Analyzing the believability of game character behavior using the Game Agent Matrix

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ABSTRACT
In recent years there has been significant improvement in the simpler actions performed by characters in computer games – such as navigating the world and attacking enemies and similar actions. In previous work, the ability of NPCs to adapt to changing circumstances was found to be inadequate in many circumstances. In order to validate these findings we have studied a total of 20 games, observing NPC behavior in each of the games in many different situations, ranging from everyday town life to combat. Using the Game Agent Matrix, we found a number of different behavior categories related to the social context of the agent and its behavior within that context indicating a gap between the most convincing behavior was focused around navigating the world, using tools and using language, as well as more complex behavior such as social sanctions and ranking, connected to the narrative of the game. The middle ground, containing behaviors such as dynamic group formation and the ability to perceive the actions of others were generally seen as unconvincing.

KEYWORDS

Immersion, believable NPCs, believable behaviour, evaluation

INTRODUCTION
Within the context of computer games, the players' sense of enjoyment is a central issue. A large part of this enjoyment relies on the fact that players become engaged in the world, the characters that live there, and the narrative they help uphold. Lankoski (2004) describes how characters must act within the context of the fictive world in which they live in order to maintain the player's sense of immersion, much like Ermi & Mäyrä's (2007) concept of imaginative immersion, which is the immersion the player derives from being able to relate to the story and the characters in the world. This is similar to the description of believable agents by Loyall (1997), where the author states that agents

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(what we here will call characters) have to be well integrated into a social context and perform actions that seem to be situated within the world in order to seem believable.

In online virtual worlds and multiplayer games this function can to a large degree be fulfilled by other players, but in single player games this task instead falls solely on non-player characters (NPCs). In this paper we will analyze how close NPCs are to seemingly human player behavior (which we term believable behavior) in 20 games. The analysis will make use of an improved version of a previous NPC analysis instrument developed in (Johansson and Verhagen 2011; Warpefelt and Stråat 2013).

We will begin by providing a definition of what constitutes believable behavior, as well as a short overview of previous research within the area. We will then describe our method, and how it has evolved over previous studies. This will be followed by a description of the results of the current study, as well as how it has affected the method. Lastly, we will discuss the implications of this and the next steps that should be taken in order to further strengthen this method.

BELIEVABLE BEHAVIOR

In order for NPCs to be perceived as believable they must act in a way that is appropriate given the context they inhabit. Lankoski (2004) has previously described this, stating that the characters must be designed so that they exist in accordance with the story, and their behavior must be coherent with the personality they are said to have. This is similar to the reasoning in (Loyall 1997; Mateas 1999) who present a number of requirements for believable characters. One of these is *Consistency of Expression* (Loyall 1997) which means that the character must at all times act in a way that is appropriate with the personality, feelings, situation and such of the character. If it fails to do so, the illusion and our expectations are shattered and the character no longer seems believable.

While this may not be a problem in itself, the believability of agents is an integral part of what Ermi and Mäyrä (2007) call imaginative immersion, or what (Adams 2010) calls narrative immersion. Since single player games utilize NPCs for many of the tasks that make the world feel alive, NPC behavior that is not believable threatens to disrupt the player's sense of immersion, since those behaviors are incoherent with the player's expectations in regards to the story – thus violating the consistency principles (Lankoski 2004; Loyall 1997; Mateas 1999) and the narrative coherence (Mateas and Stern 2003).

PREVIOUS EVALUATION METHODS

Previous research has provided methods intended to describe the quirks, failings and problems of NPC behavior and believability. One example of such is (Lankoski and Björk 2007a) where the authors use design patterns to describe the behavior of an NPC in Bethesda's The Elder Scrolls IV: Oblivion. This was expanded to include a number of other games in a later study (Lankoski and Björk 2007b). While Lankoski and Björk's approach provides useful data, consisting of near 300 individual patterns proposed in a series of publications, these patterns do not seem to be created in order to be used for analytical purposes.

As an alternative, (Johansson and Verhagen 2011) based an analysis of NPC behaviour on the Model Social Agent (Carley and Newell 1994). The Model Social Agent matrix is a tool to compare different sociological theories based on agent models and amount and type of knowledge taken into account by the agent. It encompasses the whole spectrum of human social behavior, and thus was deemed useful for analyzing the closeness of NPC

behavior to what would be expected from humans. Using the matrix to find what behaviors are less well represented, one can determine weaknesses in the behavior repertoire of the NPC and its knowledge of the situation in which it is acting. This analytical tool has clear ontological boundaries compared to the design pattern as proposed by (Lankoski and Björk 2007a; 2007b). A few alterations were made in order to develop this analytical tool further and to address the drawbacks encountered with the social fraction matrix (cf. Johansson et al. 2013; Warpefelt and Stråat 2013). This also helped to adapt the tool for the game domain, and resulted in the matrix seen in figure 1.

The Game Agent Matrix

The Game Agent Matrix (GAM) (Johansson et al., 2013) is focused on the evaluation of the *exhibited behavior* of a non-player character. In the GAM, the rows describe the maximum level of social interaction that a character is capable of. These are partly derived from the agent categories identified by (Russel and Norvig 2009), where the acting and reacting agents roughly corresponding to simple reflex agents and model-based reflex agents, respectively. Interacting agents are an expansion on this philosophy, and the different agent types are characterized as follows:

- An acting agent does not interact with other entities in the world, but instead acts completely by internal volition. While it is aware of the physical structure of the world, it is only so to the degree that it can navigate static obstacles. It is completely unaware of other entities acting in the world, i.e. players or other characters. In essence, an acting character views everything as rocks that may need to be navigated around.

- A reacting agent has a greater degree of awareness of the world, but only to an extent that it can adapt to changes in the social environment. If it does perform social interaction, this is in response to simple stimuli, such as another entity moving within a certain range. Reactions are often repetitive and predictable, and the results from previous interactions are not remembered – it will gladly answer the same question multiple times in a row. A reacting agent is aware of the existence of other entities in the world, but is not capable of modeling their internal state. It may have a model of its own internal state though (model of self).

- An interacting agent exhibits a much larger degree of social capability, and is able to alter its behavior to match changing social situations, for example acting to maintain norms within the culture or taking turns in conversation. Behavior is generally characterized as being varied and able to in a flexible way carry social interaction, rather than the repetitions exhibited by the reacting agent. An interacting agent is aware of other entities in the world and can model their internal state.

The columns in the GAM describe the different environments in which an agent (or NPC) acts. These are mostly reused from the Model Social Agent matrix (Carley and Newell 1994). As can be seen in figure 1, not all cells in the GAM have values assigned to them. This is a product of the agent types described above. It would not be useful for an acting

	Single Agent	**Multiple Agents**	**Social Structural**	**Social Goals**	**Cultural Historical**
Act	Goal directed **Route following** Uses language Uses tools	N/A	N/A	N/A	N/A
React	Adaption Acquires information Crisis response Interruptability **Awareness** Models of self Rapid emotional response **Navigation**	Learns from others Models of others	Class difference Mob action Social ranking	Disillusionment	Advertising Institutions Roles
Interact	N/A	Face to face Group making Social interaction Turn taking	Coercion	Clan Wars Cooperation Group conflict Patriotism Power struggles Team player	Etiquette Norm maintenance Sanctions

Figure 1 The game agent matrix

agent to have any values available further right than the *Single Agent* columns, since it is by definition unaware of other entities. Conversely, there can be no values for the intersection of *Interact/Single Agent* since there can be no interaction with only a single agent, and all the relevant values are already covered by lower level agent types since these are subsets of a complete *Interacting* agent.

The values in the cells of the GAM are derived from the Model Social Agent matrix, where we have used the results from (Warpefelt & Stråat 2013) to position the values in the cells in the matrix. The ambiguity of the value *Lack of Awareness* in the Model Social Agent matrix caused us to reformulate it as *Awareness*. Two additional values specific for games that were added to the GAM in (Johansson, Stråat, Warpefelt & Verhagen, 2013) are *Route following* and *Navigation*.

METHOD

This study uses a methodology based on observations of NPC behavior in games where game sessions are recorded and the games are played by "playing the game as a player would" – i.e. by following the story line in the game as well as roaming around the game world (to the extent that the game allows it). The gaming sessions were captured as videos for later analysis, resulting in a library of videos captured from a number of games. The video recordings were then analyzed using the GAM (figure 1). NPC behaviour was taken at face value from a black-box perspective. As such, we do not take

into account the implementation details of the NPCs. We compared the NPC behavior in different situations to the values in the matrix for that situation. Each value was graded as positive or negative, strengthening (i.e. behaving as expected) or weakening (i.e. behaving counter intuitively) immersion.

Included games and the selection thereof

The games included in this article can be seen in table 1. They were selected from big-budget studio titles (what is normally called an AAA title), were not older than 10 years, and were games where the player takes on the role of one character at a time. These criteria were chosen in order to ensure that the games were fairly recent, and that the developers had a large enough budget to not completely disregard the artificial intelligence components of the game. The limitation on only controlling one character at a time was enforced in order to keep the social interaction more recognizable, and to avoid misunderstandings . Since we re-used the data from our previous study (Warpefelt & Stråat's study 2013), we are also bound by these selection criteria. While they do limit the scope, they serve the purpose of examining modern games with fairly large player bases.

ANALYSIS METHODOLOGY

The data collected was analyzed in order to elicit findings in regards to two aspects; the ability of the GAM to describe the behavior of NPCs, and the believability level of the behaviors commonly exhibited by NPCs. We analyzed which values in the GAM that occurred in the different games, and if any sort of clustering of values can be seen. Since severity was not the focus point for this part of the evaluation, we only counted each grading/value pair (i.e. *Adaption*/*Negative impact*) once per game.

Title	Developer	Year	Description
Assassin's Creed: Revelations	Ubisoft	2011	Historical fiction role playing game
Dragon Age: Origins	Bioware	2009	Fantasy role playing game
Dragon Age 2	Bioware	2011	Fantasy role playing game
Fable 3	Lionhead Studios	2011	Fantasy role playing game
Fallout 3	Bethesda Softworks	2009	Post-apocalyptic role playing game
Mass Effect	Bioware	2007	Science fiction action role playing game
Mass Effect 3	Bioware	2011	Science fiction action role playing game
The Elder Scrolls III: Morrowind	Bethesda Softworks	2002	Fantasy role playing game
The Elder Scrolls IV: Oblivion	Bethesda Softworks	2006	Fantasy role playing game
Vampire, the Masquerade: Bloodlines	Troika Games	2004	Modern horror role playing game
Warhammer 40,000: Space Marine	Relic Entertainment	2011	Science fiction third person shooter

Table 1 Games included in study

We also examined the descriptions from the in-game videos where negative values were encountered for similarities in how problematic behavior in relation to a value was exhibited by the NPCs. This enabled us to identify common problems across the different games. Furthermore, this allowed us to find indications if any values in the GAM were difficult to use, or if the GAM is lacking in descriptive capability.

RESULTS

The results for this article will be presented per value, sorted after social interaction and agent types in the GAM (figure 1). This is intended to give an overview of how each value relates to existing situations. In order to keep this section concise, we will present the results relating to the most commonly occurring values, followed by a short overview of the less commonly occurring values. The definitions of the values will be presented as needed. One exception to this is the section regarding *Navigation* and *Route following*, since the difference between these two values warrants extra explanation.

Act/Single agent

Uses Language and Uses Tools

Uses Language and Uses Tools are "*Use of spoken or written language*" and "*Use of implements in order to seemingly achieve some sort of goal*", respectively. These strengthened immersion in all games, and were never problematic from a believability standpoint.

React/Single agent

Adaption

Adaption is defined as "*Able to adapt to changing social circumstances in the world at the given time*." Problematic situations relating to adaption broadly fall into two categories; either the NPC fails to adapt to improve its situation, or it adapts in such a way that its situation worsens.

The first case (failing to improve) is exemplified in *Dragon Age: Origins* where an archer fails to move into position to fight the player and her companions. In the scenario, the player approaches a group of gnolls who are distributed along a ridge and the slope up to the hilltop. Two archers are on the ridgeline, and some gnolls with melee weapons are blocking the player party's path up to the top. As the player party advances, the archers lose line of sight to the player and her companions. One of the archers then moves into position, while the other stands still. In this case, the latter archer failed to adapt in such a way that it could continue firing on the player. While this could be construed as a stratagem on the gnoll's part, the player party would have free access to the archers if the melee gnolls go unsupported. As such, the second archer's behavior is not believable given the situation.

The second case (adapting to a worse situation) is exemplified in *Mass Effect 3* where hostile soldiers change position so that they leave an advantageous position in cover in order to take up positions in worse cover, where they are in the crossfire between the player and his companions.

Awareness

Awareness is defined as "*Aware of something in its immediate vicinity.*" The problematic situations related to this value generally arise either when the NPC, as per the definition, is unaware of something that it should feasibly be aware of or when it is aware of things that it should *not* be aware of.

The first case, lack of awareness, is exemplified in *Morrowind*, where the player can go into private residences and sleep in people's beds. The owner of the bed never seems to notice that the player is doing this, even if the player does so directly in front of them.

The latter case, hyperawareness, is exemplified in *Mass Effect 3*. As the player and his party approaches an ambush, one of his companions suddenly yells "*Look out, ambush!*" While this is in itself not unbelievable, the player and his companions were heading up a slope and the player was ahead of the companion who made the warning. At the time the warning was given, it would have been impossible for the companion to see any ambushers that the player could not see. As such, the companion seems hyper-aware of the world, to a degree that he can perceive enemies through several meters of rock and steel.

Interruptability

Interruptability is defined as "*Able to stop doing what it is currently doing when another task takes priority.*" As can be discerned from the definitions, problems related to this value arise when NPCs are unable to switch tasks in response to stimuli. This is exemplified in *Assassin's Creed 2*, where an NPC gives the player a tour through Istanbul while providing plot exposition by talking about what has happened in the city. If the player lags behind or leaves the NPC's side, the NPC will still continue talking as if nothing had happened, even if the player is far away.

Models of Self

Models of Self is defined as "*Knowledge of its own existence as an entity, physical or mental.*" This often manifests itself as NPCs being unaware of actions being performed on them, such as attacks. One common problem, existent in for example *Dragon Age 2*, is that NPCs seem to fight to the bitter end. They will not run away when badly hurt, but instead fight until they drop. This indicates that the NPCs are unaware of their own limitations in durability.

React/Multiple agents

Models of others

Models of others is defined as "*Awareness of the existence of other agents, where they are and what they are doing*." Problems related to this value often manifest themselves as NPCs not being aware of other agents and their action, which results in them ignoring evident dangers or hints. This is exemplified in *Dragon Age II*, where an NPC walks straight into an ongoing fight between the player party and some other NPCs. She keeps walking amongst the combatants, blatantly ignoring miscellaneous sharp implements and fireballs flying all around. A further example is given by an *Argonian* (lizardman) in *Oblivion* who lets the player push him into a canal without protest, and then greets the player warmly when he jumps in after the Argonian. As the player pushes the Argonian, he turns his head towards the player and is plainly aware of the player's existence. However, he does nothing to forestall his watery fate.

Interact/Multiple agents

Face to face

Face to face is defined as "*Turns towards the entity it is addressing*." Behavior related to this value was most often very well performed, but failed in some cases. A notable example is *Dragon Age: Origins*, where NPCs would sometimes fail to turn towards the player when speaking to her, without this being an intentional social cue or a special dramatic measure. Conversely, the aforementioned example with the Argonian from *Oblivion* is an example of well-performed behavior in relation to Face-to-face.

Route following & Navigation

Route following is defined as "*Able to transport itself across open ground between two points in the world*", and Navigation is defined as "*Able to dynamically adjust its route through the world in order to account of for unexpected obstacles.*" As can be seen here, Navigation is essentially a higher-order function of Route following. It should be noted that while Route following and (to a lesser extent) Navigation are often problematic in older games (such as *Morrowind* and *Oblivion*) the problem has greatly diminished in newer games, and is almost relegated to a non-issue in the case of Route following.

Navigation is, however, still somewhat problematic. For example, NPCs called *Keepers* in *Mass Effect 3* are unable to navigate around the player, but instead push him a few meters before stopping.

Less common values

Among the less common values, those belonging to the bottom right corner of the GAM (figure 1) stand out. While *Advertising, Institutions, Roles* and *Group Conflict* only served to reinforce immersion, *Cooperation, Etiquette, Norm maintenance* and *Sanctions* were problematic. However, behavior related to all these values were often stilted and seemed pre-arranged – as if the NPCs were controlled by some sort of shared cognition. While this did not impact believability negatively in some cases, it does carry room for improvement. NPCs would often fail to uphold norms, point out breaches in etiquette or to apply sanctions to undesirable behavior. One example of this is from *Space Marine*, where we found that friendly NPCs did not react at all when fired upon by the player, but instead continued with what they were doing as if nothing had happened. A similar situation occurred in *Fable 3*, where the player cannot harm NPCs unless they explicitly enable that function. If one fires on NPCs without enabling the harm function, the shots will go wide. However, none of the NPCs reacted when fired upon when the harm function was disabled.

Results not mapped to a value

We have also found that the GAM (figure 1) may not be able to account for all aspects of NPC behavior. We have found that one problem with NPC believability is that they have no memories regarding previous interactions with other characters, an issue also mentioned in (Johansson et al, 2012). In many games we found that NPCs would say the same thing if asked the same question, or just repeat a general statement such as gossip. While some NPCs had a few different things to say, they would never tell the player to stop bothering them.

CONCLUSIONS AND DISCUSSION

Conclusions regarding the Game Agent Matrix

In performing this research we have found some indications that there may need to be some changes done to the GAM. For example, *Face to Face* may be slightly misplaced, since it does not really signify *interaction* as much as an acknowledgement of the existence of other entities. As such, it may be prudent to move it to the intersection of *React/Multiple Agents*. Furthermore, the problem of NPCs not remembering interactions has proven to have a negative effect on believability. Therefore we will add a value called *Memory of Previous Interactions* to the cell intersected by *Interact/Multiple Agents*. This placement is derived from the fact that a Reacting agent by definition does not remember interactions, whereas it is a requirement for Interacting agents. The choice of column is derived from the absolute basic situation needed to perform the task – i.e. more than one agent. The definition for the value will be "*Remembers previous interactions of note, both direct (conversations) and indirect (seeing each other at a significant event).*" As such, an agent would be required to remember characters it had previously talked to or met at a party, but not characters it had passed in the street.

We have also found that some values often appear simultaneously. For example Adaption and Interruptability were often coupled. While these have similar definitions, they portray different sides of the same coin. It is often the case that the failure of one induces the failure of the other. A similar relationship exists between Adaption and Models of Others.

Furthermore, the problem of NPCs seeming like they are controlled by a shared cognition is complex. However, we believe that it is a problem of representation in regards to the *Awareness* and *Acquires Information* values. Acquires Information is defined as "*Observes the world and seemingly gathers information on which to act*." In essence, where Awareness is passive gathering of information, Acquires Information is the action of actively gathering information. It would seem that the collective intelligence-like behavior we saw in our observations is derived from the fact that NPCs are acquiring information without seeming to do so, which makes it seem like they are passing information without communicating. If NPCs were to act out the acquisition of information in a more visible and individualistic manner, many of these issues would likely disappear.

There is also an interesting gap in the behavior of NPCs. While we get frequent hits in the *Single Agent* and *Multiple Agent* columns, as well as the *Cultural Historical* column, the middle columns (*Social Structural, Social Goals)* are often not represented in the games. Furthermore, behavior related to values in the *Cultural Historical* column often suffer from the collective intelligence problem mentioned above. In essence – simpler behaviors such as those found in the intersection of *React* and *Single Agent* are generally in evidence, as is to some extent the behaviors from the *Interact/Multiple Agents* cell – but more complex behaviors are severely lacking.

These problems collectively lead us back to the statements made by Lankoski (2004) and Loyall (1997): NPCs need to exhibit behavior consistent with the environment, the situation and their character in order to seem believable. However, in order for this behavior to actually be convincing, it must also be in cohesion with the context in which it is performed. While this is an important part of how our evaluation is performed, the higher-level evaluation of if the behavior fits the situation is outside the scope of our study.

We believe that the game agent matrix (figure 1) could support game developers in pointing out some of the important drawbacks of the social aspects of NPCs. It further points out a gap in the behavior potential of NPCs consisting of the social situations starting with the multiple agents towards richer and more complex social situations such as cultural historical in combination with react and interact agent types in the GAM (figure 1). The GAM pinpoints these drawbacks in a concise way that would be beneficial for the development and testing of more sophisticated NPC behaviour, more coherent with the studies on believability by (Lankoski & Björk 2007a; 2007b; Mateas 1999; Loyall 1997)

FUTURE WORK

Future work will be directed at refining the GAM further, evaluating the findings from the data collecting activities and analysis of this article. Further, additional data collections of more games with a broader scope to cover more genres will be considered.

The social gap of current NPCs will be investigated further and finally the game agent matrix will be evaluated through interviewing game developers. These interviews will answer the suitability and usefulness of the GAM relating to their experiences and the need for social believability in NPCs. A last step in the evaluation and refinement of the GAM will be done through mapping the game design patterns as proposed by (Lankoski and Björk 2007a; 2007 b) to the GAM, in order to capture relevant aspects of believability in NPCs.

Finally, testing how the potentially immersion strengthening and breaking behaviors are evaluated by players would indicate what is acceptable and not acceptable by players.

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