Multi-output bus travel time prediction with convolutional LSTM neural network

Accurate and reliable travel time predictions in public transport networks are essential for delivering an attractive service that is able to compete with other modes of transport in urban areas. The traditional application of this information, where arrival and departure predictions are displayed on digital boards, is highly visible in the city landscape of most modern metropolises. More recently, the same information has become critical as input for smart-phone trip planners in order to alert passengers about unreachable connections, alternative route choices and prolonged travel times. More sophisticated Intelligent Transport Systems (ITS) include the predictions of connection assurance, i.e. an expert system that will decide to hold services to enable passenger exchange, in case one of the services is delayed up to a certain level. In order to operate such systems, and to ensure the confidence of passengers in the systems, the information provided must be accurate and reliable. Traditional methods have trouble with this as congestion, and thus travel time variability, increases in cities, consequently making travel time predictions in urban areas a non-trivial task. This paper presents a system for bus travel time prediction that leverages the non-static spatio-temporal correlations present in urban bus networks, allowing the discovery of complex patterns not captured by traditional methods. The underlying model is a multi-output, multi-time-step, deep neural network that uses a combination of convolutional and long short-term memory (LSTM) layers. The method is empirically evaluated and compared to other popular approaches for link travel time prediction and currently available services, including the currently deployed model at Movia, the regional public transport authority in Greater Copenhagen. We find that the proposed model significantly outperforms all the other methods we compare with, and is able to detect small irregular peaks in bus travel times very quickly.