

Abstract

A digital twin is a virtual replica of a physical object that is constantly updated through mapping between them. Digital twins have the potential to improve transportation by providing insights into traffic conditions, assisting in traffic management applications, and measuring the effect of infrastructure changes on traffic flow.

The dissertation proposes a framework for building digital twins of the motorway by collecting various sensor data. The framework collects data from motorway sensors using an Apache Kafka-based communication mechanism and supports consuming data from four different sensors: inductive loops, motorway cameras, toll bridge cameras, and probe vehicles. The collected data will be passed to a sensor fusion model which will perform the data processing and error correction. The processed data will be fed into the agent mapping model, which will model the traffic flow. The agent mapping model will use an agent-based approach to simulate the vehicles as agents. Agent-based approach is a simulation modelling technique that treats each vehicle as an agent and models it individually based on its interactions with the environment. Simulation of Urban Mobility (SUMO), a microscopic simulator, will be used to simulate the modelled traffic flow. To advance the vehicles between the sensor readings, SUMO's car following model and lane changing model will be used.

The framework is inspired by the Kalman filter, a sensor fusion technique that predicts and corrects the state using previous data iteratively. Similarly, the concept of our framework is to iteratively estimate the vehicle's state based on the initial sensor data reading and advance the vehicles. The framework estimates the new state and corrects it based on the sensor data.

The framework is being evaluated by creating a digital twin of Dublin's M50 motorway. A SUMO simulation of the M50 motorway serves as the physical entity for this digital twin. The number of total vehicles and the average speed of the entire simulation are used to compare the physical entity and the digital twin. The dissertation also discusses potential future work for the framework to improve performance and accurately model traffic flow.