Urban Signal Control Using Intelligent Agents*

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Abstract

Problem of traffic jams is common in large cities. Urban traffic control systems aim to solve this problem. The major difficulty in urban traffic is large number of variables for representing the state of traffc, such as traffic flow,speed, and density. Lack of precise relations between these variables is another problem. In this paper, we present a new model for traffic flow and introduce a traffic control systems based on that.

Keywords: Traffic, Intelligent Agents, Resource Mangement

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URBAN SIGNAL CONTROL USING INTELLIGENT AGENTS

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The urban traffic jams is daily problem in large cities. Urban traffic control system aims to solve this problem. The major difficulty in urban traffic is great number of variables in order to present the traffic state such as flow, speed, density. Another bothering characteristic of urban traffic is lack of precise relation between these variables. These problems make researchers to develop several traffic models to describe the traffic behavior and build control on them. In this paper, we present a new model of traffic flow and introduce a control for this model that helps agents to control traffic autonomously.

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 the high demand many urban road facilities are frequently oversaturated and respectively congested. Through congestion the capacity of the road infrastructure is in fact reduced and particularly during rush hours when the maximum capacity is most urgently needed the performance deteriorates considerably [1].

Three approaches may be considered to solve this problem:(1) reduction of urban population by making citizens to migrate to other less populated areas, and eventually decrease demands for urban traffic, (2) development of infrastructures and (3) better use of infrastructures. First approach looks somehow silly because the problem is delegated to other areas, so let it be discarded. The second proposal is hard to be applied in some high density areas like downtown. The most favorable option is third approach. One of prescription for third approach is better control of urban area traffic flows in order to achieve efficient use of urban transportation.

Traffic control management is generally subdivided into two different classes [2]: (1) direct control measures using traffic lights and variable message signs and (2) indirect control measures like recommendations for the drivers by means of VDS (variable direction signs and text panels), warning messages (via broadcast, RDS/TMC or handy-based services), pre-trip information (e.g. via Internet) and individual driver information systems. In subsequent sections we advocate a new method traffic light control for an urban network that has been described in section 2 and in subsections 2.1 and 2.2 the underlying formulations and control algorithm is described. The proposed methods were simulated and the results are presented in section 3.

2. Traffic Control via Resource Scarcity Measurement

In fact traffic control is problem of allocating scarce resources (i.e. streets) among users (i.e. drivers), fairly, the thing that economics tries to do. But, what is the meaning of "fair" in an economy? In economical view, every good in an economy have a real price (shows scarcity of good) and each customer of good has a valuation for it (essentiality of use). The good must be allocated to the user with most valuation. In economics and more especially market science several types of mechanisms (e.g. several auction types) and theoretical foundations have been provided for this allocation. Many other allocation problems in engineering environments have been used the idea of building a market, in order to achieve optimal resource allocation [3,4]. But could urban traffic make use of market initiatives.

2.1. *Resource Scarcity Measure*

All efforts in economics are around two question 'how scarce is a resource' and 'where this scarcity going to go? Or trend of its scarcity'.

Although, in urban traffic, no market mechanisms have been proposed but, if a comparable criterion for resource scarcity could be presented; control can operate based on it. Let us call this criterion 'price'. Price of a resource should explain the state of scarcity of resource. In urban traffic, two parameters shows the dynamism of scarcity of a resource, i.e., street. These parameters are 'load of the street$_i$ (*ls*)' and 'normalized mean speed of street$_i$ (*nss*)'. In which

$$ls_i = \frac{Current\ no.\ of\ cars\ inside\ street_i}{Capacity\ street_i}$$

$$nss_i = \frac{Average\ of\ all\ cars\ velocity\ in\ street_i}{Desired\ \max.\ velocity\ in\ street_i}$$

We developed function (1) for price of street$_i$:

$$price_i = 1000 * \log(\frac{ls+\varepsilon}{nss+\varepsilon})\ (1)$$

in which $0 < \varepsilon << 1$.

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2.2. *Greedy Control with Scarcity*

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t$_i$:

$$g\left(\frac{ls+\varepsilon}{nss+\varepsilon}\right) \quad (1)$$

Eq. 1 forces the price to rise sharply as we approach high *ls* and *nss* This gives the a clear indication of the "dangerous zone" to avoid, while at the same time encouraging a relatively high utilization.

Fig. 1.helps to inspect correctness of eq. 1. All three cases in fig. 3 have equivalent loads but differ in location. In fig.1a the cars bulk is at beginning of street. Obviously, this bulk is bottleneck for arrival cars to the street. The increase of velocity will remove the bottleneck. In this case the price due to eq. 3 will decrease if velocity of bulk is increasing. Else, it will be unchanged.

In fig. 1b the cars bulk is neither bottleneck for coming cars nor prone to delay at next intersection. If the bulk velocity is decreasing the price will increase and if it is increasing the price will decrease.

In fig. 1c cars bulk is at the end of street and will wait until the permission of intersection use granted to it. If the bulk is stopping, price will increase sharply. It seems that proposed eq. 1 is good criterion for scarcity of resource and trend of it.

2.2. *Greedy Control with Scarcity Measure (GCSM)*

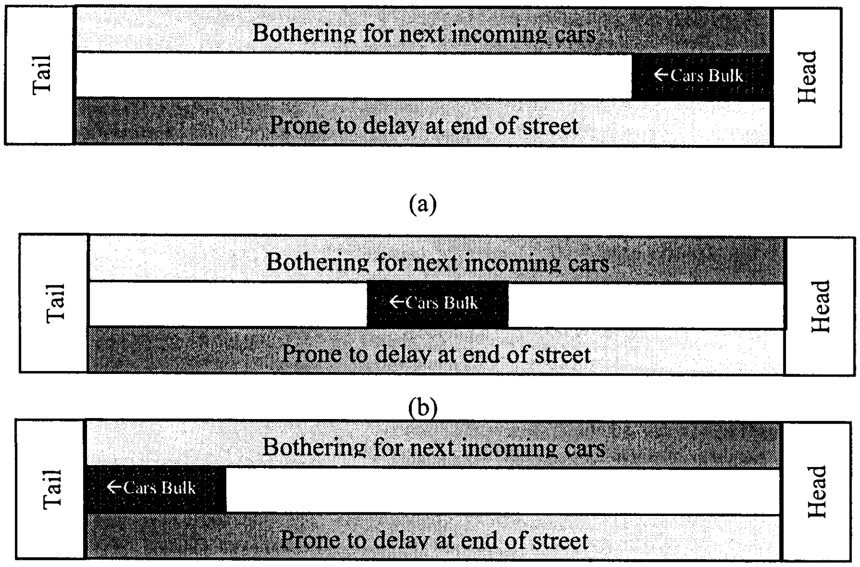
By having the price function question is 'how to use this scarcity measure in order to control the traffic?'. In urban traffic, the control applied at intersection level. Traffic control decisions make changes in state of environment (traffic flows in connecting to the intersection). The changes can be divided into

- Bettering changes
- Worsening changes

State of the environment has been defined in eq. 2 and the changes are categorized by relation 3.

$$State\ Change = Min\{|\Delta price_{open\ \ streets}|\} - Max\{Max\{|\Delta price_{open\ \ streets}|\}, Max\{|\Delta price_{downstream\ \ streets}|\}\} \quad (2)$$

$$\begin{cases} if \quad StateChange \le 0 \longrightarrow \text{Bettering change} \\ if \quad StateChange > 0 \longrightarrow \text{Worsening change} \end{cases} \quad (3)$$



(c)

Fig. 1. Resource scarcity behavior

Also intersection control should obey the environment control restrictions. The restrictions are as follows:

1- The street lights changes to green in a pre-defined order

2- The street green light length must be in interval of [min green time, max green time].

GCSM control algorithm prohibits the control agents to do worsening changes. Here a question may be raised: "How the changes will be measured when the price is a maximum value of itself (i.e. *ls*=1 and *nss*=0)?". In this case, whenever the streets reaches the maximum price. Its last biggest change in few minutes ago will be considered as worsening change.

3. Results

GCSM has been compared with pre-timed intersection control (PIC) in which they always have same green time length. The controls have been applied in urban traffic micro-simulator based on [5]. Fig. 2a and fig. 3a show the simulated urban network topologies and respectively, diagrams in fig. 2b and fig 3b show the average delay per car in both control strategies GCSM and PIC. In

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results shows that GSCM is supe

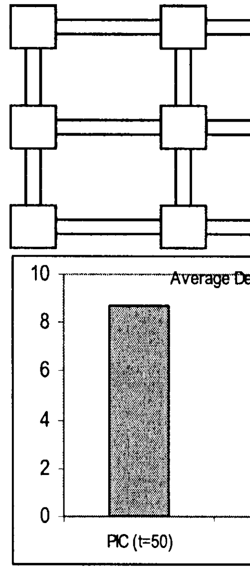

Fig. 2. (a) evalu

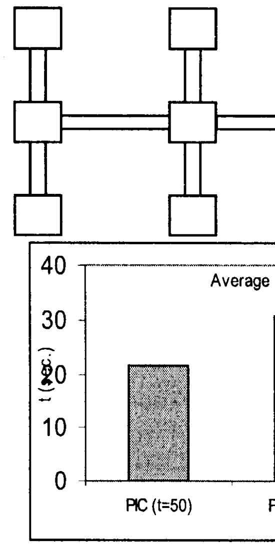

Fig.3. (a) evalu

PIC two timing has been considered t=50 sec. and t=120 sec. inspecting the results shows that GSCM is superior to PIC with both timings.

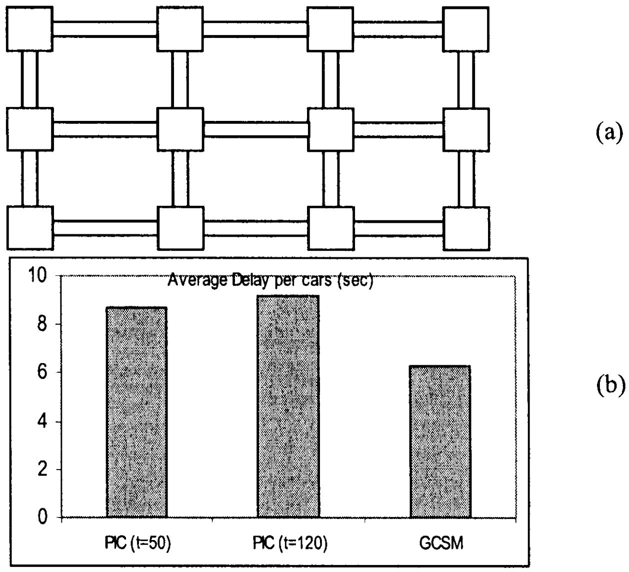

Fig. 2. (a) evaluated topology, (b) evaluation results

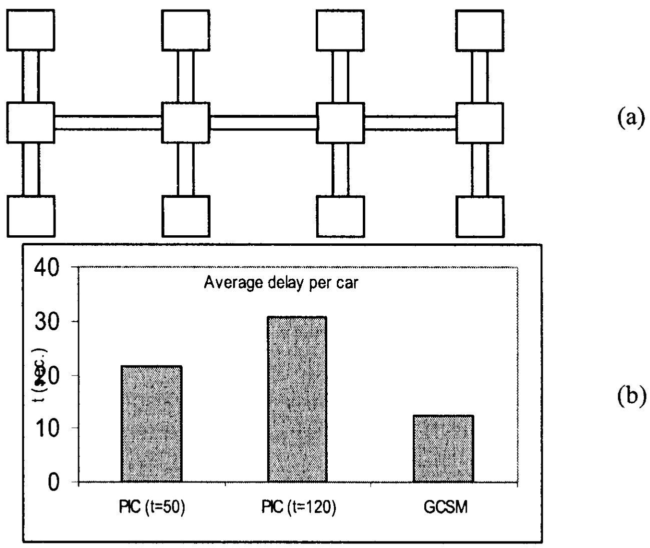

Fig.3. (a) evaluated topology, (b) evaluation results

4. Conclusion

Here, in this paper, a control algorithm for urban traffic was presented. Our GSCM algorithm is similar to control methods via feedback. The feedback in context of GSCM is a quantized value of resource scarcity. GSCM knows that its actions make changes in its environment, hence classifies changes to bettering changes and worsening changes. It assumes that prohibiting worsening changes is itself a bettering change and it tries always to do bettering changes. So, the used algorithm in GSCM is somewhat greedy. As other greedy algorithms, it is time efficient but it may be unable to reach the optimal control if it trapped in local price fluctuations.

Another feature of GCSM is reduction of decision making parameters to one parameter (price). In computer networks a variation of this method has been used [6]. But it is not formally proved in which environments control could be made by quantizing resource scarcity.

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CONSIDERATIONS ON
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Smart Homes are the subject o
which they can be used to provid
to patients and other vulnerable
Current studies of Smart Homes
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1. Introduction

Smart Homes is aimed to hel
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Spatio-temporal reasoning
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