New Division "Civil Security and Traffic" at JSC

The last decades have faced a continuously growing urban population and cities. Larger and complex buildings as well as an increasing demand on public transportation systems accompany this growth. Additionally, the frequency and extend of large public events has increased. The study of dense crowds and related safety topics gains even more importance considering the fact that since 2006 half the world population lives in cities. Cities are confronted with dense crowds, dense traffic, and mixtures of traffic types. The potential hazards related to dense crowds become obvious and real, like during the Loveparade 2010 in Duisburg (Germany). It is important to assist urban planners, architects, and safety engineers confronted with the cities' growth and the conception of future cities. Therefore, there is a high demand for new tools which consider the complexity of all involved processes.

In recent years, a working group has formed at the Jülich Supercomputing Centre (JSC) that is developing simulation models in the areas of fire safety and pedestrian dynamics. To structurally support further developments, a new division "Civil Security and Traffic" has been established at JSC in May 2012. The division is composed of scientists from mathematics, physics, computer sciences, and engineering. This interdisciplinary team develops and applies models and simulations of complex systems in the context of civil security, fire safety, and traffic planning. In combination with high performance computing it is possible to tackle challenges in the simulation of large systems using high fidelity models. The division intensively cooperates with universities around the world, research institutions as well as companies.

At the same time the demand of research on civil security is brought into the focus of the German Government, Federal Ministry of Education and Research (BMBF) and Helmholtz Association (HGF). In cooperation with the Karlsruhe Institute of Technology (KIT) and German Aerospace Center (DLR), the new division will continue its work in the HGF portfolio project "Security Research". In addition, many programmes, on European level as well, have been launched with the focus on citizens and their protection. The European Union's current Seventh Framework Programme has many sections directly dedicated to civil security. The next EU programme "Horizon 2020", starting in 2013, will also address the security of citizens. At the national level, the field "Protection and rescue solutions" is one of the funding priorities in the Federal Government's security research programme.

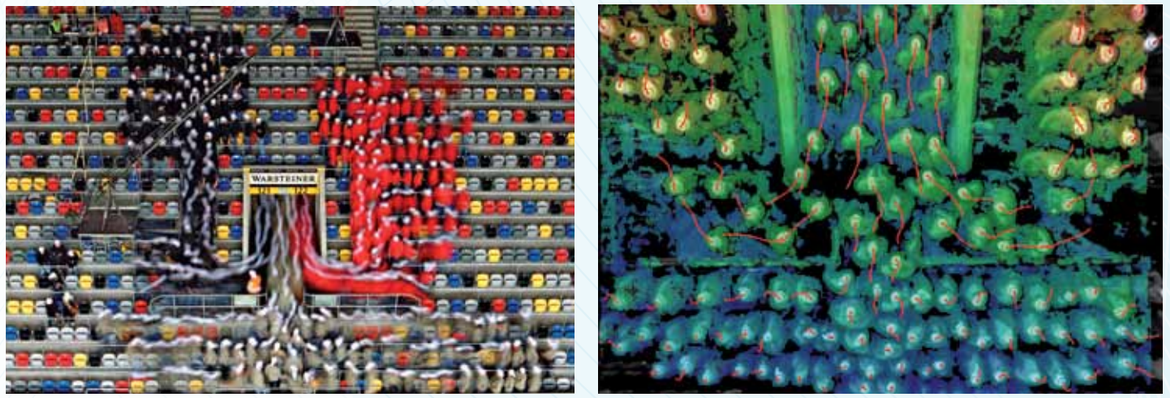

Figure 1: Left: Merging of three pedestrians streams at the gate of the tribune area of a stadium. The right picture shows the automatically extracted trajectories using the software PeTrack [5] developed at JSC.

A summary of the three main research areas of the newly founded division is presented in the following.

Pedestrian Dynamics

The investigation of pedestrian dynamics is a young and lively field of research. Along with interesting self-organization phenomena there is a multitude of applications, like the evaluation of escape routes in the context of crowd management or the optimization of pedestrian facilities for urban development. Our aim is the quantitative description of pedestrian dynamics by using microscopic models of self-driven particle systems. For model validation the group cooperates with several universities on a systematic enhancement of the empirical data basis. The group has also taken a pioneering role in the conception and execution of large-scale laboratory experiments involving pedestrians. This covers the automatic extraction of information (for instance trajectories) from experiments' video footages using pattern recognition techniques [1] and the analysis and evaluation of the information using high standard methods based on Voronoi decompositions [2]. The field is completed by the development of highly accurate models for pedestrian dynamics [3,4]

Figure 2: Simulation of fire propagation in a train compartment. Shown is a three dimensional representation of the flame distribution.

which are used in simulations to reproduce the observed phenomena. Furthermore, to increase the transparency of the research activities and promote a sustainable development, the models and analysis tools developed so far are available to the scientific community in the form of open source projects combined with databases of experimental results.

Figure 3: Left: mixed and dense traffic involving pedestrians, vehicles and cyclists in the city of Kolkata (India). Right: experiment with bicyclists performed in Wuppertal (Germany). The extraction and analysis of trajectories will give new insights into the development of bicycle traffic models.

Fire Safety

Modern and complex buildings, like airports and multi-level underground stations, represent novel architectural ideas and pose challenges for fire protection concepts. In general, official fire safety regulations are rigid and hardly applicable to such constructions. Computational fluid dynamics simulations of fire and smoke provide a flexible – and meanwhile also a reliable – tool for the outline of fire protection systems and strategies. Although fires in simple and small compartments and buildings can be reasonably computed, many models involved are based on crude simplifications. As the capability of the available fire safety software to use High Performance Computing facilities is very limited, we investigate ways to improve the parallelization of these codes. This effort will allow us to simulate large structures at an adequate numerical resolution.

Current engineering applications in our group are subway vehicles and underground stations. Here we run simulations to study the heat release rates of burning subway cars and the smoke spread in stations. These insights will be used to evaluate new ventilation setups and adaptive operation modes, including modern devices as jet fans and high pressure mist sprinkler. To ease the evacuation of passengers and the access of rescue teams, the creation of zones with a high visibility is of particular interest.

Traffic

The third area of interest is the modelling of intermodal transport, such as large areas evacuations and the modelling of mixed traffic for the planning of inner city roads. Bicycles and electric bikes increasingly enrich the traffic in cities. However, the consequences of this development for the safety and comfort on the roads have so far not been adequately investigated. In cooperation with the University of Wuppertal, initial laboratory experiments with bicycles have been conducted. Based on the results of such experiments, we compare different means of transport and provide tools to support the planning of routes for mixed traffic. It is planned to extend aforementioned activities from local evacuation of buildings or venues to evacuation of cities or regions. In the latter, the consideration of intermodal traffic is indispensable, for instance by modelling trips starting as pedestrian and using then a combination of various transports means such as cars, trains or bus shuttles.

Projects

The research activities conducted so far have been supported by two BMBF and DFG-funded projects, which were successfully completed in 2011. The BMBF-funded project Hermes [6] covered the design and implemented an evacuation assistant for large public events. The test venue was the ESPRIT arena in Düsseldorf (Germany). Succeeding Hermes, a new BMBF-funded research project BaSiGo [7] has been launched in March 2012. Beside other topics, this project studies the emergence of critical states in large crowds. For that purpose large experiments are planned.

References

[1] **Boltes, M., and Seyfried, A.** Collecting Pedestrian Trajectories, Neurocomputing, Special Issue on Behaviours in Video, ISSN 0925-2312, 2012

[2] **Zhang, J.** Experimental study on characteristics of pedestrian traffic with Voronoi-based segmentation method, PhD Thesis, University of Wuppertal, 2012

[3] **Kemloh Wagoum, A.U.** Route choice modeling and runtime optimization for simulation of building evacuation, PhD Thesis, University of Wuppertal, 2012

[4] **Chraibi, M.** Validated force-based modeling of pedestrian dynamics. PhD thesis, Universität zu Köln, 2012

[5] http://www.fz-juelich.de/jsc/petrack

[6] **Holl, S., Seyfried, A.** Hermes – an evacuation assistant for mass events, inSiDe 2009, 7(1), 60–61

[7] **Fiedrich, F.** Wie im "alten Rom": Sicherheit und Planbarkeit von Großveranstaltungen, Forschungsmagazin Research Bulletin der Bergischen Universität Wuppertal, Nr. 7/ Sommersemester 2012, http://www.buw-output.uni-wuppertal.de/p_pics/Output7_web.pdf

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