Computer games form an important sector of the digital economy, computing and entertainment industries, and are very sophisticated in many ways. They have gone beyond pure entertainment value and the game paradigm and technology are now increasingly used in education, training, storytelling and anywhere one needs to create an engaging environment. Artificial Intelligence (AI) techniques facilitate the creation of such experience, and the need for better AI in games is deeply felt and recognized by industry, and is expanding as a new successful area in research.

This special issue focuses on the connection between Games and AI in the broad sense. Games offer novel challenges and excellent application domains for AI research. Vice versa: applications of AI and Machine Learning (ML) techniques are increasingly used to improve not only the dynamics of the games, but also their graphical representation and interaction techniques, pushing the frontiers of 3D graphics, Virtual Reality and Human Computer Interaction (HCI) research.

To date, the AI techniques that typically appear in digital games, are of a basic kind, and the more advanced techniques seldom make an appearance. Reasons for this have historically been (a) that game designers were usually trained in programming or digital arts, but not in AI, and more importantly (b) that powerful AI techniques are demanding to run, and require a lot of computer processing time and memory to be feasible in a commercial game.

These are no longer limitations, and the contributors to this special issue show some of the possible applications of AI: When used well, AI can add a great deal to digital games.

AI is a disparate research field, and it is not possible to cover all of it in a single issue; but these articles do give both a broad impression of many sorts of AI work being done in games, and a deeper sense of what may be possible tomorrow. The articles include literature reviews of their various areas, which would be helpful ways into relevant research for those new to the field, wanting a more comprehensive overview.

The topics covered in this issue are not focused on the state of the art of current established games, but rather on active current research into AI and games yet to come. This includes ways to improve automatic story-telling, the
possibilities of sophisticated interfaces with the human player’s physiology and even brain, in order to make games that are more responsive and adaptive, and methods to make games able to comment automatically on the play, in ways that are understandable to non-experts. Just to show that the AI – games traffic is not all one-way, there is even an article that unusually applies digital gaming to improve AI methodology. There are thus many surprises in the issue; but the reader should end up realising that the future of AI in games, though exciting in its wide potential, is nevertheless not so far away.

The articles in this special issue arose from the annual AISB Symposium in AI & Games held in 2009 and 2010, with selected papers supplemented later by an additional call for papers. Because this journal is an interdisciplinary one, the authors have gone to some trouble to make their work more readable for a general readership, so that readers of varied backgrounds may benefit by sampling today’s research in the intersection between AI and digital games.

The first paper in this collection (Hodhod, Kudenko and Cairns) brings some classic AI approaches to the challenge of making narrative games that can adapt to the player’s state of knowledge. The game is an educational one, intended to teach moral reasoning to school children. Narrative games can be scripted, which is good for the narrative but detracts from the play experience because the player has little genuine autonomy. Alternatively, the games can dynamically generate their narrative structure depending on the player’s decisions.

Hodhod et al present a hybrid approach to give both a direction to the narrative and a more active experience, contacting the player’s own sense of identity. This is made possible by the inclusion of a small user model in the system architecture. Such user modeling in AI is a key technique to making software systems that can adapt to the user; and educational games need to adapt to fit the player / learner’s needs. The aim in this case is for a game-based learning system (GBL) in which learning occurs organically. The player learns ethics through the narrative, when the virtual character (or avatar) is presented with various morally challenging situations. The game logic selects what the situations should be, according to the user model’s determination of what learning goals are most appropriate for the player at the time. The AI technique that implements this logic is the classic one of “production rules”: they are most famously used in expert systems.

The game is shown to be effective at teaching ethics to schoolchildren, in that some of them appear to have developed their own moral reasoning, partly made possible through their strong virtual identity with their avatar. Some children report changes in their moral attitudes as a result of playing the game.

In this case, AI techniques helped to track the player’s state of knowledge, which is of high importance for educational games; but emotional reactions were also evoked in the children as they played. That is an indicator of its success, but was only evident from the after-game interviews.

In future it will be possible to include some “emotional intelligence” in games so that they can adapt to the player’s emotional state. This would be useful to game designers, to help fit the difficulty of the game to the player’s skills by detecting stress levels, for example. Low stress may indicate the player is getting bored, whereas high stress for more than a short time may lead to frustration and fatigue. In either case the player may stop playing the game for emotional reasons, defeating the object for entertainment games; and for serious games too. Some serious games, such as games to train paramedics, may even have a purpose to see how the player responds under pressure.

Moreover, knowing the player’s emotional state would offer opportunities for radically new kinds of game, in which non-player characters could react to the player by displaying appropriate emotional responses of their own, for example.

In the field known as Affective Computing, progress towards detecting emotions is being made, with a variety of approaches, models and techniques, and there have been several
attempts to include emotion detection in games as well. They use different hardware devices to record various kinds of physiological data, different algorithms to categorise them into different sets of emotions; and they meet with differing degrees of success. The work is still at an early stage, but it may be time to consolidate now. The second paper in this collection (Arroyo-Palacios and Romano) presents BAGI (a bio-affective gaming architecture) which is intended to do just that.

As well as reviewing literature and a range of games that have included some form of emotion detection, the paper introduces BAGI as a single framework which can support further research in the area, allowing any of a range of hardware and software modules to be plugged in, so that any desired emotions may be detected from the physiological data captured with the devices (e.g. skin conductance, heart-rate and so on). To demonstrate the concept, an experiment was run to detect the user’s emotions and categorise them into one of four emotions, using up to eight physiological measures. The categorisation was done by two alternative software modules, implementing two different types of artificial neural network. Both algorithms performed at well above chance level, and the better of the two recognised the most appropriate emotion about 80% of the time, which is quite accurate for this kind of work.

The next paper, by van de Laar, Oude Bos, Reuderink and Heylen, explores another way that the player’s own mental state can influence a game, namely a BCI (brain-computer interface). These days we see many new ways to interact with a console game, including hand-held motion detectors used as game controllers, or hand gestures and body movements detected by video camera alone. The new techniques of BCI offer possibilities to control and interact with a game without making any overt movements at all: simple thought control can be enough.

van de Laar et al review the BCI literature as applied to games, and then go on to describe their own BCI system architecture, which is complex and sophisticated software, including linear discriminant analysis algorithms to detect the mental activity from the EEG data from electrodes attached to the player’s head. They test it on a very simple game in order to answer questions including whether a BCI system can detect the intended action better if the player physically performs the action. They find that the brain signals are less easy for the BCI to detect if the action is purely imagined, and not actually performed.

It also emerges that the users have a quite different experience under the two conditions. Contrary to what one might suppose, controlling a computer system with only the effort of pure thought can be more fatiguing than actually performing physical actions.

The sophisticated hardware and software that this BCI system has, and the need for the player to wear a skullcap with wires attached to a computer, may be too much to expect for today’s commercial games; but as a prototype the BCI shows what will likely become familiar in the future. It remains an open question as to what range of possible actions could be supported by such systems, and whether players will be able to use them comfortably for long periods.

The next paper (Hoppenbrouwers, Schotten and Lucas) turns the usual AI/games relationship in reverse. Instead of applying AI techniques to improve games, Hoppenbrouwers et al develop a prototype game to help with a longstanding problem in AI: namely, in knowledge acquisition (KA). In order to develop an AI system that contains any kind of expert knowledge from some domain (e.g. medicine), the knowledge has to be captured from domain experts (e.g. doctors). But they are experts only in their own domain, and not in AI techniques. Traditional KA methods, to capture knowledge from domain experts, include interviewing them, recording “think aloud protocols” and protocol analysis; but the process is still expensive and error-prone. It is expensive because the domain experts are typically busy and highly paid professionals, and the KA process takes a lot of time. Hence there is said to be a knowledge acquisition “bottleneck” (KAB).
Hoppenbrouwers et al take the novel and creative approach to make a “game” for the domain experts, that captures their expertise as they play. In this way they can express their knowledge without needing any specialised training, mathematics, or even diagrams. Games ideally can teach their players how to play them as they go; well-designed games do not need a user-manual. This is advantageous for the KAB problem. In addition, the game could be made interesting or even fun to play, making the KA process less onerous for the domain experts.

The prototype game was evaluated by asking experiment participants to play the game to share their knowledge of tasks such as the (typically Dutch!) example of repairing a flat bicycle tyre. They were not told in advance how to play the game (or use the system), and some did struggle to begin with; but most of them learned quite well as they played on. They later reported that they found the game “moderately satisfying” – which is not exactly “fun,” but probably a lot better than traditional methods of knowledge acquisition would score.

However, the results indicate that they still have some problems with formalization; even the lighter formalization demands of the game. Another issue was that the players tended to continue playing in a way that they found moderately successful, and did not explore the more advanced features that were available to them. This meant that the formalizations they produced were of lesser quality. That is disappointing, but we should remember that formalization itself is a key cognitive skill, and often underestimated in its difficulty and ambiguity. KA itself is not thoroughly understood by its AI researchers, and can be said to remain a craft rather than a science. Every formalization entails ontological commitments that even the experts are not fully aware of. It is not surprising that the participants found this process difficult – surely, they always will do.

Important issues need further work, such as improving the game design to: (a) award credit for players’ performance so as to best align with the deeper KA goals of the game; and (b) make the game more engaging to play (one day perhaps even “fun”). However, the paper represents a strong initial attempt to show the path for further development, and to argue the case for applications of games well beyond their niche to date. In future we may see games being used to help in all sorts of formalization tasks, beyond AI / KA. If so, the paper by Hoppenbrouwers et al will be the first one in its field.

The final paper in this issue (Zheng and Kudenko) returns to the central focus of applying known AI techniques to improve games. In this case machine learning (ML) algorithms are applied to the difficult problem of automatically generating game commentary. Some sports video games include a spoken commentary, just as televised sports have commentators to explain the chief events. Invariably however, this commentary is predictable and ignores the game context, and so it soon becomes boring and irrelevant; and it generally seems to miss the point of the action. Zheng and Kudenko modify a popular football (soccer) video game to produce a running commentary automatically, and in real-time.

A good commentary can enhance the enjoyment of the game, but it is difficult to produce automatically, and so the paper presents an entire approach to doing so. Firstly, traces are recorded of several games played, to serve as a training set for the learning algorithms. Secondly, the traces are hand-coded with the key concepts that will form the basis of later commentary. These concepts include “ball controller” (or which player has possession of the ball), “ball receiver”, “offside position”, and more generally each “position” that players can take up on the pitch. A little thought will reveal that even just deducing which player is in what position at any point in time, in any dynamic soccer match, is not easy. Thirdly, a mapping from game trace situations to key concepts is learned, from these human coded traces, by an AI learning algorithm. In the paper three alternative ML algorithms are tried, which are all freely available in a public domain AI workbench (namely, they are: C4.5, for learning classification or decision trees; Naive Bayes-
ian learning; and the K-nearest neighbours algorithm). Fourthly, the results are tested by cross-validation, and the three ML algorithms compared for accuracy. It is shown that two of the algorithms, at least in the case of this game, show good promise. But, more than that, it is the whole method that is validated by the results, and not only some particular machine-learning techniques.

The commentary system deliberately does not deploy certain other AI techniques, for natural language generation say, or speech production, and only uses simple template sentences to express the commentary to the viewer. Rather, it concentrates on the hard core of the problem, which is the identification and formalization of key concepts, and the development of an intelligent system that can learn to reproduce human-coded commentaries.

The approach developed is generalisable to other types of game, in principle. It could be extremely useful in serious games, for example, to have automatically generated commentaries on what the players all did. This could both serve as part of their performance evaluation, and help them learn how to perform better in the domain, which is after all the main point of many serious games.

As editors of this special issue, we hope to have shown that the future of AI in digital gaming is bright and exciting. AI is not only about expert systems and chess any more; and neither is it just unrealistic fantasy, but rather it is emerging into the modern world where it promises to make big changes in digital games. Conversely, the virtual worlds developed for games make good domains for testing and developing AI techniques, so that the field of AI itself will in turn be invigorated by its application to games.

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