

PhD thesis review

Ing. Marek GAYER

**Real-time Visualization Techniques
for Modeling of Combustion and Fluids**

Prague: Czech Technical University 2005, 124 pages + DVD

The goal of the dissertation is „to design and implement techniques that together could be used to form a solution allowing interactively visualize pulverized coal combustion in real time“ (page 4).

In computer graphics, there are still many problems open. Among them, there is a general **flow visualization problem** – how to obtain a reasonable visualization of complex behavior of physically-based models in real time. In fact, we deal with a contradiction. Typically, physical models require to solve differential equations, using numeric methods, which should be robust and precise. On the other hand, the real-time limitation is prohibitive for physically adequate heavy computations. Computational Fluid Dynamics is based on Navier-Stokes theory, which is a prominent open problem itself (included into the set of 8 top prominent open problems by Clayton Foundation). The author – under the supervision of Prof. Pavel Slavík – focused on pulverized coal combustion. Using the planar sections of a boiler, there is the 2D version of the problem stated and solved.

a) The theme is highly actual.

The English text of the thesis consists from an **Abstract** and 15 numbered chapters or parts. One can find an included DVD without any annotation. This documents the implementation and other digital content (articles, publications, original software tool MyPCC, presentations, animations, we linkks, etc., 2 436 450 kB in total). The DVD is not mentioned in the table of contents. The chapters are: **1 Introduction and motivation, 2 Introduction to simulation of fluids and combustion processes, 3 Selected existing visualization methods for fluids modeling, 4 Isotherm-free stream, 5 Modeling of the physical behavior in the boiler, 6 Pre-calculated Fluid Simulator States, 7 Pre-calculated Fluid Simulator States Tree, 8 Hierarchical trees of unsteady simulation datasets, 9 Flow visualization using hardware accelerated spoline interpolation, 10 Interactive model of combustion for education, 11 Summary and contribution, 12 Future work, 13 Conclusion, 14 Awards, and 15 References.**

The work is done and written in a professional quality. The author has published/co-authored 1 referred journal paper and 9 referred papers at international conferences. Besides that, he published 8 other papers, most of them related with the PhD topic. His research was awarded with 3 local awards in Prague and Brno. The methods and visualizations were successfully presented at international level. The project web page is at <http://www.cgq.cvut.cz/~xgayer/mypcc/>.

The main result (a solution allowing interactively visualize pulverized coal combustion in real time) is undoubtedly unique and innovative.

b) The dissertation fulfills the given goal in a full extent.

The methodology of this research project combines several advantages of well-studied and understood methods. This applies for the tricky datastructure, real-time speed-ups, etc. The recent specialized flow visualization workshop – Topo-In-Vis (Budmerice, September 2005) presented and discussed some other special approaches, but the special nature of combustion was - in my view – more adequately visualized using the 2D approach, Eulerian model, grid, and a new coal special particle idea.

c) The methods are fully adequate and fit perfectly to the main stream research in flow visualization.

The new results or ideas include Simulation System Architecture, Pre-calculated System States, Coal Particles, Tree Cluster Structures, New Simulation-driven Interactivity, better results and features if compared with FLUENT 5.5 solution... The contribution is useful for practice and education, as well. Nearly all thesis results were published.

d) There is a sufficient and representative set of new results.

The new visualization approach can serve as a strong inspiration for another authors and can be used in practical applications, and even in a real-time visualization of real technologic process – combustion, filtering... whatever which can provide real-time feedback or measurements.

e) The importance for practice and further development of science is therefore without any doubt.

- f) The dissertation satisfies the requirements of creative independent research work and the author enriched the knowledge with several original ideas and their well-done implementations.

g) Additional Comments and Remarks

One can provide some minor negative feedback. There is missing a verb in the very last line in Abstract (page III). For the references, I would append the Real-time Rendering book by Haines-Moller because of unique discussion on real-time graphics. The DVD should have a readable label. For an interactive project, there should be a usability study or a collection of experience of potential users.

These remarks do not decrease the valuable contribution of the work and I consider them as a reviewer's feed-back to a bit noisy presentation of robust new ideas.

In the discussion, I would like to know how the 2D results can be composed into a 3D visualization model.

Conclusion:

The work of Ing. Marek GAYER in my opinion fulfils all requirements for PhD thesis. Therefore, I recommend to the doctoral committee at Czech Technical University in Prague to accept the work as a dissertation for defense according to the respective law in Czech Republic and to honor – afterwards - the author by the PhD. degree.

Bratislava, December 29, 2005