Reactive Agent for Urban Traffic Control

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Abstract

The urban traffic jams are daily problem in large cities. Urban Traffic Control (UTC) Systems aim to solve this problem. Because of spatial distribution of urban traffic, multiagent systems are suitable framework for implementation of UTC. In this paper, we present a new abstract model of traffic flow that and explain how a reactive control agent can be built based on it.

1. Introduction

Urban road networks serve a significant part of traffic demand. For example in Germany 30% of some 600 billion car kilometers per annum are traveled within metropolitan road networks. Because of high demand many urban road facilities are frequently oversaturated and respectively congested.

Inherent distribution of urban traffic makes multiagent systems and agent technology suitable option for UTC. An important reason for the growing success of multiagent technology is its potential to cope with high complexity problems that show a priori distribution. From the technical point of view, the inherent distribution allows for natural decomposition of the system into agents that interact so as to achieve a desired global functionality. By this, reusability is prompted, not just by the agents' modularity, but also on their autonomy.

In subsequent sections we advocate a new method for traffic light control for urban network. According to the Hoyle, problem formulation or modeling of processes is the most important part in solution of control problems. So, in section 2 our model is explained and then in section 3 a reactive control is proposed. In the last section the results and conclusions are drawn.

2. Traffic Control by Resource Scarcity Measure

Doyle [1] advocates that every computation is a resource allocation. Several works [2][3] have modeled their problems as resource allocation. Resource allocation problem deals with problem of optimal allocation of resources among several users.

UTC aims to allocate resources (i.e. streets) to users (i.e. cars in other streets). An intersection is not itself a resource, rather it permits users to release one resource and allocate another one. So, the UTC problem is, inherently, a resource allocation problem in which user of a resource occupies a resource when releases another resource. But, how in can be dealt?

In order to answer to this question we only need to know how scarce a resource is. Hence, UTC is only responsible for propagation of scarcity from scarce resources toward less occupied resources. Here is a question:" which parameters characterize scarcity of a resource? "

Resource Scarcity Measure

In urban traffic, we used the "cost" criterion for resource scarcity. Cost of a resource should explain the state of scarcity of resource and trend of it. Our experiments showed that, two parameters show the dynamism of a resource, i.e. street. These parameters are 'load of the street (ls)' (1) and 'normalized mean speed in street (nss)'(2).

$$ls_i = \frac{\textit{Current no. of cars in street}_i}{\textit{Capacity of street}_i} \qquad (1)$$

$$nss_i = \frac{\textit{Average of all cars velocity in street}_i}{\textit{Desired } \max. \textit{ velocity in street}_i} \qquad (2)$$

Our experimental resource scarcity function has been shown in (3).

$$\text{Cost}_i = 1000 * \log\left(\frac{ls_i + \varepsilon}{nss_i + \varepsilon}\right) \qquad (3)$$

in which cost, is resource scarcity criterion and $0 < \varepsilon << 1$.

ls_i decreases as nss_i increases and vice versa. This forces the cost to rise as we approach high ls and low nss. This gives the clear indication of the "dangerous zone" to avoid, while at the same time encouraging a relatively high utilization.

Reactive Agents for Urban Traffic Control (RAUTC)

Intersections are places in which a resource could be released or allocated. Thus, the control agents should stand at them. Actions of a RAUTC will make changes in environment, i.e. streets connecting to the intersection. The changes could be categorized as:

1. Bettering changes
2. Worsening changes

Action of RAUTC is passage permission to a street and closing others. We expect that cost of open street be decreased and cost of closed and downstream streets increased. Therefore, the state changes measured by 4, and the environment changes are classified by 5.

$$\textit{State Change} = \mathit{Min}\{\Delta cost_{open\ streets}\} + \mathit{Max}\{\mathit{Max}\{\Delta cost_{closed\ streets}\}, \mathit{Max}\{\Delta cost_{downstream\ streets}\}\} \quad (4)$$

$$\begin{cases} \text{if } \; StateChange \le 0 \longrightarrow \text{Bettering change} \\ \text{if } \; StateChange > 0 \longrightarrow \text{Worsening change} \end{cases} \quad (5)$$

Actions of a RAUTC should obey the environment control restrictions; that includes:

1. Control strategy of an intersection defines order of streets signal changes.
2. The street green light length must be between [minimum standard green time, maximum standard green time].

By use of above criterion, RAUTC control algorithm only reacts to environment changes in order to prohibit the worsening changes.

RAUTC architecture constituents as shown in fig. 1 are:

1. *Action selection module* that is responsible for taking action respecting to state change evaluation and control strategy.
2. State change measurement module that measures the intersection state changes.
3. *Evaluation module* in which determines whether the changes are bettering or worsening.
4. *Control strategy exploration module* that gathers all daylong state changes by every control strategy and chooses most suited one as permanent control strategy of RAUTC.

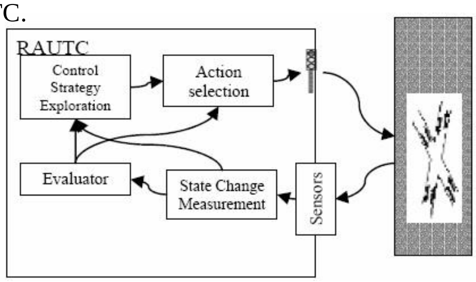

Fig.1 Internal Structure of a RAUTC

3. Results

RAUTC has been compares with pre-timed intersection control (PIC). The controls have been applied in urban traffic micro-simulator based on [4]. Fig. 2 shows the comparison of RAUTC with PIC with two timing t=50 sec and t= 120 sec. The results show superiority of RAUTC to PIC.

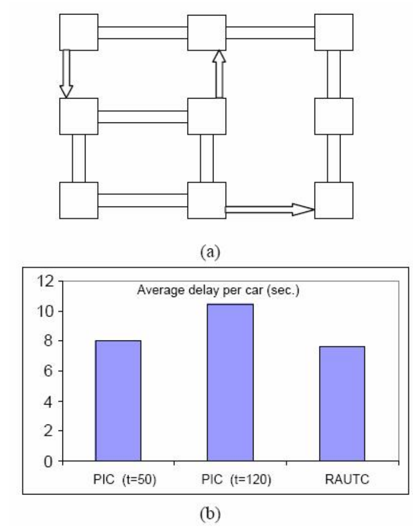

Fig.2. (a)evaluated topology (b) results

4. Conclusion

In this paper, we showed that a resource scarcity measure can be employed to build a reactive control agent. The reaction algorithm is similar to control methods via feedback. The feedback of RAUTC is a quantized value of resource scarcity. RAUTC knows that its actions make changes in its environment, hence classifies changes to bettering changes and worsening changes. It assumes prohibiting worsening changes is itself a bettering change. RAUTC algorithm is somewhat greedy. This reactive approach is time-efficient but it may be unable to reach the optimal situation if it trapped in local cost fluctuations.

References

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