**AAIS C2 Question 4**

In this assignment, I have applied my foundational knowledge of Prolog, as taught over the semester, to simulating a real-life intelligent system in urban traffic management.

In Question 1a/b, I analysed the provided scenario.pl files to calculate the optimal greentimes for the stages of the junctions associated with the given in-links, per scenario. Using these calculations, I then proposed adjusting the greentimes of the opposite stages inversely, as to keep the cycle lengths of the junctions fixed. The aim of this question was to theoretically eliminate queues on the given in-links.

In Question 1c, I implemented a Prolog program which can extract and analyse the current traffic plan from a scenario, then perform the same optimal greentime calculation as theorised in Question 1a/b to adjust the greentime for the stage of the junction associated with any provided in-link. This program also adjusts the greentime of the opposite stage inversely, as was proposed in Question 1a/b. This program takes as input one in-link and returns as output a list of the two adjusted greentimes. Additionally, the program amends the plan, overwriting the previous greentimes with the adjusted greentimes.

To facilitate this program, I created three additional sub-programs which are used within the main Question 1c program:

* stage\_name (L, S): which retrieves the stage associated with the input link
* total\_flow\_in\_rate (L, S, FI): which retrieves the total in-flow of the input link during a cycle
* opposite\_stage (L, OS): which retrieves the stage of the junction not associated with the input link

In Question 2, I implemented a Prolog procedure which monitors queue length on 4 in-links during a simulation. If a queue on any of these in-links exceeds 10 PCUs, the procedure calls the Question 1c program to optimise the greentime of the stage associated with the in-link on which the queue has built up. This should prevent the queue from building further, and ideally, reduce the queue.

In Question 3, I implemented a similar Prolog procedure to Question 2, except instead of using the Question 1c program to optimise the greentime of any stage with an in-link queue of >10 PCUs, the procedure maximises the stage length of any stage with an in-link queue of >20 PCUs. As the maximise function results in a more significant change in greentime, the queue should reduce faster than in Question 2, and therefore the queue threshold has been increased for this procedure.

Whilst I believe that the strategies I implemented within the Question 2/3 procedures are effective, I believe that a more optimal strategy I could have implemented would have been one that monitored all in-links simultaneously and used the Question 1c program to optimise the greentime of the stage with the largest in-link queue, provided that its queue is >5 PCUs.

Following the optimisation of a stage, the procedure could have marked it unoptimisable for 10 seconds, allowing a ‘cooldown’ period for its in-link queue to reduce and for the procedure to optimise other stages if necessary.

By monitoring every in-link within the system, every potential queue within the simulation could be minimised. By setting a low queue threshold (i.e. 5 PCUs instead of 10/20) the procedure could perform optimisation more often, without optimising a stage unnecessarily (e.g. if its in-link has no queue or a very small (<5 PCUs) one).

This coursework uses a reactive-based autonomous approach to traffic management. In each of my implementations, I monitor queues within the simulation but only perform changes once a queue crosses a predefined threshold. My implementations are modelled macroscopically, as only the flow of traffic is considered, rather than individual vehicles.

The implementations within this coursework operate upon the plan derived from the UTM case study, which was generated via deliberative autonomy, or automated planning. The plan generation process requires inputs of the domain model, its current state and the plan’s tasks or goals in order to generate a plan. The plan is a sequence of specific actions which will enact/achieve its tasks/goals.

Reactive autonomy (e.g. the coursework implementations) operates by pre-set rules and behaviours without maintaining any internal state or considering any other autonomous agents, akin to a human reflex. Deliberative autonomy (e.g. the UTM case study) operates by retrieving behaviours, maintaining an internal state, predicting the effects of actions and considering any other autonomous agents, more akin to human thought and rationalisation. (Stone, 1997)

There are many different suitable UTM techniques, ranging significantly in levels of autonomy. For example, the level of autonomy exhibited within this coursework is more complex and dynamic than in ‘fixed green time’ strategies. This is because the coursework implementations perform real-time changes to the traffic plan, whilst fixed strategies are pre-emptively and statically designed; meaning fixed strategies are poor at handling abnormal or unexpected traffic flows.

On the other hand, UTM techniques such as SCOOT which employ real-time adaptive autonomy to manage a group of junctions could be considered more autonomously complex than the coursework implementations as they cover a much larger area.

Overall, a reactive-based UTM approach is useful as it allows for real-time traffic flow optimisation. Such an approach also provides some degree of handling extreme or abnormal traffic flow that couldn’t be handled in an alternative fixed system. However, any real-time system is also extremely complex, with lots of software and hardware to manage and maintain. This complexity grows as the system domain grows.

In conclusion, I believe that a reactive-based UTM approach, similar to the approach used within this coursework could be usefully used in practice, provided that its application domain is small enough to be manageable under given resource constraints.

References:

Stone, P. (1997). Reactive vs. Deliberative agents. Retrieved from https://www.cs.cmu.edu/afs/cs/usr/pstone/public/papers/97MAS-survey/node14.html