A popular science summary of master thesis, Division of Fire Safety and Engineering, Faculty of Engineering, Lund University.

The analysis of results of stochastic evacuation models

All people are unique. We have different characteristics and we make different decisions. This poses a problem when designing a building to be safe in forms of providing the possibility to evacuate when needed. The models we utilize to represent human behaviour and simulate evacuation are based on mathematics, but how can this be done when human behaviour is not based on precise mathematical calculations and how can we consider this when designing a building?

The kind of uncertainty associated with variability in human behaviour is often called "behavioural uncertainty" and makes for one kind of uncertainty in evacuation modelling. Engineers are familiar with making models of the physical environments due to our relatively good understanding of it. Problem arises when we try to do the same for psychological processes within the human brain. It is also fair to say that we most often associate uncertainty with something bad that should be minimized or eliminated in the models we design. Behavioural uncertainty is however not something that is only present in the models we design but is a fundamental characteristic of actual human behaviour and it should therefore be carefully considered when we design our models which purpose is to represent the reality as accurate as possible. When we design buildings, the purpose of an evacuation analysis is to show that the building can be safely evacuated at all times, but we are typically uncertain on the exact people that will occupy the building and the circumstances in that situation, making it difficult to determine their behaviour.

This kind of uncertainty is sparsely incorporated in the models of today. Most models make use of randomizable/stochastic variables for different occupant characteristics such as walking speed and time until the occupant start to move towards an exit. The decision-making process that humans go through when making decisions in an evacuation scenario are however yet to be implemented in the models.

The challenge lies in how to effectively assess and analyse this kind of uncertainty and in particular assess how many randomized runs of the same scenario is needed in order to say that human behaviour has been represented sufficiently. Previous work has shown that the mathematical concept of functional analysis, i.e. a method to quantitatively assess the difference in two curves has been efficient in analysing difference in evacuation time curves, and coupled with the central limit theorem, to analyse convergence in results. Evacuation time is however only the result of human behaviour. Other variables derived from the field of fluid dynamics etc. are used to measure the evacuation process, i.e. density, flowrate etc. The thesis contributes by developing a methodology on how these variables and others could be included in the analysis. A tool is also developed which purpose is to help the users of evacuation simulation software to conduct this kind of analysis on a regular basis.

To test the proposed methodology, a case study was conducted, and the results showed that the methodology was successful in analysing convergence in results for the variables studied. This means that the analysis of the effects of behavioural uncertainty can be done at a higher level of detail than what has previously been shown, ensuring that the underlying behaviours (crowding etc.) that govern evacuation time also have converged. The methodology developed may also be used in validating evacuation simulation software against real evacuation scenarios with regards to behavioural uncertainty, if data from repeated evacuation events/trials were to become available in the future.

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