Review of the Ph.D. thesis of Mr. Marek Gayer

Mr. Marek Gayer in his Ph.D. thesis focused on research of methods for modeling and visualization of combustion process in order to achieve its real-time simulation and visualization. The submitted Ph.D. thesis contains a very good example of multi-disciplinary work. While the focus is mainly on computer graphics aspects, the work was obviously demanding as Mr. Marek Gayer had to study much wider are of science than usual. The work not only interesting but also important as the simulation and visualization of combustion process in real-time has a good potential to contribute in improvement of combustion process in various devices.

The Ph.D. thesis successfully summarizes the state of the art of visualization, fluid simulation, and also combustion simulation while the main focus is on the methods directly useable for the work presented in the thesis.

On the formal side, the submitted thesis is very nicely done. The text of the thesis is very clear, readable, and of good typographic quality. The subdivision of the text of the thesis into the chapters is also feasible. One remark, however, could be done on extensive usage of plural in sentences (e.g. “Our goal…”, “Our system…”, etc.) – the author presents his own work and not a group work so such approach is formally incorrect. (Note, please, that Mr. Marek Gayer did clearly state in Paragraph 1.6 that most of the thesis is his own work and also clearly identified the small parts that have been done with co-authors.)

The technical content of the work is clear and understandable. The presented work is a successful attempt to combine simulation and visualization process and its contribution is, in my opinion, mainly in the fact that the simulation of combustion processes was made real-time and thus feasible for quick evaluation of various parameter changes during the combustion processes.

Chapters 1, 2, 3, and 4 summarize the motivation and the state of the art. The contribution of Mr. Gayer starts in Chapter 5 which is focused on the novel method of simulation.

The idea of representation, storage, and visualization of unsteady data flows, as presented in Chapters 6, 7, and 8 seems very good and Mr. Marek Gayer demonstrated in the thesis their very positive impact on speed of simulation/visualization process.

Chapter 9 is dedicated to exploitation of contemporary hardware-accelerated graphics boards for further speeding-up of the visualization process. The proposed approach is logical and, as shown in the thesis, well working.

Mr. Marek Gayer demonstrated the functionality of the proposed methods also through a working software – "Interactive model of combustion" – prepared for educational purposes. This system is described in Chapter 10.

Chapter 11 summarizes the contribution of Mr. Marek Gayer and clearly shows that the work contains non-trivial novel contributions for the combustion process visualization which is to some extent (as Mr. Marek Gayer correctly pointed out) usable also in wider, more general, extent. The direction of possible future work is shown in Chapter 12.

The submitted thesis is concluded in Chapter 13. In addition to the text part, a CD is also attached and contains authors previous publication and the working software package described in the thesis.

Overall, the impression from the thesis is very positive and it clearly indicates that the amount and quality of work of Mr. Marek Gayer is quite remarkable. This thought is also supported by the fact that Mr. Marek Gayer received some awards for his work (as shown in Chapter 14). Also, the publication activity of Mr. Marek Gayer is very good.

Anyhow, after reading the submitted thesis, some questions/issues still remain open and I would like to suggest the following ones to be discussed/answered:

1) The presented thesis does contain description of a novel "simplified" fluid and combustion modeling/simulation method (Chapter 5); it also contains comparison of the results of the method with other simulation system (comparison with Fluent 5.5, see Table 5.1, page 44) and from that comparison it seems that the simulation results of the proposed method are not very precise (some of the global values are over 20% different). Given these facts, is the proposed modeling/simulation method still usable for investigation of e.g. the airflow?

2) Has the proposed combustion process visualization system been evaluated from the point of view of "accuracy" of perception of the process by humans? Do any visualization parameters (e.g. way of shading of the particles as shown in Figure 10-2 versus 10-3, color assignment, etc.) affect the "understandability" of the image by humans?

3) The precision of the simulation process generally depends on the integration (simulation) time step. Does the proposed real-time simulation in general achieve optimum precision from this point of view? If not, does the system have any information about the precision of simulation (e.g. "now the simulation is too complex and to achieve real-time performance, the precision has been given up…")?

Finally, to my opinion the submitted thesis presents novel and valuable work and it definitely should be recommended for defending.

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