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Predicting Bus Travel Times in Washington, DC Using Artificial Neural Networks (ANNs)

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Among U.S. cities with the highest public transit commuters, Washington, DC ranks second, with approximately 9% of the working population using the Washington Metropolitan Area Transit Authority (WMATA) Metrobuses to commute. To provide reliable service to these commuters, transit authorities need to know accurate travel times of these metrobuses. Using Artificial Neural Networks (ANN), this study developed prediction models for transit buses to help improve service quality and patronage.

Study Methods

ANN can help to visualize complex patterns or predict an output for an unseen dataset by learning from the existing data, hence, mimicking the learning process of a human brain. In addition to regression models, we developed ANN models for this research based on AVL (Automatic Vehicle Location) and APC (Automatic Passenger Counters) data.

We used six (6) months (January – June 2019) of AVL and APC data for six bus routes operating in the DC area. Since traffic characteristics depend on the time of the day, we developed separate models for AM Peak (7:00 – 9:30 AM), PM Peak (4:00 – 6:30 PM) and Mid-Day Peak (10:00 AM – 2:30 PM) periods. Based on a combination of independent variables, we used the approximation method in Neural Designer Software to predict bus travel time. The independent variables analyzed were:

1. Number of Served Bus Stops
2. Length of Route
3. Average Number of Passengers
4. Average Dwell Time of Buses
5. Number of Intersections between Bus Stops

The datasets per peak period were split randomly into training (75%) and testing sets (25%) by the software for analysis. We used the training datasets to train and develop separate models while using the respective testing

datasets to validate the models. Finally, we compared the normalized Squared Errors obtained after training the datasets to observe the credibility of each model.

Findings

Transit bus travel times and the dwell time of buses at stops generally increased over time of the day.
The longest travel times for buses serving 9 bus stops were as follows:

1. AM Peak Period: 33 minutes
2. Mid-Day Peak Period: 86 minutes
3. PM Peak Period: 46 minutes

We obtained correlations between the independent variables and the target variables (bus travel times) for different peak periods. The highest correlations with travel time for the different peaks are as follows:

1. AM Peak Period: number of served bus stops
2. Mid-Day Peak Period: length of the route between two served stops
3. PM Peak Period: number of intersections between two served stops

We used both Quasi-Newton and Levenberg-Marquardt Optimization Algorithms in the neural network training process. Overall, the Quasi-Newton optimization algorithm produced lower errors for all peak models.

By obtaining bus travel time equations for peak periods, we can use independent variable input to provide accurate bus travel time (in seconds).

Three sets of perceptron layers with different numbers (2, 3 and 5 layers) were used in the Quasi-Newton Method to learn from the datasets. Normalized Squared Errors (NSE) on the testing errors were evaluated following the training process. It was observed that the models trained using Quasi-Newton Algorithm having 2 perceptron layers generally had the lowest NSE followed by models with 3 perceptron layers.

Mid-Day Peak models had the lowest overall testing errors for all number of layers.

Policy/Practice Recommendations

The findings and models developed in this research can be used by transit agencies to improve bus scheduling and operations. Ultimately, this research can help provide better and more reliable transit services and improve patronage.

About the Principal Investigator

Dr. Arhin is an Associate Professor of the Department of Civil and Environmental Engineering of Howard University, the director of the Howard University Transportation Research and Traffic Safety Data Center (HUTRC), and the director of this transit research project, conducted under the Mineta Consortium for Transportation Mobility.

To Learn More

For more details about the study, download the full report at **transweb.sjsu.edu/research/1943**

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