Review of the dissertation thesis

Author: **Mgr. Martin Černý**

Title: **Reducing Complexity of AI in Open-World Games by Combining Search-based and Reactive Techniques**

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The thesis concerns itself with several key issues related to managing AI (i.e., "artificial intelligence") code complexity in present-day open-world games with many virtual characters; that is, related to development of techniques that can be used in practice by game studios. The thesis can be considered as applied gaming AI research. Unlike many academic works on gaming AI, its important part is real-world case-studies, developed within the framework of a contemporary AAA open-world game Kingdom Come: Deliverance.

The author opens the thesis with discussion on gaming AI code complexity, introducing two dimensions of complexity: rule complexity and size complexity. The author then addresses in detail two issues on small rule complexity and large size complexity and one issue on large rule complexity and small size complexity. Specifically:

1) Section 5 presents the concept of Behavior Objects (BO) as a parallel to Object Oriented Programming. These BOs, and their various subtypes (as defined by the author), are an abstraction for chunks of gaming AI code for ambient virtual characters acting in a large open-world game. They can be in fact viewed as guidelines/methodology for game developers on how to design and program control algorithm for this type of autonomous characters. To a large extent, the BO concept has been guiding implementation of the AI system in the KC:D game. While the AI system in KC:D is, to a large extent, a work of the company's developers, the BO conceptual framework has been developed primarily by the author, capitalizing on and extending the notion of smart objects already used by the industry and the academia. A small-scale evaluation study of the BO concept with game scripters has been also conducted as part of the thesis. Overall, this part of the work has been published in an IEEE gaming AI journal and as a chapter in a book on game engines development intended for the industry.

2) Section 6 addresses one limitation of BOs: difficulty in handling certain situations requiring global information. The author proposes to use the CSP as a technique that can describe some of these situations and that can help in controlling the characters in such situations. The idea has been implemented by the author in so-called Situations: specific moments in which multiple characters can briefly interact in a pre-scripted way. The CSP is used to select appropriate characters for the interaction based on global constraints and characters' properties. This part of the work has been evaluated by means of a set of case-study scenarios. It has been published at the AIIDE conference, which is considered as a top forum for disseminating applied gaming AI research, and it won the best paper award in 2014.

3) Section 7 complements the previous work by addressing an issue of large rule complexity and small size complexity; particularly action selection in one-to-one combat. The author

employs an adversarial search technique, integrates it with the game, finds its parameters, and demonstrates its usefulness in a study with human players. This is the most recent part which has not been published yet, but its outcomes are promising.

Generally, this is a high quality thesis with substantial contributions; both practical and theoretical. It is well written and well situated in the current literature. The author's publication outcome is considerable.

Apart from minor formatting issues, my only major negative comment is that the analysis for Section 5 is, in my opinion, incomplete. Its pieces are scattered here and there throughout the section, and parts are missing. Also, part of the DVD attached to my copy of the thesis cannot be read, but this is not the author's fault.

I **recommend** the work for defense and I believe the author **should be awarded** the Ph.D. degree.

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