In 2010, 21 people lost their lives in Love Parade electronic dance music festival in Duisburg, Germany, because of crowd stampedes. 36 people died out of stampedes in 2014 during New Year's celebrations in Sanghai, China. 3 people were killed and more than 1,500 others were injured when panic erupted during a screening of the UEFA Champions League Final in Turin, Italy, in 2017. In Houston, United States, 11 people suffered cardiac arrest and 300 people were injured at a crowd surge in an annual music event in 2021. Even in 2022, on October 29, 150+ people were killed in a crowded, narrow alley during Halloween celebrations in Seol, South Korea. The list goes on and with increased rate of urbanisation, the world has experienced numerous crowd disasters killing several innocent lives. The deadliest crowd accidents belong to the annual Hajj pilgrimage in Mecca and Mina, Saudi Arabia, killing 5000+ people in a span of about 25 years.

Figure: Crowd disaster in Duisburg, Germany during Love Parade music festival in 2010. The crowd trapped under the tunnel tried to escape with 'mass panic', which later resulted in stampedes. Images taken as screenshots at 11:10 (left) and 12:54 (right) from https://www.youtube.com/watch?v=rq5bcWOjdrU.

In almost all of the cases, the reason behind these accidents were inadequate crowd management facilities taken up by the organizers of the events. Crowd management is about managing expected and unexpected crowd occurrences. Research on the motion of a crowd finds its importance in providing efficient techniques for crowd management. In urban spaces, in most of the cases, the crowd is basically a group of pedestrians walking through the streets, traffic-signal junctions, railway or metro stations, shopping malls, sports stadiums etc. During emergency situations (such as fire, earthquakes, sudden appearance of a gunman), successful evacuation of the crowd needs well-researched preventive measures. However, even without a panicking situation, managing a large crowd is definitely a challenging job, e.g., when a large number of people come out of a stadium after a sports event.

In this project we intend to work for better understanding of human-crowd behavior, such that it can provide better techniques for effective crowd management. To understand the crowd behavior one has to rely on experimental data using real human beings, but these experiments are very difficult to conduct from financial and ethical points of view. For this reason we turn to simulate the crowd using available experimental data, thanks to the improvement of computational facilities in the past few decades. The research area of crowd simulation concerns the design and use of simulation algorithms to understand, predict and reproduce the behavior of human-crowds. At high-densities, the crowd behaves like a fluid-flow and treatments from the field of fluid mechanics become an essential tool for crowd modelling, which we are going to explore in this research.

The real challenge of this research lies in the attempt of analyzing a social behavior as a physical phenomena. We plan to develop physics-based approaches where the apparent physical phenomena would be combined with the observed social behavior – making this a very challenging interdisciplinary research in the junction of social sciences, physics, biology and computer science. The most important output of this research program would be a unified crowd simulation framework that can deal with a variety of complex crowd situations and help to strengthen our understanding of how a crowd would behave under different circumstances.