Doing things with particle filters

Tom Elliott
University of Auckland, Auckland, New Zealand
E-mail: tom.elliott@auckland.ac.nz
Thomas Lumley
University of Auckland, Auckland, New Zealand
E-mail: t.lumley@auckland.ac.nz

Summary. The prediction of transit vehicle arrival time is a complex problem with the added difficulty of its real-time nature. Reliable predictions require the combination of both vehicle and network states, implying that real-time traffic congestion information is incorporated into the predictions. Inevitably, however, there is a lot of uncertainty around arrival times: road speeds fluctuate, particularly around peak time, and multimodality is added with every stop passed (which may or may not cause the bus to stop depending on passenger demand). Therefore, not only do we need to predict arrival time, but also assess and report the uncertainties involved. We present a method of using a particle filter to combine the states of both vehicle and network to obtain arrival time distributions. These are then discretised in such a way that allows real-time calculation of event probabilities for use in journey planning applications.

Keywords: particle filter, transport, real-time, GTFS

Hello ...

1. Introduction

- the problem of predicting bus arrival - it needs to use real-time traffic information Citation Needed (2020)
- however, many deployed methods are either specific to a provider/city, or don't make use of real-time data (only vehicle position and/or arrival delays, e.g., in Auckland)
- since the only logical source of "traffic data" in this setting is the transit vehicles themselves, makes sense to develop framework that uses them to estimate real-time network state Elliott and Lumley (2020)

- in this example, particle filter is used to obtain a sample of points from the arrival time distribution - many many points, which cannot possibly be distributed or stored efficiently
- we propose a method of reducing this to a simple discrete CDF of arrival time (in minutes)

Some of the references include:

- Cathey and Dailey (2003)
- Yu et al. (2006, 2010, 2011)
- Hans et al. (2015)

2. Background

Before describing the process of obtaining arrival time distributions, we must first define the framework with which we obtain vehicle and network state estimates. Elliott and Lumley (2020) present a process for constructing a transit road network from raw GTFS data.

2.1. A transit road network

- information about GTFS
- the concept of converting it into a network (as per Elliott and Lumley (2020))
- end product is real-time estimates of traffic state

2.2. Estimating network and vehicle state using particle filtering

- particle filter on vehicle state
- used to estimate vehicle speed, position
- obtain distribution of travel times for each vehicle along each road

3. Predicting arrival time

3.1. Particle filter etas

- use particle filter and network state to obtain ETA estiamtes for each particle/stop
- include dwell time uncertainties, etc
- result is a distribution estimated by N particles

3.2. Simplified ETA CDF

- round to minutes
- compute the CDF by definition "number of particles arriving within x minutes"

4. Journey planning applications

- CDF makes it possible to answer many (often complex) jouney planning questions
- P(catch)
- P(arrive on time)
- P(transfer)
- this is a simple computation - can be done client side (i.e., on a user's phone) by passing CDF (small size, as e.g., JSON)

5. Discussion

- what this means
- how this makes JP more accessible

5.1. Future Work

- automated route selection
- improved particle filter
- improved network construction
- improved network state forecasts

5.2. Conclusion

- simple conclusion of the paper

References

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