Invitation to lecture series
„Simulation Sciences"

Wednesday, November 21th 2018, Seminar room of Institute for numerical and applied mathematics, University of Göttingen, 4:30 pm

Prof. Dr. Sven Müller
## University of Applied Sciences Karlsruhe

will talk about

A pilgrim scheduling approach to increase public safety during the great pilgrimage to Makkah, Saudi Arabia

Content of the lecture:

The Hajj - the great pilgrimage to Makkah, Saudi Arabia - is one of the five pillars of the Islamic religion. With more than three million pilgrims performing Hajj rituals, it is also one of the largest pedestrian problems in the world. Until 2006, severe crowd disasters have repeatedly overshadowed the pilgrimage. Ramy al Jamarat - the stoning of the devil ritual - is known to be particularly crowded. In the aftermath of the Hajj in 2006, several measures were implemented to improve safety and to avoid crowd disasters. One particular measure is the development of a time schedule for the pilgrims to perform the stoning ritual. In this paper, we present a model and a solution approach to the Pilgrim Scheduling Problem. The model minimizes the deviation of the scheduled stoning time from the preferred stoning time, while considering infrastructure capacities to avoid critical densities of pilgrims. At the same time pilgrims are assigned to routes leading to the ritual site and back to the camp site. The routes enforce a rigor one-way ow in the surrounding area of the ritual site. We solve the

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Pilgrim Scheduling Problem by an intelligible fix-and-optimize heuristic. The schedule is evaluated using a mesoscopic pedestrian simulation and discussed with local authorities. Critical feedback is then incorporated into the final schedules. Our approach was an integral part of the planning process for Hajj in the years 2007-2014 and 2016, and no crowd disaster happened during this time. We illustrate our work with computational results and validation data for the Hajj in 2016. In 2015, a severe crowd crush happened close to the ritual site. In that year the authors were not in charge of the scheduling and routing for the stoning ritual. We provide a short discussion of the crowd accident and the approach used in 2015.
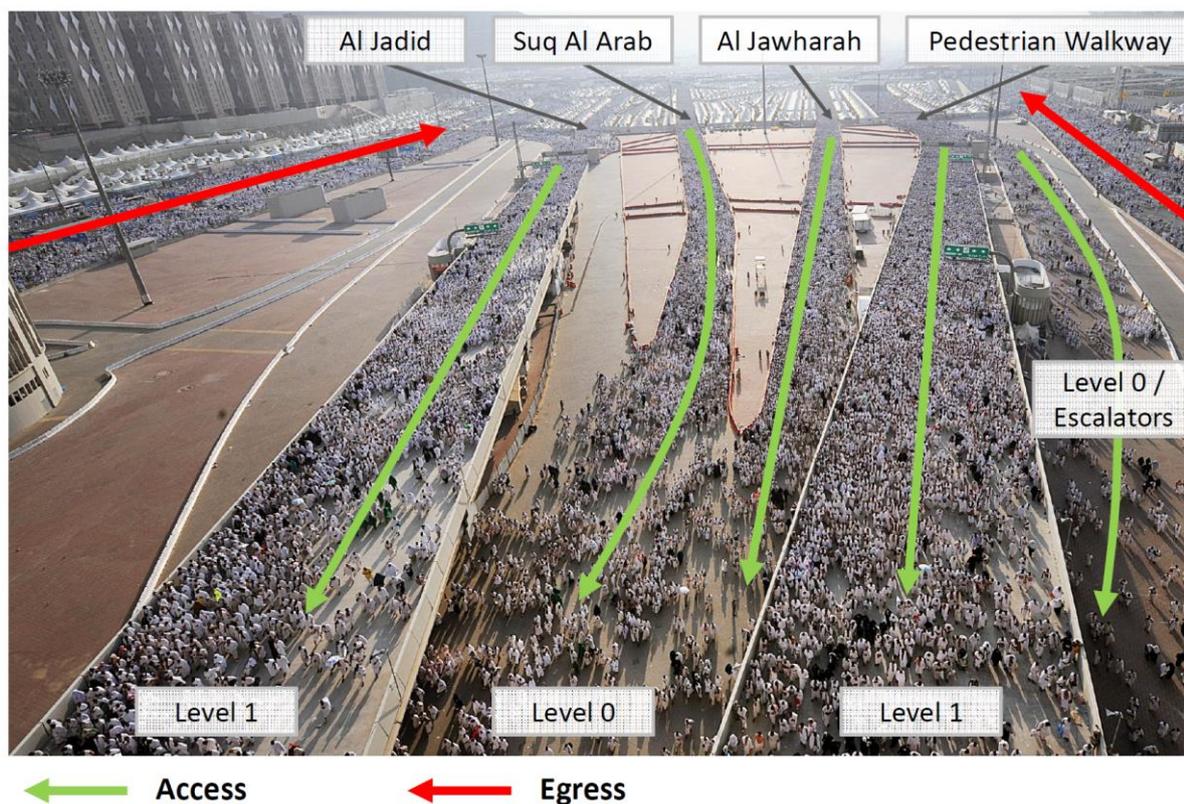
Guests are welcome.

The lecture will be held in this building:

Institute for numerical and applied mathematics,
University of Göttingen
Lotzestraße 16-18
37083 Göttingen