

Review of the dissertation thesis

Author: **Mgr. Tomáš Plch**

Title: **Believable Decision Making in Large Scale Open World Games for Ambient Characters**

Supervisor: **Mgr. Cyril Brom, Ph.D.**

Tomáš has designed in his thesis a **complete AI system for large open-world AAA games**, co-implemented it and supervised a team of people who implemented portions of it with him. The system is designed so that it can control hundreds of virtual characters all at the same time (in real-time). This is a **unique achievement in the academia**, only possible because the work of Tomáš has been done as part of a formal contract between Faculty of Mathematics and Physics and Warhorse Studios (which has been developing the Kingdom Come game). At the same time, the company decided to put a strong emphasis on AI. For this reason, not everything developed could have been included in the thesis; especially not software code. Also, inevitably, portions of code were developed by collaborators of Tomáš, but Tomáš is still the main author of key ideas put forward in the thesis, along with Martin Černý, another (former) PhD student of the faculty, who co-developed the idea of smart entities described in the thesis.

In the thesis, Tomáš gradually introduces the reader crucial parts of his AI system; including general architecture, decision making system, and knowledge representation. He builds on recent ideas concerning **gaming and agent AI**. In several aspects, he extends the state-of-the-art substantially (e.g., smart entities). Tomáš also borrows from the area of **operating systems**; he basically views the AI system as a kind of operating system. This is positive and significant, as it shows that the gaming AI for open-world games and operating systems fields may be more related than previously thought. The description of the system is well written; the text reads almost as a documentation rather than a “dry” academic work (which I think is the advantage in the present case, given the expected readership).

The implementation part behind this thesis is enormous. The AI system has been almost fully implemented and iteratively refined within a high budget AAA game (which is still under the development at the time of writing this review). It took more than **ten man-years** to develop just the AI system itself (and this has been only possible because several programmers under Tomáš’s supervision worked on it).

That said, the issue here is that the reader can view the work as a description of a particular solution for a particular game rather than a general AI system for open-world games. Indeed, Tomáš’s thesis is probably the most complex open description of an AI system for a commercial open-world game ever. I personally think that most aspects of the system can be re-implemented elsewhere and the whole work basically paves the way for developing better artificial intelligence in future open-world games.

However, the idea I just stated may not be easily apparent to the academic readership (i.e., based on reading the text of the thesis) and I thus advice the author to defend the notion that what has been

presented in the thesis is indeed a general solution (or in other words, that the thesis presents guidelines for implementing similar systems in the future).

Another somewhat thorny issue is the evaluation presented in Chapter 9. Here, the author has faced a substantial challenge because baselines for comparison as well as real-world data are lacking (e.g., there are no data describing precisely enough behaviour of medieval peasants, nor is it possible to collect these data anymore). It can be argued that the very fact that the system has been implemented, as demonstrated by its performance and usability evaluations in Chapter 9, is an evaluation of its own, but the reader can still wonder whether more could not have been done.

I suggest the author to defend the idea that his evaluation has been appropriate given circumstances.

Another drawback of the thesis is that, here and there, literature review could have been more profound (e.g., as concerns knowledge representation; i.e., semantic networks). The work includes over a hundred of references, but only around a dozen or two are papers from the last five years. Also, the thesis is not without typos (e.g., p. 110: "Reference source not found.").

Generally, this is a significant thesis as concerns the size of implementation, contribution to the Kingdom Come game, and contribution to the gaming AI field. However, the author should highlight in his defense the work's contribution beyond the Kingdom Come game.

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

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