

Institution: Teesside University
Unit of Assessment: 11, Computer Science and Informatics
Title of case study: Interactive Storytelling Technologies
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>In this case study, we describe the development of Interactive Storytelling technologies, and its influence on techniques used in the digital entertainment industry, in particular computer games. The output consists of both software technologies (Artificial Intelligence) and principles for the development of new interactive media. This impact has taken place through two basic mechanisms: i) the take-up of research results by the game industry in published titles, including as an outcome of joint projects and ii) the use of our publicly disseminated results in patent applications for newly developed technologies, including by major actors in the digital industry.</p>
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>Although experiments in interactive cinema have been reported as early as 1967, a renewed interest in interactive narrative emerged in games Artificial Intelligence (AI) circles in the late 1990s, as an extension of research on autonomous characters. The context of computer games offered a practical solution to the problem of alternative narratives, as computer graphics and animation support dynamic content generation.</p> <p>This new challenge attracted a research community mostly from games AI, which grew rapidly and now sustains two annual conferences, with hundred of papers published in recent years on various aspects of Interactive Storytelling. The development of Interactive Storytelling makes new gaming genres possible, in particular by reintroducing filmic aspects, departing from genres based mostly on physical simulation (sports games, first-person shooters). It is also relevant to training and simulation systems when there is a need to incorporate narrative elements; finally, its component technologies are also relevant to interactive technologies at large.</p> <p>Our research has developed AI technologies for Interactive Storytelling, as well as advancing basic concepts and paradigms. We have investigated the role of Planning in supporting story logic and in preserving narrative consistency in the presence of user intervention. During this process we have introduced a distinction between character-centric and plot-based approaches. We have explored various Planning techniques (Hierarchical Task Networks 2002-2005, Heuristic Search Planning 2007-2009, and Landmark-based planning, in conjunction with search-based planning, since 2009).</p> <p>One of our major contributions is to have investigated the main problems of Interactive Storytelling (such as expressivity of formalisms, authoring and scalability) through several (> 7) fully-implemented prototypes, and to have eventually established the need for abstract control of planning trajectories: this concept appeared in [3] and was subsequently fully formalised in [6] when we adopted the more expressive landmark-based approach. Another innovation that we have introduced is the “baseline plot variant” approach to interactive narrative authoring, which consists in defining a planning domain for a baseline plot (often inspired from the plot of an existing motion picture or novel) and progressively introducing a set of alternative actions, without imposing them a place in the narrative sequence so as to maintain combinatoric properties.</p> <p>This research has been extensively published in the most selective conferences including AAMAS, ACM Multimedia, ICAPS and IJCAI. It has received the best paper prize at the first International Conference on Virtual Storytelling (ICVS) in 2001, the best paper prize at the second ICVS in 2003¹, and more recently the 2nd grand challenge prize at the EuroITV 2011 conference, and the best application showcase award at ICAPS 2013.</p>

¹ These were part of our RAE 2008 submission.

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It has been supported by the following grants:

- DTI Technology Programme (Design, Simulation and Modelling): BARDS project, in collaboration with Eidos Interactive plc, 2006-2008, Teesside funding £100,000.
- FP7 Network of Excellence Integrating Research in Interactive Storytelling (IRIS), co-ordinated by Teesside, 2009-2011, Teesside funding 550,000€.

Staff who have taken part in this impact case are Prof. Marc Cavazza (since 2001), Dr Fred Charles (since 2001) and Dr Julie Porteous (since 2009).

3. References to the research (indicative maximum of six references)

[1] Marc Cavazza, Fred Charles, Steven J. Mead. 2002. Character-based Interactive Storytelling. *IEEE Intelligent Systems*, vol. 17 n.4, pp. 17-24.

One of the first major outputs of this line of research that we initiated in 2001, this is one of the first presentations of Planning-based Interactive Storytelling, which illustrated all basic concepts with a complete implementation within a game engine. To date, this paper has received 274 citations (Google Scholar), making it one of the most cited academic papers on this topic. It was included in our RAE 2008 submission.

[2] Fred Charles, Marc Cavazza. 2004. Exploring Scalability of Character-based Storytelling. *ACM Third Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*, New York, USA, pp. 872-879.

This paper was included in our RAE 2008 submission.

[3] Marc Cavazza, David Pizzi, Fred Charles, Thurid Vogt, Elisabeth André. 2009. Emotional Input for Character-based Interactive Storytelling. *Proceedings of the 8th International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, Budapest, Hungary, May 2009, pp. 313-320.

This paper is included in our RA2.

[4] David Pizzi, Jean-Luc Lugin, Alex Whittaker, Marc Cavazza. 2010. Automatic Generation of Game Level Solutions as Storyboards. *IEEE Transactions on Computational Intelligence and Artificial Intelligence in Games*, vol.2, no.3, pp.149-161, Sept. 2010.

This paper describes a derived use of Interactive Storytelling technologies to generate game level solutions. It is based on real-world data from a AAA franchise (Hitman by IO Interactive published by Eidos). It is also an output from the DTI Technology Programme project BARDS (with Eidos Interactive plc), and one of few academic papers co-authored by a game company. It has received 21 citations to date (Google Scholar), and was featured on the IEEE Computational Intelligence Society web site in March 2011.

[5] Julie Porteous, Marc Cavazza, Fred Charles. 2010. Narrative Generation through Characters' Point of View. *Proceedings of the 9th International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, Toronto, Canada, May 2010.

This paper is included in our RA2.

[6] Julie Porteous, Marc Cavazza, Fred Charles. 2010. Applying Planning to Interactive Storytelling: Narrative Control using State Constraints. *ACM Transactions on Intelligent Systems and Technology (TIST)*, 1(2), December 2010, pp. 1-21.

This paper introduces our next-generation technology. It is based on the landmark theory of Planning, for which the first author has received the influential paper award at ICAPS 2013. Part of the definition of Interactive Storytelling on Wikipedia has been drawn from this paper, which has already received 30 citations (Google Scholar).

4. Details of the impact (indicative maximum 750 words)

We describe how our research in Interactive Storytelling has influenced the development of technology in the gaming industry as a result of our engagement with game companies. We also

suggest that the dissemination activities for this type of research have improved the knowledge base available to the digital industry, which is reflected in patent data citing our work.

Pathway to Impact

Our main strategy to secure impact for this research has been by engaging with end-users, in this case game companies. Interactive Storytelling, being a novel paradigm, did not initially constitute a user-defined problem or user-led research. On the other hand, once early results had been achieved it became possible to interact with users about i) potential market applications of the concept itself and ii) take-up of component technologies in the context of existing game developments. This has taken place through two different routes. The first one has been to acquire more specific knowledge on game titles under development or consult actual design documents. To that effect, NDAs have been signed throughout the reporting period with the following companies: Sony Computer Entertainment Europe, Elixir Studios, Eidos Interactive plc, and Epic Games Inc.

The second aspect of user engagement has been joint projects, which started a few years after our first results on character-based storytelling [1], with the acquisition of joint funding with Eidos Interactive plc as part of DTI's Technology Programme "Design, Simulation and Modelling". The project, which started in 2006, was one of the very first joint projects with the gaming industry that was fully dedicated to entertainment applications. The Lambert agreement we signed as part of the project was one that granted intellectual rights to Foreground to the industrial partner, with Teesside retaining rights for use in a non-commercial research context. In addition, as part of BARDS and in order to facilitate transfer of source code, we adopted Eidos' software development conventions for our own research on the project.

Overcoming known barriers to impact and collaboration has also been an important element of the impact strategy in this case. The game industry is known to operate under strong constraints in terms of product life cycle, IPR and reuse of technologies and we have strived to adapt to that in terms of confidentiality (NDA above) and by choosing the collaboration agreement most appropriate to them (for instance Type 4 Lambert agreements).

Impact Achieved and Significance

The first impact is constituted by the transfer to game companies of technologies that spun out of our research, which are derived from our Planning-based narrative technologies. This includes actual transfer of software at source code level (with appropriate documentation), or knowledge transfer allowing them to develop their own implementation of the methods. In all the cases listed below, we have interacted directly with the users. This includes:

- the transfer of a full HSP Planner (source code) adapted to gaming context (Eidos),
- the transfer of an integrated level solution generator for the game title Hitman [4] (IO Interactive),
- a narrative generation method (We R Interactive) which has been incorporated into a commercial game based on social networks.

Impact significance is presented in increasing order. In the latter case, there has been a direct influence in terms of technology underpinning a commercial product, as per the accompanying statement from We R Interactive².

In addition to the above influence on methods and techniques in the game industry, our published results have been incorporated into background references for six patents filed internationally in the USA, Japan and Singapore, including two patents by Microsoft corp. and one by IBM corp. The complete set of patents is provided in section 5. The significance of this impact is the fact that the results contained in the cited papers are deemed to constitute relevant background for a patent, hence identifying them as relevant to industrial methods. It is further enhanced by the limited

² This is evidenced by the following quote from the support letter of the CTO of We R Interactive: "Work on knowledge representation and the unification engine has contributed directly to the development of IAmPlayr on Facebook which has been installed by over 14 million users."

Impact case study (REF3b)

number of background non-patent citations generally used in patents.

We claim that this should be considered as effective rather than potential or future impact, since patents are objective assets, which have an intrinsic commercial value. Furthermore, the nature of the assignees for those patents suggests that these have been intended to protect genuine IPR (rather than systematic patenting, also known as “patent trolling”).

Finally, we were able to file one patent (US patent application 13/677,797) out of specific results from our participation in the FP7 Network of Excellence IRIS, which developed a novel approach to video-based storytelling making use of the same type of planning technologies as described above.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[1] Alex Whittaker, Chief Technology Officer, We R Interactive Inc. (support letter available) alexw@werinteractive.com; URL: werinteractive.com; telephone: +44 (0)20 7520 0060

We R Interactive
13-19 Vine Hill, London, EC1R 5DW

[2] Patent title: Picture book production system, server for producing picture book, and recording medium. Assignee: Hudson Soft Co., Ltd., Hokkaido (JP)

Patent number: US 7,162,197 B2

URL: <http://goo.gl/ClwJTr>

[3] Patent title: Dynamic interaction menus from natural language representations

Assignee: Microsoft Corporation, Redmond, WA (US)

Patent number: US 7,627,536 B2

URL: <http://goo.gl/TCsxgm>

[4] Patent title: Method and system for automatic computation creativity and specifically for story generation

Assignee: International Business Machines Corporation, Armonk, NY (US)

Patent number: US 7,333,967 B1

URL: <http://goo.gl/XRqUTc>

[5] Patent title: Method and system for using geographic data for developing scenes for entertainment features

Assignee: Navteq North America, Llc, Chicago, IL (US)

Patent number: US 7,921,136 B1

URL: <http://goo.gl/y3RUjH>

[6] Patent title: Dynamic storybook

Assignee: Microsoft Corporation, Redmond, WA (US)

Patent number: US 7,890,534 B2

URL: <http://goo.gl/FFo57F>

[7] Patent title: Method and system for classifying a user's action

Assignee: Agency for Science, Technology and Research, Singapore (SG)

Patent number: WO 2011/159258 A1

URL: <http://goo.gl/Jzf8BB>