Assessing the computational complexity of pedestrian models: A framework

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Stadiums, cruise ships, festivals, trains stations and airports. All these places have a thing in common, many people moving around at the same time. Pedestrian models are the prime tool to model these movements and as such they are used widely by engineers to assess if people can move around in these places safely, comfortably and efficiently. As a result, many different pedestrian models have been developed over the last few decades. These models differ in many aspect such as modelling techniques and the level of detail at which they describe the pedestrian flow.

To assess how well these different models can be applied in various situations two factors are of great importance. The validity and the computational complexity. The validity provides information about the scenarios in which the model can be expected to provide accurate results. The computational complexity, in turn, provides information about how many computational resources and time it takes to compute these results in different scenarios. Both are important, as a fast model that cannot provide accurate results is useless as is an accurate model that cannot provide the results in time.

Out of these two factors validity has gotten much more attention with multiple frameworks existing that can guide a modeller or model user in assessing the validity of a pedestrian model. Furthermore, most papers presenting a new model assess the validity of their model. The computational complexity of a model, on the other hand, is rarely assessed or even mentioned. Currently, also no framework exists to guide modellers in this exercise. Hence, this study aims to create such a framework.

The first step in creating the framework is defining what exactly the computational complexity of a pedestrian model is. We define it as *the computational burden per unit of simulated time,* with the unit of time selected to be 1 minute in this study. To obtain a good insight into this computational complexity of a pedestrian model the framework contains three different methods and a battery of test cases.

The three methods employed by the framework are the asymptotic complexity method, the atomic operations counting method and the empirical method. Each of these methods has its own strengths and weaknesses and depending on the level of detail and type of computational burden one is interested in one or two of the methods need to be used. For example, if one wants the computational complexity estimate of a pedestrian model that is independent of the exact hardware and software used, one of the two theoretical methods is applicable. If, on the other hand, one wants and estimate of the actual computation times when using certain hardware, the empirical method is applicable.

The battery of test cases ensure that the computational complexity is assessed for a wide variety of scenarios. The composition of the test cases is such that both the different application of pedestrian models and the properties of the different types of models that might affect the computational complexity are taken into account. This ensures that one can fairly compare different models and that one can obtain good insight into how a pedestrian model would perform in different situations.

To assess the framework, the computational complexity of five models is assessed using all three methods and all test cases. Each of these models represents a major group of pedestrian models. As of writing, this assessment is yet to be performed.