UNIVERSITY OF TECHNOLOGY SYDNEY

Believable Exploration: Investigating Human Exploration Behavior to Inform the Design of Believable Agents in Video Games

A DISSERTATION

SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

for the degree

DOCTOR OF PHILOSOPHY

Field of Information Technology

by

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May 2017

CERTIFICATE OF ORIGINAL AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as part of the collaborative doctoral degree and/or fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Student:

Date: 24 May 2017

List of Publications

Journal

Si, C.*, Pisan, Y., Tan, C.T. & Shen, S. 2017, 'An initial understanding of how game users explore virtual environments,' *Entertainment Computing*, vol. 19, pp. 13-27.

Si, C., Pisan, Y.*, Tan, C.T. & Lv, Z.H., 'Understanding Believability of Spatial Exploration Agents in Digital Games' (Submitted).

Conference

Si, C., Pisan, Y. & Tan, C.T. 2016, 'Understanding players' map exploration styles,' *Proceedings of the Australasian Computer Science Week Multiconference*, ACM, pp. 1-6.

Tan, C.T., Leong, T.W., Shen, S., Dubravs, C. & **Si, C.** 2015, 'Exploring gameplay experiences on the Oculus Rift,' *Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play*, ACM, pp. 253-63.

Si, C., Pisan, Y. & Tan, C.T. 2014, 'A Scouting Strategy for Real-Time Strategy Games,' *Proceedings of the 2014 Conference on Interactive Entertainment*, ACM, pp. 1-8.

Si, C., Pisan, Y. & Tan, C.T. 2014, 'Automated terrain analysis in real-time strategy games,' *Foundations of Digital Games (FDG)*.

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Abstract – By nature, human beings are curious about their environment. Arriving in a new place, they observe, recognize and interact with their surroundings. People collect information about the new place, and locate objects in that space that help them to make further decisions. This is a typical scenario of spatial exploration. Spatial exploration is common human behavior, where humans explore unknown environments to acquire information and resources. It is pervasively seen in real-world and virtual environments, from exploring new living/working spaces to charting the oceans or venturing beyond the boundaries of our planet. Just as humans explore 'real' environments, they also investigate artificial environments in video games. Computer agents, which perceive surrounding environments with limited visual range, often appear in exploration activities, acting as tools or partners for explorers. Despite the broad range of human activities that employ exploration behavior, this element has been insufficiently investigated and understood. Additionally, even though it is commonly accepted that believable agents benefit people in human-computer interaction systems, the research into creating computer agents with believable exploration behavior has been neglected. To solve these issues, I extract the patterns of human exploration behavior in virtual environments, and explore the methodologies of developing believable agents, which explore spatial environments in human-like ways. In the pursuit of this goal, this thesis makes the following four contributions to the emerging field of believable agent exploration: 1) I employed video games as a testbed to investigate human behavior of spatial exploration. Human players played specialized exploration games, verbalized their behavior during playing and discussed their thoughts in the post-play interview. Behavioral patterns were extracted based on replays of playing, think-aloud data and interview data via thematic analysis. 2) Differences of exploration

behavior between human and computer agents were identified through a third-person-observation assessment of believability. 3) A *heuristic agent* was developed, which mimics human exploration methods reflected via the behavioral patterns. Three heuristics, as components of the *heuristic agent*, were designed to filter potential options when the agent decides where to explore in each step. 4) An *integrated agent* was developed by filling the behavior gaps between human and computer agents, where an integrated architecture embedded expectations of human-like exploration from mid-level players. Both the *heuristic agent* and the *integrated agent* passed the third-person-observation assessment of believability. Therefore, findings in this thesis contribute to fill the gaps in the fields of understanding human exploration behavior as well as developing believable agent.

Index Terms – autonomous exploration, spatial exploration, real time strategy (RTS) games, Turing test, believability assessment, human-like intelligent agent, believable bot, thematic analysis, heuristic method.

Acknowledgements

I would like to thank:

- My principal supervisor, A/Prof. Yusuf Pisan, and co-supervisor, Dr. Chek Tien Tan, for providing guidance and encouragement. It is their encouragement that allowed me having a chance to pursuit my Ph.D. in Australia. I learned to have an overall view and practical plans to make things happen from Yusuf. He guided my research work, helped me to think deeply on research problems and supported me in establishing a work-life balance. His wisdom and insights will be valuable both in my future career and life. Meanwhile, Chek consistently encouraged me to challenge difficult problems, which deepened my understanding of research and technologies. Their knowledge, passion and rigorous attitude to science deeply infected and inspired me.

- The University of Technology, Sydney and China Scholarship Council for providing the necessary funding for this research.

- Past and present members of the Games Studio and especially Megan Pycroft, Wenlong Zhang and Songjia Shen for discussions and support. They helped to organize experiments, and discussed with me about the project. The discussions with them produced many good ideas.

- Dr. Meryl McQueen, Dr. Jaime Garcia Marin and Dr. William Raffe for reviewing the drafts of my work and providing feedback. Meryl offered me an impressive guidance of academic writing, and helped to edit and correct my thesis several times. Meanwhile, the professional feedback from Jamie and William contributed to improving the thesis a lot.

- All my friends during this time who provided the necessary emotional support and put up with my complaints.

- My parents, Jianhua Si and Caizhi Chen, for making it all possible.

- And finally, Yang Ning, my wife, for encouraging me, for accompanying me on adventures, for reminding me that there is more to life than the thesis and for helping me finish in more ways than I ever imagined.

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