Traffic Flow Prediction at signalised road intersections Using Markov chain and ANN. A comparison

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Contents

Motivation

- Traffic congestion is a prevailing problem globally
- Predicting Traffic congestion is necessary for traffic modeling, better planning and road traffic control
- Markov chain models are heuristic sequential models, which find the next traffic state based on present state
- Artificial Neural networks like RNNs and LSTMs can store continuous sequential information of all past states to predict the next state

Markov Chain for Traffic congestion prediction

- States
  - Low Traffic (State - a)
  - Moderate Traffic (State - b)
  - High Traffic (State - c)
- State Transition Matrix

$$\begin{bmatrix} P_{a,a} & P_{a,b} & P_{a,c} \\ P_{b,a} & P_{b,b} & P_{b,c} \\ P_{c,a} & P_{c,b} & P_{c,c} \end{bmatrix}$$

- This problem is solved using assumption of First order Markov chain, where next state depends only the present
- Steady State probabilities

$$\begin{bmatrix} e1 & e2 & e3 \end{bmatrix} = \begin{bmatrix} e1 & e2 & e3 \end{bmatrix} \begin{bmatrix} P_{a,a} & P_{a,b} & P_{a,c} \\ P_{b,a} & P_{b,b} & P_{b,c} \\ P_{c,a} & P_{c,b} & P_{c,c} \end{bmatrix}$$

Contd..

- Traffic is observed on hourly basis and one transition matrix each is maintained of each weekday
- Transition matrices are updated after observation are made
- Process of moving from one state to another state can be derived from the equation

$$P(K) = P(0) \times P_{i,j}^{k}$$

Where,

- P(0) is Traffic volume for a low, moderate, and high vehicle movement
- $P_{i,j}$ is state transition Probability matrix
- P(K) Probability of at a particular hour on a particular day of the week

Contd..

- Probabilities for every next hour for every possible state transition is calculated from the state transition matrix
- Present state is identified after observing the density of incoming vehicles
- Next state is predicted as whichever state transition has highest probability.
- Transition matrix is updated after every observation

ANN for Traffic congestion prediction

Data sets were prepared after observing speed, distance of vehicles and then output observed was in terms of time taken for vehicles to cross the signal.

- Inputs : Speed, Distance
- Outputs: Time taken to cross the signal in the intersection

Contd..

- Neural network architecture and training conditions
  - Number of hidden layers : 1
  - Number of neurons in hidden layer : 9
  - Number of epochs the NN is trained 100
  - Best results on test data observed at epoch 7
- After time needed for each vehicle to cross signal is calculated, we can find if traffic will be congested at every continuous intervals.

Comparison and Conclusions

- According to the paper ANN showed better performance when compared to heuristic model like Markov chains
- Although Markov chains show slightly lesser performance, computation power required is quite less when compared to ANN.
- Markov chains are far less complex when compared to neural networks but give comparable and considerable performance

Reference

Title: Traffic flow Prediction at Signalized Road Intersections: A case of Markov Chain and Artificial Neural Network Model Link: https://ieeexplore.ieee.org/document/9476173
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