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17. ENHANCING GAMEPLAY: CHALLENGES FOR ARTIFICIAL INTELLIGENCE IN DIGITAL GAMES

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ABSTRACT

Computer power in recent years has been advancing very rapidly and as increasingly more Artificial Intelligence (AI) experts turn their attention to game design, there is a clear opportunity to think more radically about digital game AI design. We suggest that not only is it timely for significant AI innovation but that it is essential to appreciably enhance key interactive aspects of digital game design, create opportunities for novel gameplay scenarios, and to progress the medium as an art form. Issues arising from the enhanced utilization of AI in digital games are discussed and the implications for gameplay explored; such as affecting player emotion, moral dilemmas, player created stories, dynamic and adaptive game worlds, and character believability.

KEYWORDS

Artificial Intelligence, dynamic learning, gameplay

INTRODUCTION

AI is currently one of the buzzwords in the games industry, whether in game reviews, publicity or conferences, and in recent times the quality of a digital game AI seems to be discussed almost as much as the quality of graphics and other technical game aspects that relate to gameplay. The reason for this is obvious; when the game AI is well designed it can significantly enhance the game player experience and enjoyment, and it then also becomes a key selling point for the game – Halo (Microsoft, 2002) and Half-life (Sierra, 1998) are good examples of games that have benefited considerably from a high quality of AI. Nevertheless, while most games over the past four decades of game development have had at least a rudimentary element of AI, most digital games have only been able to allocate limited processor time to the game AI compared to other aspects of the game program. As a consequence game AI design has tended to be more functional than revolutionary. However, now as the computing power of our gaming machines increase to incredible levels and more of the graphics processing and game logic moves from CPU to GPU, we have begun to see more resources becoming available for AI. Perhaps understandably, most of the new computing resources that have become available tend to be used up immediately with incremental improvements of existing AI technology. Many of these improvements simply utilize the additional processor time so as to make existing AI routines more accurate, as with path-finding, or more refined, as with finite state-machine models. These more incre-

mental improvements are important, of course, but a case may be made for a more radical consideration of AI strategies and architectures within our digital game AI design.

In this paper a range of issues and ideas relating to the current state of digital game AI are explored. We then examine some recent, novel research and development, and move on to discuss a number of areas within game design in which the use of innovative AI can significantly enhance the variety and quality of gameplay within digital games.

THE CURRENT STATE OF AI IN DIGITAL GAMES

In the early days of arcade videogames, releases such as Space Invaders (Midway, 1978), Pac-man (Namco, 1981), and Donkey Kong (Nintendo, 1981) used very elementary Artificial Intelligence that tended to comprise of a few straightforward rules and scripted events/sequences. Combining these approaches with an element of randomness in the decision-making enables behaviour to become less predictable, and a reasonably adequate illusion of intelligence was created. Many modern games also contain simple AI structure and adhere to a few straightforward principles such as: make the AI visible to the player, create AI in the mind of player and inject a small amount of randomness to AI calculations [10]. Add to this that a primary goal for implementing AI within a game as that of providing believable, expected, and consistent actions and behaviour [18], then we have a commonsense set of heuristics that form a good foundation on which to construct the AI for a game. The central message is straightforward; a player must believe that intelligent behaviour is being exhibited; otherwise any AI coding in the game – irrespective of how clever – is much less effective (except it improves game efficiency). The disparity between the amount of effort required to create effective AI and the gains that are clearly visible and accessible to the player, is one of the main reasons why the use of AI in digital games has generally stabilised to a fairly straightforward and widely adopted standard model. The majority of games still use a fairly limited set of AI technologies such as finite-state machines for character and object behavioural AI, path-finding techniques – normally variations on the A* algorithm [17] – for character and vehicle movement, and an assortment other techniques such as event scripting, and a variety of decision making techniques. Over-riding these approaches is the general view that the use of illusion to provide an impression of intelligence is seen to be adequate or even superior to methods that attempt construct more realistic and complex models of intelligence.

If different genres are examined separately quite a coherent picture emerges of the types of AI used in particular formats of games. In racing games, for example, such as Gran Turismo 3 (Sony, 2002), the AI primarily involves the control of an artificial opponent in order to follow an optimum path on a racetrack (or similar) and may incorporate a higher-level plan in order to successfully navigate the course. The pace of games within the Real Time Strategy genre is not as frantic as in others, and so there is generally comparatively more processor time available for the AI. Games such as the StarCraft (Blizzard, 1998), and the Command and Conqueror (Virgin Interactive, 1995) series are among the best examples within this genre and demonstrate that most of the AI games of this type contain AI comprised primarily of predefined behaviour, high level tasks and strategic planning. However, because of the extra processing time available for AI in these games there is an opportunity to use more interesting and traditional AI techniques such as an expert system to drive the strategic planning of the game units [19]. The Adventure Game genre on the whole has a more gentle format

than a full-blown action game, though it may have elements of fast-paced action the modern adventure game is as likely to have a comprehensive set of puzzles to solve, such as in ICO (Sony, 2002) or Tomb Raider (Eidos Interactive, 1996). As with pure action games the artificial non-player characters (NPCs) in the game normally have their behaviour defined by a finite state-machine, and will also be given some rudimentary path-finding ability to track and chase the player character. The use of AI in this genre is perhaps not too "adventurous" because the gameplay is generally quite linear and directed – the focus of the gameplay is on exploration and problem solving. The Action Game contains some of the most frantic gameplay and the purest form from within this genre is the 1st person shooter (e.g. Doom – ID Software, 1993), and in particular the multiplayer varieties of the genre (e.g. Unreal Tournament – GT Interactive, 1999). Encounters between the player and game opponents are central to games of this type and as such a more complex and efficient character AI is generally required. The standard planning, path-finding and state-machine AI architectures are usually built into the NPCs as in action-adventure 3D games but often a significant effort is made to improve the effectiveness and believability of the artificial player opponent. Some innovation in the design of AI has taken place within this genre, for example, genetic algorithms and neural networks have been used to train Quake and Unreal Tournament "bots" off-line so that they will have an enhanced capability to react dynamically to unpredictable scenarios within the game. In recent years, games such as Half-life (Sierra, 1998) and DeusEx (Eidos Interactive, 2000) have demonstrated an evolution of the 1st person shooter action game to provide a very much more varied gameplay experience, and games of this type may now contain elements of role-play, adventure, action, and puzzle. This provides more opportunities for using unusual AI technologies, for example, intelligent story-telling is much more of a possibility. Half-Life was one of the first games to effectively use a flocking algorithm to simulate intelligent group behaviour in opponent troops. Along with Action Games, the Role Play (RPG) genre holds a lot of appeal for those us who are interested in developing more effective AI in digital games. Virtually all modes of digital game AI are applicable to this genre: player and non-player AI state-machines, path-finding, player-alterable AI scripts, developing story lines, intelligent environmental reactions, etc. An interesting example of an AI technology is within the game Baldur's Gate (Interplay, 1998), which provides the player with the option of changing some of the basic AI behaviours of their characters. Within the Simulation genre we have the social simulation game, The Sims (Electronic Arts, 2001). Love it or loath it, this style of game lends itself to interesting applications of behavioural character AI. The game is a bit like a Barbie (or Ken!) with a brain – you get to dress and house your player character (PC) etc. and your PC is also able to interact with the environment and other NPCs. The potential set of rules for a PC to learn is huge so preferably AI architecture should not be entirely rule based and the PC should continue to learn as the game progresses. The Sims is probably the first game to use "intelligent objects" in that each object in the Sim household radiates signals to a nearby Sim to pass information about it's status – e.g. a fridge could tell a passing Sim that it presently contains food.

In general, there has not been a great deal of ground breaking AI innovation in commercial digital games for reasons that has been previously discussed, and apart from the examples described above there have only been a few notable exceptions. For example, neural networks have started to be used more in games (e.g. Black and White), genetic algorithms have been used for training NPCs (e.g. the Quake series), and

various artificial life techniques have been adopted for unique gameplay scenarios (e.g. Creatures, Warner, 1996). There are also some promising signs of evolution in AI design within a few up-coming games such as Half-life 2 (Sierra, 2003) which promises contextual AI with regard to the environment, and Fable (Microsoft, 2003) in which the game environment and the non-player characters within the game world are said to respond dynamically and persistently to the exploits of the player.

THE CASE FOR AI INNOVATION

Not all game genres will benefit to the same extent from our pushing at the boundaries as to what constitutes AI within games, but there are a few central issues that can motivate us to consider our approach to AI design across the genres.

Quality AI Lends Itself to Enhanced Gameplay

One of the primary goals in producing a commercially successful digital game is to create a game with a high quality of gameplay – i.e. that the game plays well. Ultimately, this also has to be the primary purpose for coming up with new uses of AI for games and more fully exploiting AI technologies within games. Innovative AI approaches may bring increased responsiveness or speed in the game control mechanism, more believable AI, flexible character behaviour, or enhanced graphics, but in general the prospective game player will not care about these improvements except they are an integral part of what makes the game enjoyable to play [19]. So one of the fundamental goals of AI innovation within digital game design and development must be to enhance gameplay while maintaining or improving game efficiency. For example, in the crowded genre of 1st person shooters it is difficult for games to stand out from the crowd. One way for a game within this genre to make a greater impression in the face of the competition is to have a better or more believable AI. Half-Life (Valve, 1999) is a good example of recent of game that demonstrates at least one well-designed element of AI that significantly adds to the quality of gameplay. With Half-Life, the AI strong point is co-operative opponent behaviour, and the quality of the design of the AI in this game is such to make us consider our strategy as a player carefully. The artificial opponent seems to have an intelligence plan, which it appears to be able to adapt on the basis of player behaviour and how the encounter with the player pans out. The consequence of an improved game AI design and implementation for the player is that the game provides a more rewarding and interesting challenge than it would have done otherwise.

AI Innovation Leads to Novel Design and Gameplay

Related to the previous factor is the point that innovation of AI can lead new game design formats and gameplay scenarios. Although the games industry has become a very large market and it continues to grow at a steady rate, it may be argued that there is greater intellectual property poverty [14] per game than there has ever been. No doubt this is a complex issue and the reasons for the limited amount of innovation in the industry may be due in part to the financial pressures of publishers and their need to remain profitable (or survive in some cases). Nonetheless, the industry needs to continually revitalise and refresh itself otherwise it will stagnate, and one of the ways to avoid this inertia is through the addition of novel game compositions and gameplay scenarios. AI is still a largely untapped aspect of game design and may be utilised more fully to innovate in game design and gameplay. We will examine a few of examples of games that have attempted or promised innovation with AI in the next chapter, and we will progress to a discussion on the potential for innovation in future games.

Improved AI Increases the Degree of Immersion in a Game

Assuming that a player can initially be persuaded pick up and play a game, the responsibility of the game designer is to engender in the game player the desire to have "just one more go" and to encourage the player to keep coming back for more. One of the illusive characteristics that we pursue in game design that may add to the "addictive" nature of gameplay is game immersion. The Artificial Intelligence in a game is perhaps one of the most influential ingredients for enabling a game player to suspend disbelief long enough to become properly immersed into the gameplay. If characters or objects behave in an obviously unexpected – or unintelligent – way, then the game experience is very much diminished. The quality of graphics in digital games has reached an incredible degree of realism, as witnessed by games like Doom III (ID Software, 2003), and realism of visuals is important, of course, because many of us enjoy the "wow" factor afforded by the visual impact of the newest and most graphically advanced game – this facet clearly sells games. Visual realism is only a part of what makes a game world and the characters in it believable, if any aspect of the game shatters our immersive gameplay experience and we are less able to suspend disbelief within the game world. In other words we may have a beautifully created wall using the latest vertex and pixel shader programs to enhance the illusion of the game world existence, but the illusion is shattered when our supposedly intelligent character continually bangs his head off the wall in an attempt to get round it! This is only a simple example that we can all relate to, especially if we play games of the RPG (role play game) genre, but there are many other examples of AI behaviours in games that have a negative impact in our immersive gameplay experience. While many other immersive aspects of games have been enhanced substantially, innovations and enhancements in AI have been relatively slow.

Widespread Appeal

Perhaps not an obvious or much discussed issue relating to digital game AI but an important one nonetheless – that of attaining a more wide-spread appeal to entertainment of playing digital games. We need to keep the state of the games industry in perspective, the games industry continues to grow rapidly but it still represents only a small percentage of the entire entertainment and media industry. Even though there are a wide range of age groups playing games now, thanks in part to the release and marketing of the PlayStation and the more mature content of PC games, there is still a wide range of people who simply never even try to play a game, or simply give up after a short attempt. This again is a complex issue and relating as much to inherent negative perceptions about games and general apprehension in trying something new, but enhanced AI can play a role in the creation of gameplay that appeals more widely, either through new styles of gameplay or simply by enabling the game to recognize and react to a variety of abilities in a game player. Whether digital game playing will reach the level popularity and participation of the medium of film or whether the interactive nature, and investment of time will continue to be a bar for many, time will tell, but we can certainly encourage more people to enjoy playing games by using AI to create more dynamically adapting game environments, characters and stories. AI methods may be incorporated into games that are more intelligently interactive with the player and respond to the needs and desires of the individual player.

Digital Games as an Art Form

Related to the issue of widespread appeal, is that of the digital game as a medium for art. It may be said that the use of a digital game as canvas for art seems contrary to the goal of gaining more widespread appeal; after all art-house movies rarely

make as much money as a Hollywood blockbuster. However, it may be argued that for the industry to grow and for it to be seen less of an extension of the toy industry and more as an integral part of the entertainment industry, that games need to be developed that have an artist appeal and gain general critical interest. We are not particularly close to this goal as yet, and there are many innovations in game design and technology that are still required to more fully enable digital games as an interactive art form. We may move closer to this objective by creating more believable and dynamic emotions within characters, particularly in facial expressions. By developing more dynamically adaptive game worlds and characters for player-specific story generation, and including effective mechanisms for affecting more wide ranging emotions in a game player other than just fear and humour – e.g. sadness. As will be illustrated in the next section AI can have a large part to play in the pursuit of artist goals.

KEY AREAS FOR AI INNOVATION

In this section three key areas for research and innovation in digital games are highlighted: storytelling, dynamic learning, and affecting emotion. The importance of each of these to the development of improved or novel gameplay in future games is outlined and reference is made to some of the current academic research in the area.

Storytelling

A recent – and perhaps ongoing – debate relates to the role of storytelling within digital games [8]. While this dialogue has primarily been instigated by academics with an interest in game culture, it is still important for more technically focused digital game researchers understand the limitations for innovation with narrative and storytelling within the context of interactive entertainment. Aarseth [1] states that stories and games are "orthogonal concepts", and this draws attention to the inherent inequality between traditional narrative methods and the interactive medium of digital games. Nonetheless, it is clear from the evidence of recent, commercially successful games, such as Half-Life (Sierra Entertainment, 1999), DeusEx (Eidos Interactive, 2000), Baldur's Gate (Interplay, 1999), and Warcraft III (Blizzard, 2002), that the development and telling of a story within interactive digital games is not entirely uncorrelated with less interactive media such as books, audio, cinema and particularly with verbal narrative. These games have been successful because the designers associated with these games have learned that they are not simply telling a story as you would in a less interactive medium such as a book or movie. They have understood that the implementation of a story within a digital game is not independent from the construction of the game levels and characters but that the game story must be considered as a wholly integral aspect of the game design and the game world, from the beginning of the design and development process.

The central issue is interactivity – digital games are created in essence to engage a player to actively participate. Although there are incidences of interactive theatre [3], interactive play environments [4] and, for example, a mother may dynamically change a storyline based on feedback from her child, by-in-large most story-telling media apart from digital games require a mainly passive participation. Due to the interactive nature of digital games and other issues, such as game non-linearity and player led gameplay, it is quite natural that we attempt to use Artificial Intelligence to enhance the use of story within games. Recent research in this area has included methods for the intelligent control of camera in interactive storytelling [5], and approaches for the automatic generation of narrative within a game world from story scripts [24]. Although there has

been substantial improvement with the integration of story into single player games, especially in RPGs, there is still a considerable challenge – and opportunity – for AI design within specific genres.

As a case study let us consider an RPG sub-genre that has a lot to gain from an advancement in intelligent story telling or building – the MMORPG. The 3rd generation of MMORPGs are now upon us and it remains that within this genre the crucial element of story development and a player's dynamic relationship with the world is still rather limited and perhaps even stale; every player character in essence experiences the same story, which is developed through a combination of NPC interaction, mission/quest completion, monthly episodic releases, and explicit story quests (sometimes known as "vaults"). In current MMORPGs, players act out an individual story by simply playing the game in their own way and through the development of unique characters – this is particularly true if the player fully engages in role play. A player may gain some degree of fame or notoriety in front of other game players through inter-player co-operation and the culture of game fan websites. Although, this may be an effective strategy for a certain demographic of player, the majority of players prefer their gameplay experience to be contained largely to the game world. Within current MMORPGs a player character's story is still not communicated very effectively to other players sharing the same game world and the dynamic relationship between individual characters and the game world is still very limited. The challenges for interactive story development in MMORPGs are undoubtedly due to the massively multiplayer format of these games, as well as the size and persistent nature of the game worlds. However, these same factors also make it a necessity and even a priority that more interactive and dynamic technologies are developed. At the same time, these characteristics also present considerable opportunity for game designers to create enriched, rewarding, and unique gameplay experiences with strong story elements. The development of efficient, intelligent methods and the creation of tools to set up more complex interactive mechanisms are essential in the pursuit of these goals.

Dynamic Learning

Learning technologies for digital games have become increasingly important [20]. Yet, while there a number of examples of games that use "off-line" learning – for example, Quake III Bots may be trained using artificial neural networks or genetic algorithms – there are only a few examples of games that explicitly use "on-line" dynamic learning within a game. Black & White is the most high profile example of a recent game that utilises in-game learning – neurons are incorporated into an AI module for the game avatar, and these neurons are iteratively re-trained based on game feedback. The game uses a form of Perceptron [21] learning within modules, for example, to model an avatar's desire [9]. The output of the neuron providing a measure of desire based on inputs which represent levels of "desire sources" for avatar attributes, such as: hunger, tastiness (of food), and unhappiness. The agent architecture is loosely modelled in the first place from psychological/philosophical ideas.

Social simulation games such as The Sims (Electronic Arts, 2001) naturally lend themselves to dynamic learning; these games are based on interaction between characters and objects due to environmental and social input. A character makes decisions within the game based on their current state and the state of the environment, for example if a character is hungry and they are close to a fridge containing food then they will prepare some food and eat it. A character may change their prefer-

ences or reactions over the period of the game based on "experience". Some academic research has begun in this area, e.g. [15], to create intelligent social controllers for agents that represent non-player characters. While dynamic learning is a very desirable feature in digital games for many reasons, e.g. dynamic game balancing to adapt to different player gameplay styles and qualities, it can be problematic to set up. The most significant issue with the implementation of this type of technology is that on-line learning can on occasion produce very unpredictable results; sometimes these effects serve to enhance but more often it leads to erratic game behaviour that reduces the quality of gameplay, and in worse scenarios will introduce dynamic game bugs. Testing, debugging and balancing games that incorporate learning is quite a challenge [2]. There are many obstacles in the way of developing generic, robust and effective dynamic learning algorithms and architectures for digital games but the potential rewards are great. Perhaps the greatest potential gain with on-line learning is with the dynamic adaptation to player behaviour, play patterns and skill levels. In particular, a worthy pursuit is to develop technologies that may learn where a player is being challenged too much or too little and modify player character attributes, opponent behaviour or game environment accordingly. These alterations may be temporary, just to finish a particularly challenging section or the changes may be implemented for a longer time and player's progress monitored. The flexibility afforded by dynamic learning mechanisms may also be used to counter a player benefiting unduly from – or being hindered by – unforeseen player behaviour or minor bugs in the game design. The capability of a game to self-adapt in these situations to prevent a significant deterioration in gameplay due minor design oversights and player behaviour is certainly a laudable goal.

Research and development has begun in the area of dynamic learning with techniques based around: adaptive genetic algorithms, recursive neural networks, emergent and evolutionary learning and a variety of hybrid methods. However, this is still a very young area of research with much potential for development.

Affecting Emotion

One of the ways that we become fully immersed into the worlds portrayed in novels and movies is by becoming emotionally involved with their story and characters. The relationship between cinema and digital games has been coming under scrutiny recently [13] and though the correlation is weak in many ways – due, for example, to the difference of interactivity – there is still a certain amount of positive cross-fertilization of ideas between the two formats. Run Lola Run (1998), and Groundhog Day (1993) are examples of successful movies that structurally resemble games, while there are quite a number of digital games that successfully borrow ideas from movies. Techniques such as multiple camera angles, cut-scenes, atmospheric music, and sound effects are used both within games and movies. Of course, there are many examples of failures with this crossover of ideas, particularly with the "licensed" game from a movie concept and vice-versa. However, games like Max Payne (Take Two Interactive, 2001), which implements a slow motion technology called "bullet time", Matrix (1998) style – this movie in turn borrowing from digital games – demonstrate that when appropriately used, movie-inspired features can appreciably enhance a game.

A wider debate relates to whether digital games can be art or are they simply entertainment, however for academics with a good understanding of digital game design, development and play this is not so difficult to answer; "it's a false distinction. Games are a

lively art. They are an art because they engage our senses, stimulate our imagination, encourage a playful and creative response, provoke powerful emotions, give shape to our lives and turn the computer into a toy. In other words, they are an art because they are entertainment" [12]. Commercial digital games are already very effective in setting up mood through music and in developing the player's relationship with a game character through high quality voice acting. However, up until recently it has been very difficult to realistically and effectively represent character emotion in the animation of body and face, in real-time within 3D games. This has limited the development of digital games both in gameplay terms and as an art form. When real-time character animation within digital games approaches the quality of Gollum in the recent Lord of the Rings (2002) movie, then we will have an improved opportunity to present increasingly interesting and complex gameplay scenarios that may involve more emotionally charged and even moral choices with more significant consequences to the player.

There have been a number of recent research developments that bring us closer to our goal of representing emotion in digital games. FAÇADE [16] is one approach, which is an attempt to deal with "expressive AI" by combining AI methods with story development and graphics. Other research focuses more specifically on the challenge of using intelligent methods for dynamic character animation [11]. There are a couple of facets to this type of research: developing character movements that animate intelligently, and the use of AI methods to improve that quality of animation. In the first case the goal is to have the character animate appropriately for both predicted and unforeseen circumstances. One approach to improve flexibility in character animation is to interpolate between frames of animation for all separate character body parts and to use an intelligent controller in order to select combinations of animations. Mesh blending, in which a full character frame is contained in single mesh, can produce smoother animations by allowing more than one transformation matrix to affect the vertices that form the skin of a character, and a programmable vertex shader to affect the transformations [22]. The result is a character with more permutations of animation for the resources required.

A Neural Network may be used as the "decision maker" for an animating character and when paired to a fuzzy controller system this particular agent architecture can be quite successful [23]. Neural networks may have broader uses in character animation; for example, it should be possible to train a neural network to act as a transformation matrix in order to interpolate in the mesh blending technique described above. Added to this is the extra flexibility afforded by the improved functionality in graphics cards and graphics APIs such as DirectX. With DirectX 9 and the increased functionality of the HLSL (High Level Shader Language) matched and supported in hardware, there is considerable opportunity for improved intelligent animation methods. In turn, improvements in these technologies will support us in our goal to use AI to improve our representation of emotion in digital games.

CHALLENGES FOR ARTIFICIAL INTELLIGENCE IN DIGITAL GAMES

There is a positive future for AI in digital games, in particular because with a higher quality AI then novel and exciting gameplay permutations will evolve, however there are few challenges facing any AI innovation:

AI Standardisation: It would be beneficial for a set of base standards of commonly used AI technologies to be widely accepted and used by developers. There

is some evidence that this process has begun, for example, the International Game Developer Association (IGDA) currently has a group working on AI interface standards, which will outline a set of common standards based on current AI in games, that may be used by game development professionals throughout the industry and in the academic world. The increased interest in AI within games has also lead to a number of AI middleware products such as RenderWare AI (Criterion), and AI-Implant (BioGraphic Technologies) [7]. As the game development industry matures in its use of AI within digital games then the functionality that middleware AI products provide will stabilise to define a common subset, perhaps in line the IGDA standards, and so the development of hardware game AI cards/chips may become a serious possibility.

Catering for the Individual Player: Interactivity is at the core of any digital game and it will seem increasingly obvious as the use of innovative AI techniques in games becomes more common place that AI can enhance the interaction between the player and the game. In the previous section, three important areas of research and development for AI in digital games were outlined and some of the work that is already underway was discussed. In summary, AI techniques and architectures can improve the dynamic nature of the game world, providing a more intimate relationship and interaction between the game environment, characters, story and each player. Each player has an individual capability and preference for playing and there is a lot of scope for tailoring the gameplay to provide separate player experiences within a game. Of course, there are difficulties in providing dynamic game worlds, such as game balancing, testing game permutations to ensure a consistent quality of gameplay, and that due to the increased scope of more dynamic games then extra game content may have to be created. However, the potential rewards are great.

Overcoming the Limitations in Existing Approaches: The AI community at large will eventually need to come to terms with the limitation of rule-based systems. That the complexity of rule-based systems tend to rise exponentially with each extra rule required – and so game developers must deal with the fact that the added complexity demanded in AI architectures within future games may not be handled efficiently by current rule-based systems. For example, it may become more common to see character animation being controlled by neural networks or similar systems on the basis of environmental input the character. Many of the necessary AI enhancements imply not only an incremental change in architectures but also a fundamental rethink of some of the structures. There are a vast range of AI related techniques from within neural networks, and artificial life research alone that are untapped by the game development industry, and as the AI community at large has become more focused on techniques such as agents and belief networks there is a wide range of published work that may applied to constructing AI within game development.

AI Innovation in a Commercial Environment: Big licences, such as Tomb Raider, Sonic, and movie crossover titles sell in the games industry whether or not the game is well put together, and publishers are more likely to support games with a well-guaranteed market. Innovation of technology and gameplay can help sell games but it has more of an impact on the hard-core gamer than the general gaming population. Nonetheless, it should be accepted that for the gaming market to mature and evolve then innovation is necessary – the same style of game can only be repackaged and sold over and over for so long before the market stagnates. AI has a role in the regeneration of the industry and the attraction of new gamers.

Thinking Outside the Box: The discussion on future AI technologies in games may be opened up to even broader topics and issues. For example, will we be able to devise character AI architectures in which we can "grow" or evolve a game character off-line – independent from the game – and then insert this character into the game so that it will continue to learn. Could such a character be retrained and used in future games – a bit like a game actor? Would a player be able to extract an intelligent character from one game for use, with retraining, in a future game release? – like an extended, intelligent, version of the character game save. Whether this will happen time will tell, but potential new technologies like this do illustrate the point that a revolution of AI within game design and development may have a significant impact on game design.

Moral Issues: With more lifelike characters and realistic emotional representation in our games we may have to consider the moral implications of decisions made by gamers even more than we do now and deliberately design-in effective consequences for actions. Of course games that have a more cinematic impact is a worthy goal but we must remember the difference of interactivity between games and movies. Movie viewers are passive, whereas a gamer interacts with the game world and may affect outcomes. The moral issues become more significant as game characters approach some form of realistic consciousness [6]. Nevertheless, utilising AI to construct well-designed moral dilemmas and emotionally effective set pieces with games opens a range of new and interesting gameplay scenarios.

CONCLUSION

We have outlined some of the current ideas relating to the state of digital game AI research and development and used this context to motivate the need for AI innovation within digital games. Three areas of focus for future innovation were proposed. These areas – story-telling, dynamic learning and representing emotion – are not independent of each other, but often to progress in one area also requires innovation in another simultaneously. Though there are challenges to significant AI innovation, academic research within this area can lead to new ways of thinking about game design and provide exciting new gameplay styles.

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