**THE HETEROGENEITY** **INSIDE POPULATION TO ENHANCE CROWD MODELLING IN EMERGENCY SITUATIONS**

***Abstract:*** *explore the crowd dynamics from diversity of population which likely occur in emergency situations, also data collection framework and optimization techniques to acquire corresponding data*

1. **Background**
2. **Literature Review**

**3. Motivation and Research Questions**

Rapid urbanization and population growth always are inevitable challenges for every country in the effort of planning infrastructure, estimating traffic needs and capacities, and increasing the safety of pedestrians since over 70% of the world population is predicted to live in cities by 2050 (Weidmann, 2012). With the increase in the number of events and the accidents often happen during these events (Evers, 2011), the prediction of congestion, planning of evacuation strategies, and the assessment of building layouts become important aims for risk management in urban design and crowd safety. The key to achieve these aims is the understanding of the mechanisms of crowd dynamics leading to the formation of crowd self-organization at different events and situations especially in emergency situations (Moussaid, Helbing, Johansson, Theraulaz, 2009). Commonly studied crowd’s self-organization include lane formation, herding, bottleneck, turbulence, stop-and-go waves. Therefore, many models of pedestrian behaviour have been proposed to describe how pedestrians move and interact to produce the patterns emerging at the scale of crowd. Highly recommended model are social-force models, Nomad model, and cellular automata model, behavioural heuristic rule model (Hoogendoorn, 2013).

To make these models are sufficient to simulate crowd behaviour in emergency situations, two main efforts have been done. First effort is the studies focusing on calibration processes to find realistic parameters of current models. Second effort is the studies trying to understand and simulate uncontrolled behaviours (herding, leader-follower, competitive) in emergency situations (Shiwakoti, 2010).

State of the art in the first effort is to find actual parameter values of crow models. Well-known models such as social-force model (Helbing, 2000), Nomad model (Hoogendoorn, 2003) were calibrated through video recordings of pedestrian’s trajectories in Germany and Netherland to find realistic data of model’s parameters such as average velocity, desired velocity, interaction strength of pedestrians (Johansson & Helbing 2007), (Daamen & Hoorgendoorn, 2012). Social-force model was then used to explain the LoveParade disaster happened in Germany, 2010 (Helbing, 2012). The report of survivors from another fire disaster occurred in the nightclub Lame Horse in Perm, Russia in the year 2010 was used to calibrate a panicking model’s parameters including velocity, crowd density on forward directions (Bratsun, 2013). Another recent study (Zeng, 2014) also performed acquiring actual parameters of social force model when simulating pedestrians at crosswalks. The study was performed and calibrated in Japan since more than 30% of fatal traffic accidents there were pedestrians. Another study, (Aguirre, 2011), used agent-based model to simulate the crush disaster happened at the Station Nightclub, USA (2003) through the technical report technical conducted by National Institute of Standards and Technology, USA.

In the second effort, various social factors have been investigated and then integrated on agent-based models to simulate realistically known disasters or evacuation scenarios. It aims to describe how pedestrians are influenced by other’s behaviours when moving towards exits.

Previous studies show that possible familiar person, rather than selfish (Aguirre,). Move in direction… Social group have been investigated in agent-model to justify disaster (…). Other simulation models (Cross, ) (Leader communication), have been proposed. Social force model (Helbing,) in normal… *A recent study show that the difference in escape rate when applying social force model with model using different .(Nature), (Swakoti, 2011) pedestreian escape by group, different escape by individually. (Read more paper about herding),*  pertinent

Proximitty Aguirre ,multi agent system,

However, above two efforts almost make the assumption that populations are homogeneous and well-mixed, which is not true for real population at different pedestrian-oriented places such as sport stadium, high schools, company venues (Johansson, 2012), (Leeson, 2014). A recent calibration work through experiments imitating emergency situations (Hoorgendoorn, 2012) found that pedestrian types, who are different in ages, interact very differently in congested or evacuation conditions than in normal condition. Therefore, the impact of different pedestrians in the same population on crowd dynamics hasn't yet been explored. It yields a fundamental consideration about whether or not a single model with single parameter set is sufficient to cover the different parameter distributions of pedestrian types in emergency situations.

Key is balance personal and group, find factor affect panic through disaster happened, and simulation model to justified panic. Group also become a potential to reduce complexity in hybrid crowd models (). *Herding, footy, mobile phone at different places (), group member,*

collective behaviour during emergence/panic, agent-based model, and group model of Helbing created, group behaviour include simulation model, specific scenarios. When crowd changes its behaviour, how intergration behaviour force is good, social influence depend on what factors, how to define model this changes (dependence on speed, distance of current agent with leader,) or group, moving fast or low because of group leader, group size, weight role of leaders, in different, for different pedestrian types (follows by which)collective behaviour, herding, competitive, lead-follower,. How these changes under panic/ emergency situations, how current between pedestrian types , avoid other groups (competitive-disease). (Couzin) cohesion, personal information, group size Finally, integrate with social force is possibility (Swakoti). Herding factors affects, always go by groups, they maintain their groups,

Moreover, understanding crowd dynamics in situations of turning, merging, and diverging scenarios is necessary for evacuation plan in traffic networks containing different micro-flows (Shiwakoti, 2011).

Thus, this PhD study proposes two research questions to investigate heterogeneous information in the same population to understand crowd dynamics including pedestrian-type dynamics and group dynamics in emergency situations.

**Question 1**: How to model the difference of pedestrian types in ages in the same population in emergency situations?

**What is the impact of social group influence in scenarios of** ?

-Perform with different pedestrian types, perform with individual-group cohension,

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* What is the impact of different pedestrian types in one-exit gate, merging, diverging, and turning situations?
* How to acquire actual data for different pedestrian types in above situations in technical and social aspects? *Is there a chance to collect in actual emergency?*
* How to calibrate and validate model in these situations?

**Question 2**: ~~How to model group dynamics between~~

* What is the impact of group influence in above situations?

Two proposed research questions aim to construct a set of differential equations for pedestrians in same population in emergency situations and investigate insightful data for emergency response when these situations unfold. The questions are expected to give practical uses. It allows flexibility when performing real-time crowd modelling in different places. Also, it offers key information from crowd phenomena in live events which can give event organizers decisive minutes to try and restore the order of crowd before deteriorative situations can occur.

**2. Research Methodology**

To address the question **Q1** that aims to model the difference of pedestrians in different scenarios of merging, divering, and turning, social force model (Helbing, 2000) is used to perform simulations since it is sufficiently to produce commonly observable crowd phenomena (Hoogendoorn, 2013).

//figure here

A simulation tool is developed based on the model. Developing this tool will allow us to easily customize initial parameters of each pedestrian and environment, and monitor expected information from crowd.

Investigating what causes the difference in escape rate and blockage occurrences is then performed respectively on one and two dimensional simulations with simplified versions of social force model. It aims to understand the impact of possible reasons (e.g. parameter distribution, placements, velocities of pedestrians during simulation duration before phenomena occur).

Exploring the impact of pedestrian types in different scenarios is then investigated from real-world video recordings. They include real-world data of 1200 interchangeable participants over five day experiment in Germany generated by International Partner Investigator Armin Seyfried (Lammel, Seyfried, Bernhard, 2014) in turning, emerging, and diverging scenarios. This study will analyse different approaches using pedestrian tracking and particle advection (Moore, 2011) to extract the average distribution of parameters in social-force model used to simulate these scenarios. Since the data doesn’t comprise explicitly information of different pedestrian types, we then derive parameter distributions likely for different pedestrian types but make sure the constraint of average distribution parameters. The parameter distribution generation follows the comparison rules between interaction distributions of elders, adults and young pedestrians (Hoorgendoorn, 2012). Possible impacts such as the turbulence in crossings, how quickly they diver in multiple corridors are investigated.

Constructing actual parameters of pedestrian types in these scenarios is performed through

With the potential of human sensing nowdays (2013), (Leeson,2014) and MIT calibrate social force (,2014)

* Is there a difference in escape rates and blockage occurrences between models using single and different parameter distributions in one-exit gate evacuation situation?
* What is the impact of different pedestrian types in merging, diverging, and turning situations?
  + Turbulence,
  + Crowd pressure
* How to acquire actual data for different pedestrian types in above situations in technical and social aspects?
  + Fit construct different scenarios, workshop, ibeacon, indoor , an application will be downloaded , put into pocket, Bluetooth will record their indoor position. Lightweight (time, cost) method, pedestrians move naturally rather than in lab-controlled experiment. Easy to test in different situations placees.
    - A simulation 2D of FIT floor is constructed,
    - Evolutionary in different scenarios after collecting data
  + Deploy in other place as conference in Melbourne
  + An application on device will added on and need volunteer in naturally boxing day
    - At same scenario, derive maximum desired speed of children, adult, elderly. They don’t have to participate at same time. Information will be collected and then put in 2d dimension simulation to derive other information
  + Framework to manage that data
  + Velocity, and surrounding information let us know herding, follow, group social, different pedestrian types, aim to measure the difference between models of social forces
* How to calibrate and validate model in these micro flow? Log-likelihood estimation, evolution?

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