미래도시의 교통신호 제어 데이터 수집에 관한 연구

An approach for the data collection for traffic Signal Control in the u-City

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목 차

1. Introduction

The Korean government plans to build futuristic cities, ubiquitous City(u-City), with the latest information technology (IT) infrastructure and "ubiquitous" environment (Songdo City, 2007). This plan will be achieved by integrating IT infrastructure and ubiquitous information services into urban space. In the "u-City", Intelligent Transportation System(ITS) will be one of the important services like Hong Kong (W. LAM, 2001). ITS refers to transportation related guidance, control and information systems. These system uses computer and information technology to address transportation functions at the level of individual vehicles roadways and large transportation networks.

ITS needs to get the real time traffic information. Especially the problem of how to measure traffic through urban area as a real time is one of important research topic. There is reviewed several systems that are capable of estimating traffic situation using different detectors (S. M. Turner, 1995); DMI (The integration of an electronic Distance-Measuring Instrument with the floating car technique), Cellular phone (used by motorists to report their position at designated checkpoints), AVI(Automatic vehicle identification), AVL(Automatic vehicle location), GPS (Global Positioning System)receivers (S.H. Lee, 2006).

Now days, the RFID technology gained rapidly development. There could be a system using RFID tag to control traffic signal. There is a vehicle security system using RFID (e-Plate). In this case, all vehicles have an electronically tagged self-powered number plate for identifying whether stationary or on the move. In another works, it is introduced the RFID-based logistic system and information services in ITS(F. LIU, 2006). They capture and transfer logistics information on the basis of the RFID technology and the associated ITS computer network. Yang developed RF controller for ITS application(Yang G., 2007). They did not focus on traffic signal controller. The operation of a passive RFID system in fast identification application is researched and analyzed (K. Penttila, 2004). They found the achievable identification velocities of a passive RFID system. Reliable identification accuracy was achieved up to 40km/h moving velocities.

The quality of a traffic signal control system is generally defined in terms of safety and efficiency. Many methods have been developed to solve the intersection signal control problems. A commonly used signal timing model is provided by Webster(1958), who developed a detailed procedure to calculate cycle length and green times. M. Papageorgiou reviewed most of the currently implemented traffic control systems may be into two principal classes; Fixed-time, Traffic responsive (M. Papageorgiou, 2003). Fixed-time strategies for a given time of day are derived off-line by use of appropriate optimization codes. Traffic-responsive strategies (TRS) make use of real-time measurements to calculate in real time the suitable signal settings. Due to dynamic nature of the problem and technological development, traffic responsive strategies are expected to have better performance in the ubiquitous cities.

In the literature, advanced traffic-responsive programs for networks include OPAC (Garter, 1983) PRODYN(Farges et al, 1983) CRONOS(Noillot et al, 1992) and COP(SEN and Head, 1997)(M. Papageorgiou,2003). These strategies calculate in real time the optimal values of the next few switching times over a future time horizon H, starting from the current time and the currently applied stage. To obtain the optimal switching times, these methods solve in real time a dynamic optimization problem employing realistic dynamic traffic models with a sampling time, fed with traffic measurements. In another work, a Fuzzy Traffic Controller was presented with traffic responsive strategies (J. Favilla 1993). It is composed a set of two inductive loops, spaced by a distance (one set per lane), to detect vehicle as well as its speed.

On the other hand, isolated strategies are applicable to single intersections while coordinated strategies consider an urban zone or even a whole network comprising many intersections. In the ITS, it would be considered the traffic responsive, coordinated intersection control. TRS can be considered a centered and decentralized. A combination of decentralized multi-destination dynamic routing and real-time intersection signal control for congested traffic network is proposed by J. Lei and Ümit Özügner(J. Lei, 1999). They considered the effects of applying routing and signal controlling in a traffic network to handle saturated an under saturated traffic conditions.

In this paper, RFID based traffic data collection system is described in section 2. We focused on measuring traffic information in the road.

2. RFID sensors and their usage in the Urban Traffic

2.1 RFID System Architecture traffic signal control

We assume that every vehicle has its own RFID tag in the futuristic city. A unique electronic identification code is established for each vehicle tag and each unique code is linked to TIS and a database in the centralized vehicle-database. We proposed a traffic control system using semi-active RFID tag to get traffic information. The structure of this system in the two intersections is outlined in Fig.1. Consider each intersection with 4 ways and the way with 3 lanes.

The proposed system consists of two parts: (1) Traffic Information Server (called TIS), (2) Traffic control system (called TCS). Each TIS manages more than one RFID reader, which detects the presence of small RF transmitters (often called tags), and provides the traffic information to the traffic control system. The system allows controlling the omni directional range of each of the RF readers to read tags within a range of 1 to 20 meters.

The distance between reader and stop line of intersection is about 80m ~ 100meters, which is decided and could be changed by estimating the waiting queue length in the red time. One reader on the way will detect bidirectional vehicle movements.

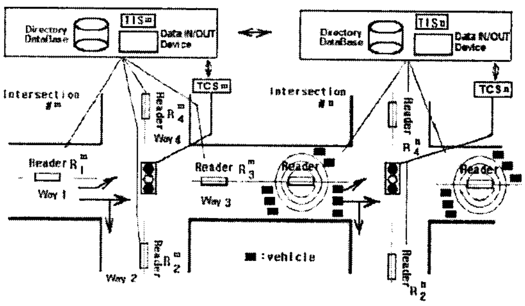

Fig. 1. The architecture traffic signal control using RFID in two intersections

TIS #m and #n communicate each other to share their data. TCS control traffic signal and calculate green time for each lane with traffic information

(queue length, incoming flow rate, outgoing flow rate, turning rate, link velocity, delay time)

2.2 Link velocity and travel time

Link velocity and travel time are important for applications ranging from congestion measurement to real-time travel information (S. M. Turner, 1995). The link velocity (m/s) can be calculated by dividing distance with travel time. In the system, the distance between two RFID readers is fixed and known on road. RFID reader detects the compatible tag(s) within its range, then "asks" the detected tag to transmit its identity. The information received by the reader is then passed to TIS database to store arriving time. The travel time of vehicle is the difference of arriving time between two readers. The link velocity V_{link} of one vehicle $V(i)$ between reader R_m^p and R_n^r is given by;

$$V_{link}(V(i),R_m^p,R_n^r) = D(R_m^p,R_n^r) \Big/ (T_a(V(i),R_m^p)-T_a(V(i),R_n^r)) \qquad (1)$$

where Ta represents an arrival time of vehicle at the reader R_m^p R_m^p and R_n^r represents RFID readers in the m, n way and intersection #p, # r; $D(R_m^p,R_n^r)$ is a distance between the reader R_m^p and R_n^r.

The average of link velocity is more reasonable to inform the traffic situation. The average link velocity V_{link_aver} between the reader R_m^p and R_n^r is set;

$$V_{link\_aver}(R_m^p,R_n^r) = \sum_{i=1}^{N} V_{link}(V(i),R_m^p,R_n^r) \Big/ N \qquad (2)$$

where N is the number of vehicle during time interval.

2.2 Queue length in the lane

The queue length on each way is considered for most traffic signal model. The turning movement rates is assumed known and fixed in the model (C. Diakaki, 2002). We showed the example to count the number of vehicle on each lane in the way in Fig. 2. In the Fig.1, TIS #p detects one tag at reader R_m^p and that tag is not detected at any other points ($R_{m\neq s}^p$,s=1,2,3,4) within the intersection, the vehicle owned that tag is come from other intersection and waiting on the way m, then TIS #p increases the queue length at reader R_m^p.

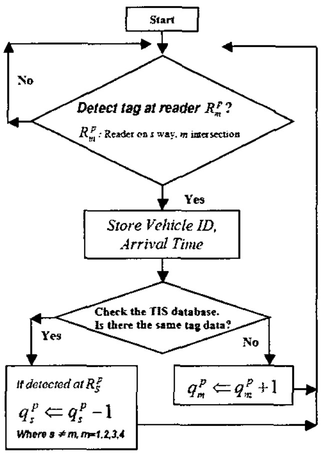

Fig. 2. An algorithm of calculating of queue length of the way m in the TIS #p

The total queue length $q_m^p(k)$ and the each lane queue length of the way m, at the discrete time kT, in the intersection #p is given by:

$$q_m^p(k) = q_{m,left}^p(k) + q_{m,straight}^p(k) + q_{m,right}^p(k) \qquad (3)$$

where $q_{m,left}^p(k)$, $q_{m,right}^p(k)$ and $q_{m,straight}^p(k)$ represent the queue length of the left, right turn and straight going lane on the way m. The traffic on each lane is expressed by numbers of vehicles conservation equation:

$$q_{m,left}^p(k+1) = q_{m,left}^p(k) + q_m^p(k)*T_{m,left}^p - q_{m,m\_L}^p(k)$$

$$q^p_{m,right}(k+1) = q^p_{m,right}(k) + q^p_m(k)*T^p_{m,right} - q^p_{m,m\_R}(k) \quad (4)$$

$$q^p_{m,straight}(k+1) = q^p_{m,straight}(k) + q^p_m(k)*T^p_{m,straight} - q^p_{m,m\_S}(k)$$

where $q^p_{m,left}(k)$, $q^p_{m,right}(k)$ and $q^p_{m,straight}(k)$) are the queue length on the left, right turn and straight going lane of the way m in the intersection #p The incoming queue length to each lane is given by multiplying total queue length $q^p_m(k)$ with the turning rate form m way to left ($T^p_{m,left}$), right($T^p_{m,right}$)and straight way ($T^p_{m,straight}$);The numbers of vehicle going out from the way m to left, right, and straight are $q^p_{m,m\_L}(k)$, $q^p_{m,m\_R}(k)$ and $q^p_{m,m\_S}(k)$. We measured the queue length of each lane using the TIS #p database.

2.3 Out-going Flow rate in the lane

The out going flow rate (vehicles/sec) on "each lane" is needed for most traffic model. We should know the numbers of vehicle during cycle time to calculate the flow rate within the intersection. With one reader on the way in the intersection, it cannot be known where the tag is from, before searching the TIS database about the tag. The algorism is shown in Fig 3. If the detected tag at the reader R^p_m is come from one of reader in the same intersection #p, increase the number of vehicle $q^p_{s,m}(k)$ between reader R^p_s and R^p_m. If there is no data about the detected RFID tag in the TIS #p, increase the number of vehicle $q^p_m(k)$ of that lane like counting queue length. We set "5 sec" to decide whether there are arriving vehicles to reader R^p_m or not. The outgoing flow rate $f^p_{s,m}$ could be calculated by dividing the queue length $q^p_{s,m}$ with the duration of passing from starting to end vehicle.

2.4 Incoming Flow rate in the lane

We could calculate the incoming flow rate (vehicles/sec) on "each lane" by dividing the incoming numbers of vehicle with the time duration of arriving vehicles at RFID reader like calculating "out-going flow rate". The arrival time and the incoming numbers of vehicle could be calculated by checking TIS database and TCS green time sequence. We briefly described about one way, but it could be extended about the other way and coordinated intersection. We focused on measuring traffic information in the proposed system; the link velocity, the queue length of each lane and flow rate.

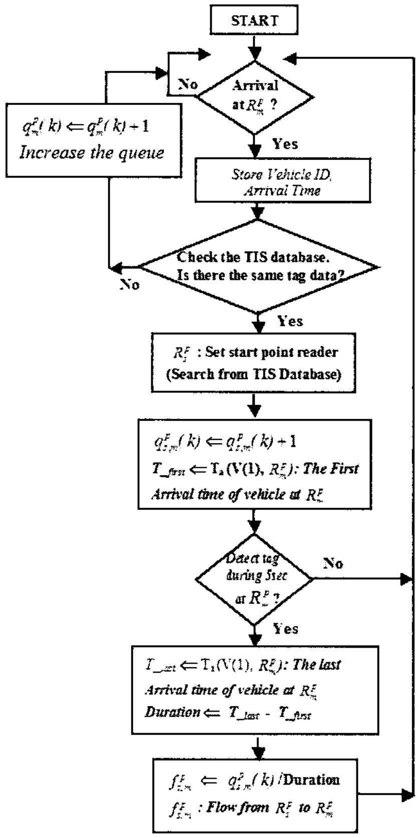

Fig. 3. The algorism calculating the out-going flow rate from the way s to m within the intersection # p.

3. Conclusion

We proposed a system using RFID for traffic data acquisition and suggested a decentralized traffic control for multi intersection case. In the future work, it is necessary more research for getting traffic actual data using RFID and storing the traffic data and searching the database in the real world.

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