inFlow: Adapting Gameplay to Player Personality

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ABSTRACT

In this document, we present a videogame that adapts its content to the player. Such a game needs to infer the player's type from his behavior, and then select how content is managed and presented to the player based on that type. In this work we focus on the later aspect, assuming we already know the player type. We also propose how such information can be used to enhance the player's experience.

After revising the literature on the subject, we decided to use the Demographic Game Design (DGD) model as our player model. Therefore, before playing our game, the player has to fill a questionnaire to assess his Myer-Briggs personality type. From this questionnaire, the game classifies the player according to the DGD model. The game is then adjusted according to this player type, which will influence how the information of the game is presented to the player, in three main aspects: presentation, difficulty management and depth of control over aspects of the game.

To evaluate our approach, we asked different types of players to play our game under different conditions and evaluated the experience using a final questionnaire based on the GameFlow model. The evaluation suggests that the player enjoyment is higher when the game is using our framework to adapt to the player.

Categories and Subject Descriptors

K.8.0 [**Personal Computing**]: General – *Games.*

General Terms

Algorithms, Management, Measurement, Design, Human Factors, Theory, Verification.

Keywords

Flow, Enjoyment, Adaptive game

1. INTRODUCTION

Modern games have evolved greatly in the past few years, with astonishing graphics, amazing sound effects, "flawless" character animation and so on. However, the research for maximizing the player's experience in videogames is still far away from producing a consistent model that can be used in most of the commercial games. This is a very hard feature to achieve, if not impossible, however some research has already been made to understand the player's motivations and experiences so that they can be used for a broader range of games, hopefully leading to more potentially optimal experiences.

Games should be fun to play. Eventually, they are condemned to lose its charm and the interest of the player, but by then the games should already have presented all of their key features. The problem is that many games stop being fun before they have the chance to do that. This happens because either the players don't like the challenges they are being given or they don't appreciate the reward the game is giving them for their effort. [1]

The experience a player has from playing a game is always different from another person that plays the same game. Each player is different, looks for different games and enjoys different things within the same game. In order to satisfy different types of players with the same game, the game has to be able to adapt to the preferences of the player. [1]

Keeping in mind that the developers and game publishers want the player to play the most of their game, there are a number of other ways in which adaptive games can be advantageous. For example, if the player is constantly losing in a section of the game, the game should detect it, and adapt itself to help the player not to fail – preferentially without the player knowing. Adaptive strategies can also be used to fight winning strategies. When winning strategies are found, the balance of the game is ruined because the players find it easier to succeed. Also, it leads to a lessened enjoyment for players because the challenge that they face is reduced and they are not encouraged to explore the full features of the game, however, players will often repeat a successful strategy over and over again because it leads to a predictable win, even if it is boring. [2]

2. OBJECTIVES

- Create a game that has an high quality standard, and allows the player to feel immersed.
- Evaluate the game based on the premises of the GameFlow model. [3]
- Design a framework that can be incorporated in a game with the purpose of adapting the game to the preferences of various typologies of players.
- Implement the framework and connect it to the game.
- Measure the Demographic Game Design(DGD) Model type of the player and validate some of the assumptions of this model. The DGD Model classifies the player regarding it's player type, describing its preferences. [4]
- Validate the framework implemented in the game through user tests.

In sum, this research seeks to find a way to maximize the player's experience while playing a videogame. The main objective is to create a game that adapts to the player and leads him to the Flow state. The hypothesis for this study is that the automatic adaption of the game to the player's preferences will have a positive impact on the enjoyment of the player.

3. RELATED WORK

Almost forty years ago, the psychologist Mihaly Csikszentmihalyi introduced the concept of Flow [5], the feeling of complete and energized focus in an activity, with a high level of enjoyment and fulfillment.

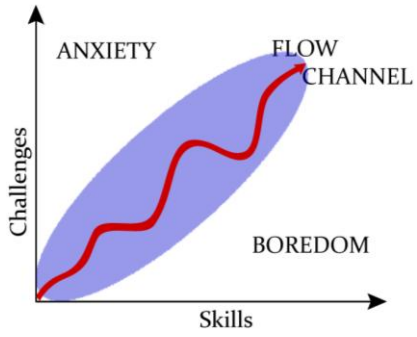


Figure 1. Flow Channel Model.

The author stresses the importance of the fact that enjoyment does not depend on what we do, but rather on how we do it, and if we feel flow or not. [6]

Figure 1 represents a model for the flow zone, and doesn't illustrate the fact that Flow often occurs when executing an activity that demands above-average challenge. To face this problem, The Experience Fluctuation Model was created in order to explore the relationship – first suggested by Csikszentmihalyi – between perceived challenges and skills, on one side, and the overall quality of experience, on the other side. [7] By looking at Figure 2, we can easily see that the top-right half of the circle represents positive emotions and therefore is represented in green. Contrary to Figure 1, we also notice that this model is more permissive than the previous model. If we look at the "Content, Confident, Relaxed" area, we can see that it would correspond to boredom in the previous model, and this may be explained by the human capacity of finding implicit challenges within the task at hand, i.e., "If I've managed to do it, now I'll do it faster and better"

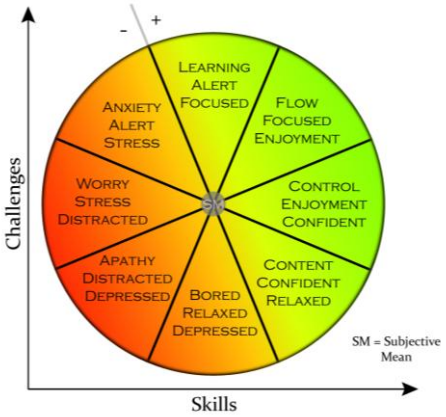


Figure 2. Experience Fluctuation Model. **[7]**

Videogames have taken a major role in the entertainment of today. Game designers understood this fact and the importance of games as a source of enjoyment and, as a result, started to design games that intentionally tried to include the eight components of flow. [1] Flow has also served as a basis for the GameFlow model that was created as an evaluation tool for games, mainly to understand whether or not a game is enjoyable. This model creates a mapping between some elements of Flow and principles on game design. [3] GameFlow defines eight elements that include a set of criteria for achieving enjoyment in games – concentration, challenge, skills, control, clear goals, feedback, immersion, and social interaction.

Immersion, as the name indicates, can be described as a loss of self-awareness from the real world and the feeling of being transported into the virtual world. Thereby, immersion can be a precursor of flow experiences. Its description resembles one of the eight major components of the flow model. The main difference when compared to flow is that a game may be immersive, but fail to provide flow experiences. [8]

Brown and Cairns study resulted in a more rigorous approach for Immersion, which clearly identified three states: [9]

Engagement

This is the lowest level of involvement with a game and to enter this level the gamer needs to invest time, effort, and attention. As we have seen, different players enjoy different game styles, and if the player doesn't like the game, he won't even try to engage with it.

If the game succeeds in engaging the player, he will become more immersed and lose track of time, which, in result, may cause a feeling of guilt. This feeling is due to the perception that time has passed too fast, and he could have done something else instead of playing. This can be countered by providing the player with rewards of success, which compensate for the invested time in the game and make it worthwhile. An example of these rewards are the achievements and trophies on the gaming consoles.

Engrossment

The gamer is already engaged to the game, and wants to keep playing. This is where he will begin to connect with the game at an emotional level, rendering his emotions directly vulnerable to the game. At this stage, the true quality of the game will be thoroughly tested. Visuals, plot, sound, attention to detail, everything will count to suspend the disbelief of the gamer, as he is directing more and more attention to the game and becoming less self-aware and less aware of his surroundings.

Total Immersion

In this stage, the game is the only thing that occupy the gamer's thoughts and feelings.

The barriers to presence are empathy and atmosphere. Empathy represents not only the emotional attachment to a character, but also the feeling of belonging to that same place for a reason. For example, we may get attached to a character that is a dinosaur, but it is hard to see ourselves as a dinosaur.

One of the first things to worry about when designing a game is to make it user-oriented. In order to do so, we must know what users want. This led to the definition of several player typologies that cluster gamers in different classes. [10]

Bartle (1996) was one of the first to define a more detailed model of players. Based on the Multi-User Dungeons that were played in that time, four player types were defined: Socializers, Achievers, Killers, Explorers. [11]

As means to improve the sales of their games, private game companies also started to define the market of gamers. Electronic

arts devised a model that is a little different, which defines three types of players: Hardcore gamers, Cool gamers and Mass market casual gamers. By the same time, International Hobo defined a model that was similar to the one that EA presented, which also has 3 types of gamers: Hardcore gamers, Testosterone gamers and Mass market casual gamers (which was then divided in two, Lifestyle gamer and Family gamer). In 2004, International Hobo created the Demographic Game Design Model based on the Myers-Briggs method for classifying individuals regarding their personality preferences. [4] The Myers-Briggs Type Indicator (MBTI) uses four bipolar dimensions to classify the personality of a person: Introversion (I) or Extroversion (E); Sensing (S) or Intuition (N); Thinking (T) or Feeling (F); Judging (J) or Perceiving (P). [12]

Based on the survey analysis by International Hobo, four main player types were defined using only the last two, and most significant, axis of MBTI: Conqueror (Thinking & Judging), Manager (Thinking & Perceiving), Wanderer (Feeling & Perceiving), Participant (Feeling & Judging). Designing a game that is enjoyed by everyone is hard. However, we can see clear differences in the way that people play, allowing us to focus our efforts when we want to design a game for a certain type of public. If we look in a commercial perspective, it's obvious that we always want to maximize customers and sales, and towards that end, adaptive techniques may be used to extend the target customers.

Developing a game that has different levels of difficulty is probably the most commonly used method for adapting a game for players with different levels of skill. This is usually done by asking the player which is his skill level, right at the beginning of the game. There are innumerous ways to change the difficulty setting in a game: using different behavior from the opponent non-playable characters [13]; limiting the access to resources such as life or ammo; creating additional puzzles, etc.

This type of system is one of the most basic, since it only receives the input from the player regarding his preferences. This is just a scratch on the surface of the possibilities for adaptation that a game may offer. Asking a player his skill level can be disastrous because he may not be totally aware of it. This is why some games devise strategies to help balancing the game according to the real skill of the player. For example, the highly acclaimed game Call of Duty: Modern Warfare 2 (Infinity Ward & Activision, 2009), uses a training camp to test the skill of the player, and in the end of the training session, the game suggests a difficulty setting according to player statistics such as accuracy, total time, civilians killed, etc.

The latest installment by id Software, Quake-Live, requires a player to register on the website in order to be able to play for free. After the registration, each user is required to enter in a portal, out of three portals available: Beginner, Intermediate, Expert. You have the Beginner portal available at start, but in order to reach the Intermediate portal, you have to perform a Rocket Launcher jump, which only a quake familiarized player should know. For the Expert level, you have to make a series of fast jumps in order to reach the portal in time, and only an expert player of Quake 3(id Software) should be able to do it on time. After you enter the portal, you have to duel an AI controlled character. If, for some reason, an expert player happens to enter in the beginner portal, the opponent AI will re-classify the player as he plays and automatically adjusts the difficulty setting in order to correctly face the player's skills. This process serves as a trial in order to match the real players by their skill, creating more balanced games.

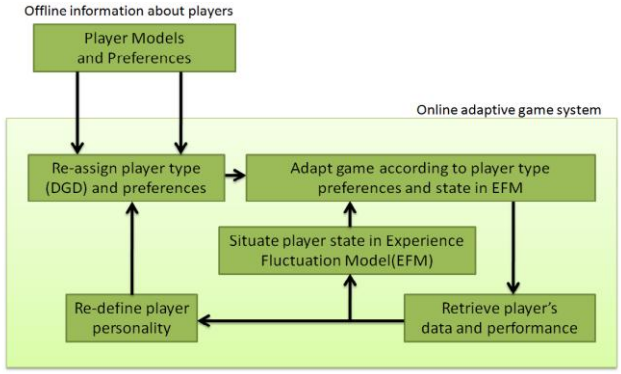
An approximation of this technique has been used on other games and studies. For example the Auto-dynamic Difficulty is a adaptive game system that retrieves several metrics from the player's performance. Using that information, this system adjusts many attributes in the player's character and the other non-playable characters, to make the game harder or easier. In their study, they also suggest that the dynamic modification in the level design might also be relevant for the successful adaptation of a game. [14] Bailey & Katchabaw also stressed the fact that a simple testbed/mini-game might not be enough for testing an adaptive game system, and it is necessary to have a complete gaming experience to fully explore the results of the adjustments. [14]

Dynamic Difficulty Adjustment is a probabilistic game adaption system, that uses the performance of the player to calculate the transition probabilities between game states. This game system is designed to keep the player in the flow channel by encouraging certain states, and discouraging others. Effectively, the goal is to keep the players in engaging interaction loops, for the most appropriate period of time, given their level of overall skill and game-specific experience. [15]

Another technique that allows for the game to be continuously adapted to the player type, is by giving different paths from which the player may choose from. These decisions may come in form of distinguished paths in the physical world, where one is shorter and harder, or longer and easier; different moral choices, which usually leads to different courses in story line and ending; creation of side quests that help the player gain skills to face harder challenges in the game, etc.

Considering that a videogame is a highly interactive application, especially if it is a storytelling game, the game should take the opportunity to retrieve information from the player and adapt to him. Thue *et al* developed an interactive storytelling system (PaSSAGE) that uses dialogues to automatically learn the player's preferred style of play, and then uses those preferences to dynamically select the content of the game. The game has different types of quests that can be offered to the player depending on his preferences. Results from this study indicate that adapting the game based on (supposed) player preferences can increase the enjoyment of playing a computer role-playing game for certain types of players. [16]

4. ARCHITECTURE



User model component (Offline information)

In this context, offline means that the information in this component is always available and ready to be accessed. This component serves as a knowledge base, in which the Online component of the solution can rely to fetch information about the player's typologies, their preferences, and metrics for distinguishing the player between these typologies.

As discussed in the related work section, many studies have already been made to identify the different types of players and their corresponding preferences. Some players prefer the main story, others prefer the component of character development, others prefer the social component, and others prefer knowing everything of the game. This component is based on the study that originated the Demographic Game Design Model [4] and the classical work that led to the creation of the Myers-Briggs Type Indicator [12], and allows for the creation of a knowledge base with the following requisites:

- Information about the four bipolar axis that classify an individual regarding his MBTI Personality Type.
- Information that allows for a correlation between the MBTI Personality Type of an individual, and the preferred player typology defined in the Demographic Game Design Model.
- Information regarding preferences of each player typology, also defined in the Demographic Design Model.

In order to move to the core of this adaptive system, we must have a knowledge base with the requisites that were presented above, plus the standard requisites for any consistent database. Naturally, for the solution to work we need a solid background, so that, in general, the solution can be fast, effective, robust and efficient. [17]

Game tuning component (Online information and adaption)

In this part of the solution, we have five states that function in a cycle during the execution of the game. These states are listed and described below:

- 'Retrieve player data and performance': When the game starts, this may be the starting point of the cycle. This state is comprised of a learning module that takes advantage of the highly favorable platform for learning: the game itself. With this, the player's performance can be tracked, classified and analyzed. The collected data may also include actions performed by the player, which is continuously saved for further analyzing.
- 'Situate player in Experience Fluctuation Model(EFM)': In this state, the goal is to approximate the player's experience while playing the game. In Figure 2 we can see the intersection between challenges and skills, and allows for the inference of the player's feeling. A rough approximation of the model can be achieved only by analyzing the player's performance in a certain situation. More advanced methods for extracting information may be used to increase the significance of the approximation, such as measuring the skin impedance and perspiration.
- 'Re-define player personality': When the game has sufficient data, this module will try to approximate the player's personality based on the analysis of the collected data. This approximation is based on the concepts of the Myers-Briggs survey, and requires a correlation between the survey and the behavior the player may have. The concept is to apply the Myers-Briggs survey implicitly, instead of explicitly asking the questions. Basically, what this module does is detect the behavior patterns on the data collected automatically by the game.
- 'Re-assign player type(DGD) and preferences': Once the system has the approximate personality of the player, the preferred player type can be inferred by checking the knowledge base present in the offline component. The mapping between each Myers-Briggs Type Indicator and the player typology is described in the section 2 of this document. At this moment, the game gains access to the supposed preference list of the player and is ready to advance to the next state, the adaption of the game.
- 'Adapt game according to player type preferences and state in EFM': At this point, the system has all the information it needs to complete this cycle. The system knows what content and challenges to give to the player, based on his personality and his player preferences, and it also knows how to balance the game, by analyzing the player state in EFM.

In sum, the most important thing in this section is the capability of learning from the actions of the player, and transform those actions into usable knowledge. In another work, Thue et al explicitly asks the player about several key subjects that influence the player's model. [16] In our solution, we propose a different approach that learns by monitoring the behavior of the player, and then approximates a personality based on that behavior. The game presents several challenges to the player that can be done in different ways. The player may see – or not – the choices he is given to solve a situation, however he is not asked explicitly to take a given action, contrary to dialogues where you are forced to think logically and answer in a more controlled manner. This information is useful for inferring the personality of the player, which later can be used to select the content of the game, based on the preferences of the individual. Also relevant to the adaptive system is the information regarding the performance, because it helps weighting the referred preferences of the player, and regulate the Artificial Intelligence with the appropriate skill level. Moreover, it also helps to situate the player in the Experience Fluctuation Model, so that the game has an idea of the player's current game experience, and what can be tuned to change it.

5. IMPLEMENTATION

Grim Business is the name of the game we created to be able to test the proposed solution. In the game, you shoot your way through enemy packed levels using a top down 360º shooting with futuristic action scenes. You have three types of weapons at your disposal: Chainsaw, Sub-Machine Gun and a Shotgun. You also possess a flashlight which allows you to find your way and aim your shots on darker levels. The game was inspired by the increasing violence and gore thematic.

In the game, the player takes control of Lt. Darren Fletcher, a retired operative looking to avenge his family. The main objective is to kill everyone, plain and simple. The player possesses three distinct weapons: Chainsaw, Sub-Machine Gun, Shotgun; as well as a flashlight, and the ability to use two powerup items. As we can see in Figure 3, the camera is not completely top-down, but something between third person camera and top camera. The only limitation in movement is that the player cannot aim upwards or downwards. However, in a case where the enemy is on an higher plane than the player is, the game automatically adjusts the aim up or down, to hit the desired enemy.

For the testing of our solution, we designed and created a straightforward level. In the beginning of the level, the player has the opportunity to familiarize with the controls and has the first contact with a pretty harmless enemy, where he can test his weapons. After that, the player has to walk through a thin bridge that requires some expertise in the controls. The player then starts to see a camp with some enemies engaging in their daily affairs. The player's objective is to kill everyone in this camp and escape the base alive. The crescent number of enemies and emergent chaos gives the opportunity for the player to learn the gameplay mechanics in a steady curve. After he kills everyone in the base, he must escape the base. The player has to venture through dark woods where enemies are lurking in the dark. The flashlight plays a crucial role in this part of the level, as it allows for early detection of the sneakier enemies. Finally, when the player reaches an illuminated area, he may be tricked by the safer looking ambiance, but a large scale ambush is waiting for him. If the player survives, he successfully completed Grim Business.

Figure 3. Screenshot of gameplay.

Table 1. Overall game changes depending on the player typology.

		Conqueror	Manager	Wanderer	Participant
Presentation	Story	None	World-oriented	Character-oriented	Character-oriented
	Objectives	General + Specific	Exploratory	General	General
	Misc	--	--	Kill Cam	Different Paths
Difficulty	Enemy Difficulty	Hard	Normal	Easy	Easy
	Starting Weapons	Chainsaw and SMG only	All with low ammunition	All	All
	Death Punish	Yes	Yes	None	None
Control	Upgrades	Manual Full Info	Manual Full Info	Automatic, High Feedback	Automatic High Feedback
	Ammunition	Buyable only	Buyable only	On the floor only	On the floor only
	Powerups	Buyable only	Buyable only	Automatic	Automatic
	Shop	Yes	Yes	No	No

From Table 1, five main modification points may be identified:

- Story
- General difficulty – the modification of enemy difficulty, starting weapons and death punish, all contributes to the general level of difficulty of the game.
- Objectives
- Resource Management – the modification of how upgrades and powerups are given, how ammunition is managed, all contributes to the resource management. This is one of the main and most significant modifications in the game.
- Miscellaneous – this includes the incorporation of a special killing camera that focuses the dying enemy, and the different physical paths in the level.

Story

To adapt the story, we developed a story manager that dynamically changed the content of the story depending on the player type, by looking at the preferences for each player type in the DGD Model and decided the following:

- Conqueror: Disable the story. The DGD model clearly states that most of these players don't value the story.
- Manager: Most of these players value a world-oriented story. They enjoy stories that engulf the player into a world full of detail and scale. Rather than knowing what makes the character move, it is more important to know what is happening in the world that requires the character to move with it.
- Wanderers and Participant: According to the DGD Model, these players develop emotional links with characters, and they enjoy character-oriented stories. This type of story focuses on the feelings of the characters, and its goal is to make the player identify himself with the character.

General Difficulty

One of the most important factors for differentiation in the DGD Model is the difficulty. Each player type enjoys different settings in the overall difficulty of a game.

The Artificial Intelligence used by Grim Business agents was completely developed by us, and consists of the union between a reactive AI and a deliberative AI – an hybrid architecture.

Below, we can see the rules used by the reactive AI, which clearly identifies three states: Attack, Hold and Patrol.

1. Sees the player alive* → Attacks player.

2. Sees player dead* → Stop shooting; Start patrol.

3. No longer sees player* → Stop shooting; Start patrol

4. Reaches patrol node* → Moves to the next patrol node.

The deliberative AI is a bit more complex than the reactive AI, and consists on the execution of the following cycle:

Update Beliefs: This function retrieves the agent perceptions of the outside world and converts them into the agent's *beliefs* – the symbolic representation of the world.

Options: This function generates a list with all the current *desires* of the agent, based on his current beliefs. After this, the priority desire is selected from this list.

Filter: Using the selected desire achieved in the previous function and the beliefs that the agent has the world, this function generates a list with all the *intentions* that can contribute to the satisfaction of the desire. Finally, a intention is selected with the highest preponderance to the fulfillment of the desire.

Build Plan: This function of the cycle serves as a manager of the state machine of each agent. Each state has an associated intention, and define a plan to be generated and executed for the current situation. Some states run once and terminate, while others auto-update by generating a new plan (and execute it) in each cycle of the state.

When linked together, the reactive architecture has priority over the deliberative architecture, which does not execute when the reactive AI reaches an important decision. This takes advantage of the rapid processing of the reactive AI on certain situations, and the ability to generate more complex plans by using the deliberative AI.

On top of this AI, we also incorporated the ability for them to communicate with each other, based on a squad system. Each agent has the ability to call for help and order a teammate to flank the player when in combat.

Given this, we had total freedom to change the difficulty of the enemies. In result, we created three different settings for the enemies:

- Hard: The enemies use the hybrid AI described above and are organized into squads. Each enemy has the ability to communicate with his teammates, which creates a feeling of chaos in the level. Once the player is spotted, they won't stop coming unless they lose track of the player. Each enemy will try to flank the player for maximum effectiveness.
- Normal: In this mode, the enemies are much more pacific than in hard mode, since they don't possess the ability to communicate between them. The beliefs that they have are their own, which lowers the emergent chaos that happens when enemies called for help. However, they are still able to listen and see the player, and won't rest until they get him.
- Easy: In this mode, enemies have their life reduced to 75% of the normal value, and they are moderately less accurate than in normal/hard. Except for these details, the other features mentioned for normal/hard still apply.

Other factor that also contributes to the general difficulty of the game is the way that player's deaths are punished. To reflect the preferences of each player type, Conquerors and Managers are punished when they die, while Wanderers and Participant aren't. Given that both Conqueror and Manager have manual resource management through the shop, the punish each time the player dies is: loses half his money; loses half his ammunition; his money multiplier returns to the initial value.

Yet another factor that influences the difficulty of the game is the amount of ammunition that is given to the player at the start of the level. This is a major factor in the beginning of the level, because it is much harder to kill with the Sub-Machine Gun, and even more with the Chainsaw, than with the Shotgun. A player that starts without a shotgun has a much lower survivability and is probable to die more easily if he isn't careful.

Objectives

For the adaption of the objectives, we created three types of objectives:

- Georeferenced objectives: These objectives must be completed so that the player can advance in the level and complete the game. These objectives may also be known as "georeferenced" objectives, since they show up in the minimap as a cross and in the game world as a large blue beacon. An example of this objective would be "Reach the Inner Base", where the point where the objective can be completed is clear, and can be shown in the minimap and in the game world.
- Plain objectives: These objectives must be completed so that the player can advance in the level and complete the game. These are plain objectives and require the understanding/exploration of the objective so that it may be completed. An example of this objective would be "Kill Everyone", where there is no specific point for completing this objective.
- Specific objectives: They are secondary and serve as a bonus challenge for the player. These objectives may also be known as accomplishments, which rewards players with an item for their efforts. An example of this objective would be "Kill 30 enemies with the chainsaw", which would then reward a player with an item, and a special badge.

The specific objectives are specially tailored for the Conqueror players, whom enjoy challenges and to be in control of the game. These objectives require the mastering of certain aspects of the game, which is supposed to attract the attention of these players. The Georeferenced type of objectives are much easier to detect, and their purpose is to try to minimize the occasions where the player doesn't know what to do, or where to go. Wanderers and Participant lose interest in a game that doesn't provide feedback about the progression, and not having clear objectives at all moments is one of those factors. On the other hand, Managers enjoy exploring and finding things by themselves, which is why plain objectives are much more appellative to this type.

Resource Management

This is probably the modification with more impact in the game. The way that the ammunition, upgrades and powerups are managed completely change the experience of the game. By shifting the control from the player to the game, we have two differentiated ways to manage the resources:

Manual: The player gains money by killing enemies. The more enemies the player is able to kill without dying, the more he receives for each kill. The player then has the responsibility to manage his money, and to choose where to spend it. The buying strategy influences the playing strategy and vice versa. The different items are divided into three sections: Weapons & Ammo(Shotgun and Sub-Machine Gun); Upgrades(Bonus

Regeneration and Improved Flashlight); Special Care(Double Damage, Adrenaline Rush, Ultimate Strike). The player may see the detailed description of each item, the price and the current money inside the shop. The player may access the shop anywhere on the map, and while the player is buying, the game is paused. A full list of the items can be seen in Appendix C, the page 79 of this document.

Automatic: The game takes full control of the resource management. Each enemy that the player kills has a 75% chance of dropping a random amount of ammunition for the Sub-Machine Gun or the Shotgun. In truth, the money system still works behind the scenes, and the game uses that to know when to reward the player with the upgrades and items. The game starts by giving the health and flashlight upgrades to the player, and then starts to give a random powerup every time the player has the money for it. We verified from diverse gaming sessions with users, that by giving the upgrades first, the player benefited for an higher rate of survivability throughout the rest of the level.

Miscellaneous

Although Wanderers and Participants have different preferences in the DGD Model, the preferences of the Participants are much more social than the rest. Because this game is single player, social components are much more difficult to change. So, for our testing, Wanderers and Participants are much alike and these changes/additions were the solution to disengage the two types from each other.

- Slow-motion Kill Camera: On a 10% kill basis, the game automatically applies slow motion for 2 seconds and shows the enemy dying up close. Adds incredible depth to the game, given that the regular game camera is a far-away third person camera.
- Different paths: The player has the option to choose between physical paths in the game world to advance in the level. Depending on the path that he chooses, the number of enemies may vary. For instance, if the player chooses left, he will face a more obscure path with less enemies, however, in the end he will have to fight two enemies that have more health than usual. On the other hand, if he chooses the regular path, he will have to face more enemies, but will have no surprises. The player is free of returning back to where he chose one path, and decide to experiment the other one.

6. EVALUATION

The idea for the verification of the hypothesis was to select a representative population for each four player types, and then randomly split the sample in two groups. The first group experiment the game with the game adapting to his player type, while the second group played the game adapted to a player type that was not his. Each participant was asked to fill in a survey with 34 dichotomous questions, which enabled for the preliminary inference and classification of each individual. In addition to the survey, we had to create a script that on each form submit, we would instantly and automatically receive the resulting player type(Conqueror, Manager, Wanderer, Participant) of the respondent. For the purposes of retrieving the player type, we only needed the questions regarding two of the four axis(Thinking-Feeling and Perceiving-Judging) of the Myers-Briggs Type Indicator. The questions and their respective factors were retrieved from the Larson study, which verified this questionnaire with over ten thousand tests. [18]

After this first evaluation, the next step was to try the game. The game was then set up in a isolated environment, with high quality headphones and a gamepad, giving the player the opportunity to focus completely on the game without external distractions. Before each participant started playing, we would explain the basics about movement and character controls. At this point, we would select the test group for this participant, and he would either experiment the game that tried to satisfy the preferences of his personality, or play the game that did the "opposite". In this context, opposite is not in the full sense of the word, since the adaptations are not necessarily opposed. However, we identified that the changes between the first two types(Conqueror-Manager) and the second two types(Wanderer and Participant) are the nearest to opposite.

After the testing session, each player was required to fill to a final feedback form. This form is much smaller than the first, and its purpose is to verify the preferences of the player, as well as the experience he felt while playing. The survey focuses on the five modification points discussed in the previous section (story, difficulty, objectives, resource management, misc), plus some questions regarding the overall game experience, which were based on the DGD model and GameFlow Model.

7. RESULTS

The results from this study suggest a corroboration of the DGD Model. We verified that a positive correlation exists ($r = 0.637$, $p = 0.02$) between the importance of the story and the type of player, as shown in the DGD Model. We also indentified a tendency ($p = 0.072$) that is consistent with the original model regarding the manner in which player type prefers to exert control over certain aspects of the game. We see a clear preference of the Conquerors and Managers for the manual control, while Wanderers show a preference for automated management. We also verified that a positive correlation exists ($r = 0.527$, $p = 0.014$) between the importance of having differentiated paths in the game world/storyline and the type of player. We found a significant difference ($r = 11.275$, $p = 0.028$) between groups when asked about the importance of stylish visual effects. The result is consistent with the assumptions of the DGD Model, which clearly states that Conquerors give more importance to game mechanics/efficiency than visual effects, while Wanderers give higher importance to these effects.

The results we obtained for the GameFlow classification of our game, suggests that Grim Business provides enjoyable experiences. The overall score for the GameFlow evaluation was high, with the near-ideal values for the questions regarding the game difficulty and the number of objectives. Similarly, the values that represent the ease of understanding of the objectives, and the level of immersion are both above 6 (6.76 and 6.10, respectively) in a scale of 7 points.

By looking at the mean and standard deviation results, it suggests that the game difficulty was better adjusted for test group 1 than for test group 2, however, we did not find a significant difference ($p = 0.339$) between the responses of the two groups when asked about the game difficulty. We also found a suggestion that the adjustment regarding the amount of control when buying items was more accurate in the case of group 1 than in the case of group

2, but we did not find a significant ($p = 0.211$) difference between the responses of two groups regarding this variable. The lack of results from the last two variables, may be due to the small number of participants. We found a significant correlation ($r = -0.452$, $p = 0.04$) between the level of immersion and the test group. This means that test group 1 felt more immersed than subjects from the test group 2. This result may be influenced by the non-linear contribution of the other variables, such as the adapted objectives and game story.

8. CONCLUSION

To verify the hypothesis that players who played the game adapted to their preferences would experience an higher enjoyment rate, we selected a representative population for each four DGD types, and then randomly split the sample in two groups. The first group experiment the game with the game adapting to his player type, while the second group played the game adapted to a player type that was not his. The test has three distinct phases: 1. Fill in a survey to infer the player's Myers-Briggs personality type – this would automatically output the corresponding DGD player type as well; 2. Test the game with the solution adapted, or not, to his player type; 3. Fill in a final survey to evaluate the experience that the player felt while playing the videogame.

The results from this study suggest a corroboration of the DGD Model. We verified that a positive correlation exists ($r = 0.637$, $p = 0.02$) between the importance of the story and the type of player, as shown in the DGD Model. The Conqueror type finds story is not to be of great importance, while Managers consider the story important. On the other hand, Wanderers and Participants consider the story crucial, as they develop emotional links with the characters, and enjoy defining their own path in the storyline. We also indentified a tendency ($p = 0.072$) that is consistent with the original model regarding the manner in which player type prefers to exert control over certain aspects of the game. We see a clear preference of the Conquerors and Managers for the manual control, while Wanderers show a preference for automated management. We also verified that a positive correlation exists ($r = 0.527$, $p = 0.014$) between the importance of having differentiated paths in the game world/storyline and the type of player. This result also validates the assumptions in the DGD Model, and can be connected with previously shown correlation between the importance of the story and the player type(one who values story may also value different paths in the same story). We found a significant difference ($r = 11.275$, $p = 0.028$) between groups when asked about the importance of stylish visual effects. The result is consistent with the assumptions of the DGD Model, which clearly states that Conquerors give more importance to game mechanics/efficiency than visual effects, while Wanderers give higher importance to these effects.

To verify the main hypothesis, we tackled the problem in two fronts. The results we obtained for the GameFlow classification of our game, suggests that Grim Business provides enjoyable experiences. The overall score for the GameFlow evaluation was high, with the near-ideal values for the questions regarding the game difficulty and the number of objectives. Similarly, the values that represent the ease of understanding of the objectives, and the level of immersion are both above 6 in a scale of 7 points. Also, the 5.38 score of the game's user interface leaves room for improvement, but can be considered as a good result. The other variable that was supposed to contribute to the GameFlow evaluation was the game pace, but we decided to rule it out because we found the question to be not well formed, and therefore ambiguous.

The other front was the verification that test group 1 had better results than test group 2. By looking at the mean and standard deviation results, it suggests that the game difficulty was better adjusted for test group 1 than for test group 2, however, we did not find a significant difference ($p = 0.339$) between the responses of the two groups when asked about the game difficulty. We also found a suggestion that the adjustment regarding the amount of control when buying items was more accurate in the case of group 1 than in the case of group 2, but we did not find a significant ($p = 0.211$) difference between the responses of two groups regarding this variable. However, the previous verification of the DGD model regarding the manner in which player type prefers to exert control over certain aspects of the game further confirms this suggestion. When asked if the story was adequate to the game, it is hard to see a differentiation between test groups. The same happened when asked about their feelings about the objectives, where the mean and standard deviation is basically equal in both groups. This may be explained by one or the combination of the following factors: the small sample; the fact that the test level is designed in a straightforward way, and that story and objectives are not crucial for the progress in the game world; the fact that game has an high workload, may cause a lack of time for the player to stop and think about the objectives or story. However, we found a significant correlation ($r = -0.452$, $p = 0.04$) between the level of immersion and the test group. This means that test group 1 felt more immersed than subjects from the test group 2. This result may be influenced by the non-linear contribution of the other variables, such as the adapted objectives and game story. Overall, results suggest that our solution is a valid approach to player adaptation, at least in certain types of games, such as Grim Business.

9. FUTURE WORK

One of the main limitations of this study was the small sample of participants. We have verified the feasibility of the work, and for future references, we think it would be important to test the solution with more participants.

In this work, we also validated the DGD Model, which lets us conclude that some adaptations that did not work were probably some misinterpretations of the original model. For example, our intuition about the adjustment of the objectives was not correct. Also, it may be beneficial to improve the way that the objectives and the story are presented in the game, because it does not seem to have a very significant impact on the experience of the player. The problem may also lie in the genre of game that we decided to use for the implementation of the game, and it would be interesting to have it tested on another, completely different type of game.

Obviously, we cannot forget that there is a "prequel" work that still needs implementing. Now that we seen the feasibility of the solution, it is necessary to implement the first part of the solution, that extracts the personality of the player based on his behavior while playing. This presents a very hard challenge, and one that needs to be thoroughly tested with users.

10. REFERENCES

1 Chen, J. Flow in Games (and Everything Else). *Communications of the ACM*, 50, 4 (2007), 34.

2 Charles, D. and Black, M. Dynamic player modeling: A framework for player-centered digital games. (Reading 2004), Proc. of the International Conference on Computer Games: Artificial Intelligence, Design and Education, 29-35.

3 Sweetser, P. and Wyeth, P. GameFlow: A Model for Evaluating Player Enjoyment in Games. *Computers in Entertainment (CIE)*, 3, 3 (2005), 3.

4 INTERNATIONAL HOBO LTD. *Head First: Demographic Game Design: How to make game design as valuable as marketing.* Manchester, 2004.

5 Csikszentmihalyi, Mihaly. *Beyond Boredom and Anxiety: Experiencing Flow in Work and Play*. Jossey-Bass, San Francisco, 1975.

6 Csikszentmihalyi, Mihaly. *Flow, the Psychology of Optimal Experience*. Harper Perennial, London, 1991.

7 Delle Fave, A. and Massimini, F. The Investigation of Optimal Experience and Apathy: Developmental and Psychosocial Implications. *European Psychologist*, 10, 4 (2005), 264-274.

8 Seah, M. and Cairns, P. From immersion to addiction in videogames. In *Proceedings of the 22nd British HCI Group Annual Conference on HCI 2008: People and Computers XXII: Culture, Creativity, Interaction-Volume 1* (Liverpool 2008), British Computer Society, 55-63.

9 Brown, E. and Cairns, P. A grounded investigation of game immersion. (Vienna 2004), CHI'04 extended abstracts on Human factors in computing systems, 1297-1300.

10 Bateman, C. and Boon, R. *21st Century Game Design*. Charles River Media, London, 2005.

11 Bartle, R. Hearts, clubs, diamonds, spades: Players who suit MUDs (1996), 19.

12 Myers, I. B. Introduction to type. *Center for Applications of Psychological Type* (1976).

13 Charles, D., McNeill, M., McAlister, M. et al. Player-Centred Game Design: Player Modelling and Adaptive Digital Games. In *Digital Games Research Conference* (2005), Citeseer, 285-298.

14 Bailey, C. and Katchabaw, M. *An Experimental Testbed to Enable Auto-dynamic Difficulty in Modern Video Games*. In Proceedings of the 2005 GameOn North America Conference, Montreal, Quebec, Canada, 2005.

15 Hunicke, R. and Chapman, V. AI for Dynamic Difficulty Adjustment in Game. *Challenges in Game Artificial Intelligence AAAI Workshop* (2004), 91-96.

16 Thue, D., Bulitko, V., Spetch, M., and Wasylishen, E. Interactive Storytelling: A Player Modelling Approach. In *Artificial Intelligence and Interactive Digital Entertainment Conference* (Stanford, CA 2007).

17 Spronck, P., Sprinkhuizen-Kuyper, I., and Postma, E. Online adaptation of game opponent AI in simulation and in practice. In *Proceedings of the 4th International Conference on Intelligent Games and Simulation (GAME-ON 2003)* (London 2003), 93-100.

18 Larson, J. Myers-Briggs and Four-Type Structure: A principal components and equimax study of the four dimensions of the Myers-Briggs Type Indicator. *Journal of Gustavus Undergraduate Psychology*, 1 (2005).