Comparison of Simulation Models for Pedestrian Risk Assessment: Fuzzy Logic and Intuitionistic Fuzzy Logic

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Abstract:

Whether we're pedestrians or drivers, we can all fall victim to the various dangers inherent in driving. However, pedestrians are always the first victims of road accidents, with drivers often the main culprits. In the event of a collision with a vehicle, the consequences can be serious for pedestrians. In this context, human behavior plays a crucial role in the risk of collision. That's why it's essential to analyze the interaction between pedestrians and vehicles in order to reduce the risk of accidents involving pedestrians. By understanding how pedestrians and drivers interact on the road, we can put in place appropriate safety measures to prevent accidents.

To do this, we used the Nagel-Schreckenberg model, a theoretical mathematical model designed to simulate road traffic behavior. It takes into account maximum speed, braking, acceleration and overtaking rules, enabling a realistic simulation of vehicle movements on a road. On the other hand, we have integrated the Ant Colony Optimization (ACO) metaheuristic into the pedestrian simulation, based on a bio-inspired approach that takes advantage of careful observation of ants' collective foraging behavior. ACO can be applied to realistically simulate pedestrian movements in a specific environment.

For a comparative study, we first integrated fuzzy logic into the pedestrian model, enriching the simulation with an additional level of sophistication in pedestrian decision-making. Fuzzy logic makes it possible to model more realistically the complexity of factors influencing pedestrians' choices, taking into account the often imprecise and subjective nature of the information available. Secondly, we have also introduced intuitionistic fuzzy logic, which offers a more faithful representation of the nuances and imprecisions associated with risk assessment. We apply these theories to two distinct risk exposure formulas in order to compare their effectiveness and relevance.

These models were implemented in the Python programming environment, using the Tkinter library. The simulation results have been presented in the form of four evocative graphs. Each of these graphs represents a distinct facet of the comparative analysis between old and new formulations of fuzzy logic and intuitionistic fuzzy logic. These graphs aim to reveal the subtleties of risk exposure in realistic traffic situations, where the degrees of indecision and uncertainty of drivers and pedestrians play a crucial role. Intuitionistic fuzzy logic offers a powerful method for studying the complex dynamics of road safety, and can serve as a sound basis for developing strategies to improve the safety of pedestrian-vehicle interactions on the road. In summary, our in-depth exploration of risk exposure assessment, exploiting both fuzzy logic and intuitionistic logic, has highlighted notable differences between the old and new approaches to risk exposure assessment.

Keywords:

Intuitionistic fuzzy logic, Accident risk, risk exposure indicator, Pedestrian-vehicle interaction.