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# BOUNDARY CONDITIONS FOR INTERACTIVE FLUID FLOW SIMULATION

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## ABSTRACT

This contribution summarizes the current state of the developments of an interactive thermal fluid flow simulator and focuses on the implementation of boundary conditions. The software consists of different components which are combined into a Computational Steering Environment (CSE). The CSE comprises a visualization client, a fast and fully automatic grid generator and a parallelized simulation kernel. The software is designated to simulate indoor air flow and to evaluate thermal comfort in an interactive way.

A graphical user interface of the CSE combines the visualization of geometry and results together with the options for the “steering” of the simulation. The visualization client can be used on different systems such as desktop workstations or virtual reality environments. The CSE allows for modification of the flow parameters and of the geometry information of the model. Modification options of the geometry include adding, removing, translating, scaling and rotation of geometric objects, e.g. inlets, outlets, furniture, heaters etc. The system takes faceted geometry (STL files) as input. Boundary conditions such as the in-stream velocity or the heat flux may also be modified during runtime (see figure 1). Those changes have an immediate impact on the simulation and its effects can be directly seen in the visualized results.

Since the computational grid has to be regenerated every time the geometry is modified, a high-performance grid generator is a decisive requirement for the interactive simulations allowing modifications of the geometric setup during runtime. The developed grid generator is based on a space-tree algorithm and is capable of automatically generating the computational grid by starting from facetted geometries. This allows even large and very complex geometric models to be processed in fractions of a second.

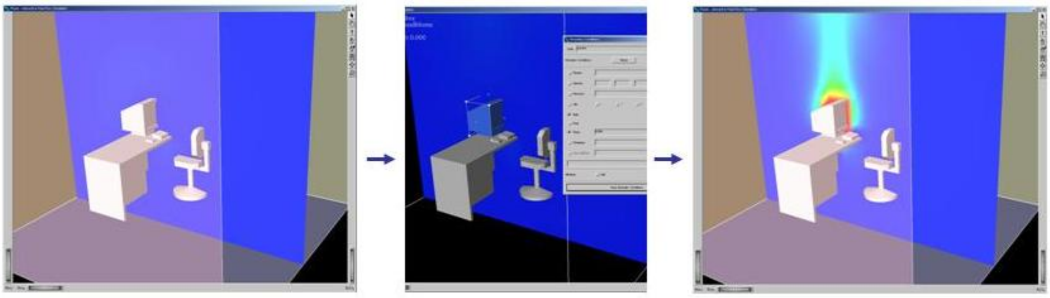

**Figure 1: Modification of the boundary condition of a geometric object: Definition of a temperature value.**

The simulation kernel is based on a hybrid thermal lattice Boltzmann (LB) method with extensions for large-eddy simulations of turbulent convective flows. To solve the mass and momentum equations numerically, a multiple-relaxation-time LB scheme is used, whereas for solving the heat equation a finite difference scheme is applied. In order to achieve the high performance needed for an interactive simulation job, the code has been parallelized using MPI and is suitable for its application on supercomputing facilities.  The computational method is based on a Cartesian grid and therefore effort had to be put into the implementation of the boundary conditions in the numerical kernel. An appropriate interpolation method has to be used in order to reach higher order accuracy at curved boundaries and to integrate the heat flux on the basis of the facette model.

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