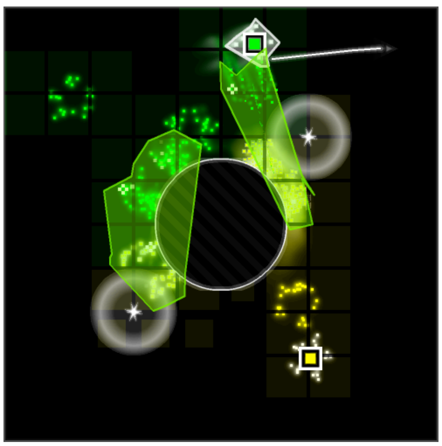
3. PIXEL LEGIONS AND QUESTIONS OF INTEREST

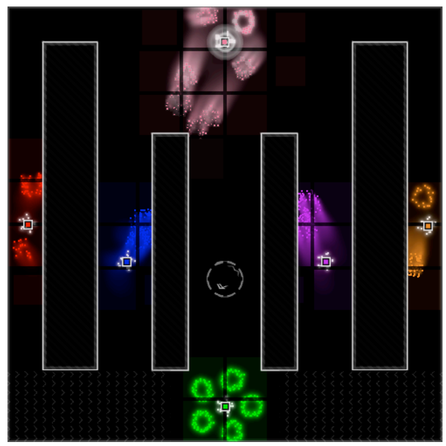
In this paper we discuss an analysis of player behavior in an RTS game called *Pixel Legions* [10] – a fast paced Flash based RTS in which players control both a base that produces squads of pixels over time and the squads themselves; the objective for each level is to defeat the opponents by destroying their base. *Pixel Legions* is in many ways a basic RTS. RTS games usually have two main mechanics: the first is some form of an economy; nearly every RTS has some way for the player to gather resources which they can then spend to acquire units. *Pixel Legions* uses the simplest approach, squads of pixel spawn from the base every few seconds (no resource gathering is necessary). The second mechanic is the control of units by issuing orders and locations to go to. In *Pixel Legions*, the player moves pixel squads and the base by drawing a path from the object to the intended destination; this is done by clicking on the object and clicking on the intended destination, which will cause the object will move towards the destination. Much like other RTS games, a squad will automatically attack an enemy object if they are within attacking range (touching). Additional mechanics include increased damage if two squads are attacking the same opponent from different angles, powerups, hazards, and blocks that push objects in a direction. Levels can be skipped or directly jumped to at any time.

Figure 1 shows a screenshot of level 7 of the game. The player (green) starts on the opposite side of the map from the enemy (yellow), the colored squares represent the base where the pixel squads spawn and the white line is a move command given to the base (it originates on the base). The large stripped circle in the middle is a barrier that prevent movement through it; and the semi-opaque polygon enclosing two groups of pixels indicates that they are engaged in combat. *Pixel Legions* is comprised of 24 levels, with the first level being a heavily scripted tutorial introducing the basic mechanics. Levels 10, 20-24 (level 24, see Figure 2) are boss levels, the rest of the levels reinforce and introduce new mechanics, such as flanking in level 3, powerup locations in level 7 (see Figure 1) or specific gimmicks, e.g., level 17 forces the bases to continuously move in a circle.

Figure 1: *A screenshot of Pixel Legions level 7, the player is in the upper left and the enemy the lower right. The white line represents the path the base's will move along. Moving the base to one of the power pylon circles increases unit production and any units going through the power pylons have upgraded attack power.*

Figure 2: *A screenshot of the 24th level of Pixel Legions: a boss battle with the boss at the direct top (pink) and the player the direct bottom (green). The circle in the middle pushes anything entering it in the direction of the arrow.*





Given this game as a case study, we developed a set of questions of interest that were a combination of our own and those from the game designer. These questions fell into two different types: *Macroscopic* questions – questions that deal with players actions between matches, and *Microscopic* questions – questions that deal with their actions within a match. In order to keep the discussion to a reasonable level of detail, we will focus on the Microscopic questions in this paper. These questions were:

1. Are the players doing what the designers expected?
2. Are there specific actions that can be associated with wins vs. losses?
3. Are players learning how to play a level?

4. TELEMETRY COLLECTED

A unique session id was recorded for each event as a way of correlating the otherwise independent events. The collection rate was set to 2% of all sessions on the client side to avoid overwhelming the server with data. The system was built with a client side flash API that allows programmers to send events with a single line of code. The data for the event was then sent to a server, which subsequently inserted it into the database table for that event.

We collected the following telemetry:

- Level information: level start and level winning
- Movement information: base movement every 5 seconds to avoid overloading the collection system and slowing the game down
- Death information: squad death including location, time, and team that it belonged to as well as killing team

The dataset analyzed was from the release of the game on the Pixelante website to the present.

5. RESULTS & ANALYSIS

Before we begin discussing the analysis we performed, we will first cover some terminology. Due to a limitation in the telemetry collection system, we were only able to collect data on a per-session basis, not per player (i.e., we have no way of knowing if two sessions are the same player). Thus, we will refer to *sessions* when talking about the collected data and *players* when we refer to possible actions of theoretical players. Given that a single session could play a level multiple times, we will refer to *matches* when we indicate the data that may include multiple playthroughs of a single level and *level* when referring to the specific level of the game.

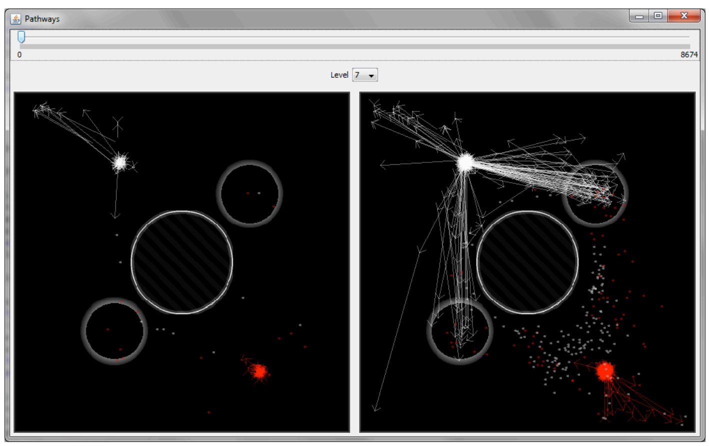
The analysis deals with how a player plays within a given match. Since the tactics a player employs might change over the course of playing a single match, we needed a way to analyze the individual actions over time. We developed *Pathways*: an interactive visualization system that visualizes multiple players' movement through a match in a 2 dimensional space. The goal of *Pathways* is to visualize a large number of different sessions at once in order to give a visual sense of commonalities that could inform designers or analysts. *Pathways* was a result of several iterations with the designer and other experts within the research team. It is unique in several ways:

- It represents player movement through space and time. For example, in figure 3, we see player's base's movements represented using the white line with arrows.
- Different events, such as item usage in an RPG or kill location in an FPS, are mapped to different visual elements, such as dots, squares, or triangles. Figure 3, shows pixel squad death locations visualized as dots utilizing.
- It also includes a time slider at the top of the window (as shown in figure 3) for the user to interactively scrub through the timeline.
- It also shows player behavior synchronized through time and split by outcome. Figure 3, shows all of the recorded matches of level 7 where win and loss conditions are tracked through time. This gives the designer a way to analyze

what players did in both conditions at the same time in an easy to see and analyze way.

We applied *Pathways* to the *Pixel Legions'* dataset. Pathways visualizes base locations over time; it uses a line and arrows to show the path of the base, and colored dots to show squad death locations (colors were associated with the team the squad belonged to); both event types were visualized at 10% opacity to utilize overdraw to give a better sense of what the average behavior was (it would show up darker due to more objects being in the location). Below we discuss the analysis we performed to answer the questions discussed above.

Figure 3. *A screenshot of the Pathways visualization system visualizing part of the data from level 7. This represents the first 10 seconds of gameplay.*



5.1 Are players doing what the designer expected?

The major strength of telemetry is checking if players are playing the game how the designer intended. To get at this question for *Pixel Legions*, we looked at specific levels where mechanics were introduced to see if players were taking the "correct" actions for the level in order to win. Figure 3 is an example of level 7 of Pixel Legions visualized in *Pathways*. As was mentioned above, level 7 introduces a new gameplay mechanic; specifically it introduces the power pylon, an object on the map where moving your squads through them makes them more powerful for a short period of time and your base will produce units faster if it's on the object. The locations of the power pylons in level 7 are the white circles in figure 3. Since figure 3 shows the first 10 seconds of all matches visualized at once, we can determine that in the matches that were won, players moved to the power pylons earlier (indicated by the mass of white arrows at the pylon's locations on the right hand side) than the matches that lost (no arrows over the pylon locations on the left); in addition we can see that there were more squads killed near the red base in matches that won. This indicates that players understood that they need to capitalize on these resources fast in order to succeed, the matches that resulted in failure probably were the result of the player being defensive and didn't capitalize on the power pylons allowing their opponent to overwhelm them. The interesting part about figure 3 is that even in winning matches players moved their bases into the same defensive position (the lines and arrow pointing to the upper left hand corner of the map); this could be the same player making small, incremental, changes to their default strategy (moving the base defensively) until they won or different players utilizing the same strategy.

Figure 4: *losing level 24 playthroughs in Pathways.*

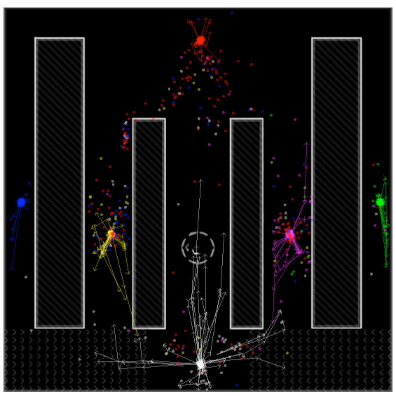
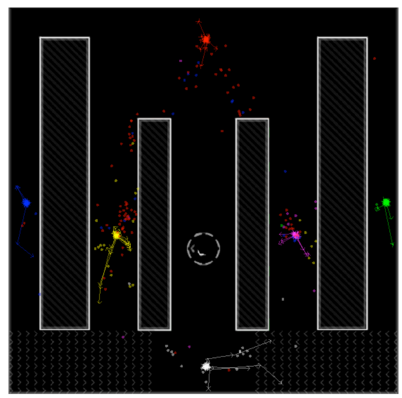


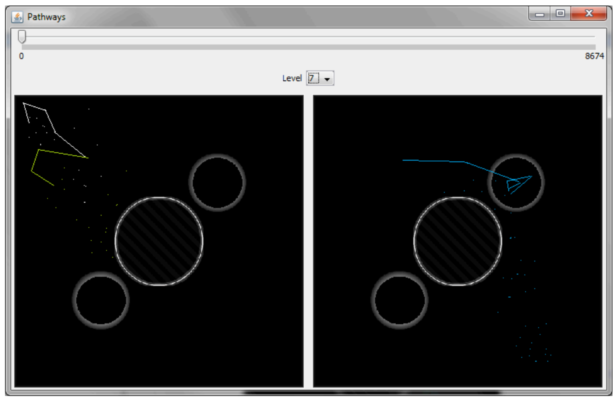
Figure 5: *winning playthroughs of level 24 in Pathways.*



5.2 **Looking at Strategies for Win/Loss**

By separating the data according to outcome, winning strategies can be easily seen. Figures 4 and 5 show the losing and winning views respectively for level 24 visualized in *Pathways* at 25 seconds into the level. The major difference is in the number of players who tried to move up the middle and sides. Moving up the middle does challenge the red team (the boss) and possibly move it out of the way but it exposes the flank of the player to the other teams. Moving the player base to the sides places it in a more defensive position by using the force arrows that push enemies towards the middle defensively but the same force arrows also force the player to focus on moving their own base (making the game harder) or risk it moving back to the middle(a number of matches showed this behaviour). Keeping the player base in the middle allows the player to minimize exposure to the boss (allowing it to kill off opponents) also giving them time to focus only on moving their using to kill off one of the 4 closer colors.

Figure 7: *A mockup of a single session's matches of level 7 visualized in Pathways with filtering and color remapping done. The first match is in white, the second in green, and the third (winning) in blue.*



5.3 Learning

One major weakness of pathways in its current form is that the ability to "drill down" on the data via selection and filtering is not implemented; we currently cannot select a certain line (or lines) of interest and visualize on the session's match data. Although the current aggregate form is useful for some forms of analysis, investigating learning within a match could more easily be assessed by looking at a single session's matches for a given level to see if strategy changes over matches. Thus, in order to answer questions about learning, we need to visualize only the session of interest's matches of the given level at once using some visual variable to distinguish them (most likely color where the first match is white, the second is blue, third green, etc.) so that the analyst can easily compare between them. This was left to future work. However, a mockup of what this might look like for level 7 can be seen in figure 7. In figure 7 the different match/rounds numbers (first, second, third) are mapped to white, green and blue respectively; because the blue path is on the right it is the winning match and when comparing the different match's paths together we can see that the winning round capitalized on the power pylon (it goes into the circle in the upper right) while the others do not; thus we can see that the player learned to utilize the power pylon in order to win.

6. DISCUSSION AND LIMITATIONS

Much of the analysis conducted on *Pixel Legions* is applicable not only to RTS games but any game in which there is a degree of player choice. We would argue that in any multiplayer game there is an interest in what players are doing on a microscopic level (within a given match). Revisiting the questions we have:

Microscopic questions:

1. Are the players doing what the designers expected?
   Using *Pathways* we were able to visualize all session's plays of a given level, this allowed us to test if the players were utilizing the mechanics introduced and see how quickly they utilized them within a single match. The greatest strength and most common application of telemetry is in answering this question, so *Pathways* would work well for other genres.
2. Are there specific actions that can be associated with wins vs. losses?
   We visualized the two outcomes separately in order to identify any specific behaviors associated with each one; we were able to see that in a specific level, moving to a specific location quickly often resulted in a loss. Investigating winning vs. losing behavior is important to many other genres besides RTS as it gets into the question of balance; if a particular item consistently leads to a win, then it diminishes strategy and potentially makes the game not fun.
3. Are players learning how to play a level?
   Due to limitations in *Pathways,* we could not analyze specific sessions to see if they are learning to play the level. However, we showed a mock up of an extension of the system we are planning to implement that will get at that question. Learning is important for many types of games.

As mentioned earlier, telemetry data doesn't tell us why a session skips; it is a record of a player's behavior, multiple different intents could lead to the same behavior. It could be that players liked level 12, but without asking the players directly, it's impossible to know.

In addition to this limitation with telemetry, the data is also noisy. Figure 5 shows play throughs extending to 8764 seconds or roughly 2.4 hours! This is most likely an artifact of timestamps and a player possibly pausing the game midway through the level and coming back hours later. Removing long play sessions by considering them as erroneous would "clean" the data but at the same time the removed play sessions could be interesting stories about play style, perhaps that player jumped from the 5^{th} level? Or perhaps they tried something no-one else did and refused to give up?

As it has been mentioned earlier, the fundamental weakness with the recorded telemetry is that ids are for a given session and not a computer or specific player. The possibility of two session ids belonging to the same player means that you cannot determine if the multiple sessions that played through a given level with similar tactics were the same player using their own tactic or two different players who happen to have a similar tactic; in short, the external validity of the sample set is suspect. The lack of player id also made it impossible to tell if the data collected was an actual player or the game designer testing a level.

In addition to the weaknesses in the collected telemetry, *Pathways* does not support selection, filtering, or remapping color to different variables within the data which makes the analysis of a single session's data require modifying the program code.

7. CONCLUSION AND FUTURE WORK

In conclusion, we analyzed *Pixel Legions, a basic RTS,* to understand what kind of analysis is possible for an RTS game using telemetry. We found that visualizing gameplay data within specific levels using *Pathways* showed whether players were playing the game as the designer expected and was able to uncover winning vs. losing behavior strategies. While telemetry and *Pathways* had several limitations, the method discussed and the case study provides valuable lessons on the use of telemetry and visualization for analysis of RTS games.

We are currently working with Relic Entertainment to apply the analysis methods to their games, and thus rectify some of the limitations we had with *Pixel Legions* telemetry data. In this collaboration, we are using *Pathways* on data from *Dawn of War II* or *Company of Heroes.* In addition to our work with Relic, we also intend to extend Pathways to add selection, filtering, and color remapping to allow analysts and designers to investigate if players are learning the mechanics introduced in specific levels.

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REFERENCES

1. Alexander, L.: Gamasutra - News - Call Of Duty: Black Ops Hits $1 Billion In Sales, http://www.gamasutra.com/view/news/32145/Call_Of_Duty_Black_Ops_Hits_1_Billion_In_Sales.php.
2. Mellon, L., Kazemi, D.: Wake Up and Smell the Metrics!: Metrics-Driven Development in Online Games, http://maggotranch.com/AGC_2008.ppt.
3. Kennerly, D.: Better Game Design through Data Mining, http://www.gamasutra.com/features/20030815/kennerly_01.shtml.
4. Drachen, A., Canossa, A.: Analyzing spatial user behavior in computer games using geographic information systems. Proceedings of the 13th International MindTrek Conference: Everyday Life in the Ubiquitous Era. pp. 182-189. ACM, Tampere, Finland (2009).
5. Drachen, A., Canossa, A., Yannakakis, G.N.: Player modeling using self-organization in tomb raider: underworld. Proceedings of the 5th international conference on Computational Intelligence and Games. pp. 1-8. IEEE Press, Milano, Italy (2009).
6. Niwinski, T., Randall, D.J.: GDC Vault - Using Telemetry to Improve Zombie Killing, http://www.gdcvault.com/play/1013152/Using-Telemetry-to-Improve-Zombie.

7. Gudmundsson, E.: QEN: Production, production, production - we want more production., http://www.eveonline.com/devblog.asp?a=blog&bid=686.
8. Thompson, C.: Halo 3: How Microsoft Labs Invented a New Science of Play, http://www.wired.com/gaming/virtualworlds/magazine/15-09/ff_halo.
9. Brudvig, E.: Crazy Mass Effect 2 Stats and What They're Used For, http://pc.ign.com/articles/111/1118657p1.html.
10. Pixelante Game Studios: Pixel Legions, http://pgstudios.org/pixel_legions.html.
11. Chittaro, L., Ranon, R., Ieronutti, L.: VU-Flow: A Visualization Tool for Analyzing Navigation in Virtual Environments. IEEE Transactions on Visualization and Computer Graphics. 12, 1475-1485 (2006).
12. Fulton, B., Medlock, M.: Beyond Psychological Theory: Getting Data that Improves Games, http://74.125.155.132/scholar?q=cache:TbeK8Y-1ADgJ:scholar.google.com/&hl=en&as_sdt=0,5.
13. Isbister, K., Schaffer, N.: Game Usability: Advancing the Player Experience. Morgan Kaufmann (2008).
14. Mandryk, R.L., Atkins, M.S., Inkpen, K.M.: A continuous and objective evaluation of emotional experience with interactive play environments. Proceedings of the SIGCHI conference on Human Factors in computing systems. pp. 1027-1036. ACM, Montréal, Québec, Canada (2006).
15. Williams, D., Yee, N., Caplan, S.E.: Who plays, how much, and why? Debunking the stereotypical gamer profile. Journal of Computer-Mediated Communication. 13, 993-1018 (2008).
16. Ramero, R.: Successful instrumentation: Tracking Attitudes and Behaviors to Improve Games. Game Developers Conference. , San Jose, California, USA (2008).
17. Tychsen, A., Canossa, A.: Defining personas in games using metrics. Proceedings of the 2008 Conference on Future Play: Research, Play, Share. pp. 73-80. ACM, Toronto, Ontario, Canada (2008).
18. Hoobler, N., Humphreys, G., Agrawala, M.: Visualizing Competitive Behaviors in Multi-User Virtual Environments. Proceedings of the conference on Visualization '04. pp. 163-170. IEEE Computer Society (2004).
19. DeRosa, P.: Tracking Player Feedback To Improve Game Design, http://www.gamasutra.com/view/feature/1546/tracking_player_feedback_to_.php.
20. Kapler, T., Wright, W.: GeoTime Information Visualization. Information Visualization, 2004. INFOVIS 2004. IEEE Symposium on. pp. 25-32 (2004).