u-City에서 교통신호 수집을 위한 RFID이용에 관한 연구

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An approach for Traffic Signal Control using RFID in the u-City

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Abstract - 현재 우리나라에는 최첨단의 정보통신 서비스를 제공을 목적으로 ubiquitous city(u-City)가 건설 중에 있다. 이들 도시에서 ITS(Intelligent Transportation Systems)는 도시거주민들에게 적절한 교통정보를 제공하는 동시에 최적으로 도시교통을 제어하는 방안이다. ITS의 한 부분으로서 교통흐름에 적합한 교통신호제어가 필요하며 이를 위해 많은 교통정보를 실시간으로 수집하여야 한다. 이러한 교통정보의 수집은 도시운영을 위하여 최첨단 정보통신 서비스가 제공되는 u-City에서는 어렵지 않을 것이다. 이러한 미래지향적인u-City의 ITS 교통제어에 적합한 새로운 시스템에 대하여 이 논문에서는 연구하였다.

1. 서 론

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.

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.

2. 본 론

2.1 RFID System Architecture traffic signal control

We assume that every vehicle has its own RFID tag in the u-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.

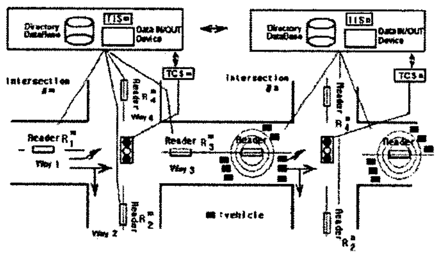

Fig. 1. The architecture traffic signal control using RFID in two intersections

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. 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. CONTROL OF SINGLE INTERSECTION

In this chapter, we proposed the queue model for a given single intersection which considers the red-green switching times explicitly. Subsequently, the model predictive control model to calculate the green signal times for N step horizon is developed. Consider a four way intersection with lanes L_j where $j = 1,2,\ldots,8$ (Fig. 2). When green signal is ON at each lane, vehicles on odd indexed lanes should turn left and vehicles on even indexed lanes should go directly or turn right. No car is allowed to turn right without a green signal at any given direction.

The summation of these green signal times is equal to the cycle time C which may vary between a lower and upper bound depending on the traffic density. A single intersection can be modeled by discrete time system in which the state variables $q_j(k)$ with $j = 1,2,\ldots,8$ represent queue length at the beginning of the kth cycle (C). Individual queue lengths are mainly determined by incoming flows ($f_j, j = 1,2,\ldots,8$), outgoing flows ($c_j, j = 1,2,\ldots,8$), and duration of the green signal time at each lane for that cycle.

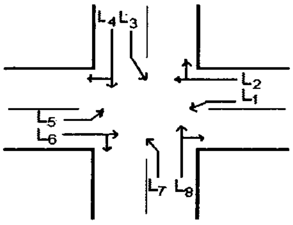

Fig. 2. Single intersection with incoming lanes

Assuming the average flow f_{av}^{td} to be known during any time interval (td), a generic queue model for the j-th lane can be written as

$$q_j(k+1) = \max[q_j(k) + t_{bg} f_j^{bg} + t_g f_j^g - t_j c_j, 0] + t_{ag} f_j^{ag}$$

where t_{bg}, t_g, t_{ag} denotes before green time duration, green time duration and after green time duration in a cycle respectively.

For an intersection in Fig. 2, the queue on each lane can be written as

$$\min_{\substack{t_i(k,N)\\ i=1,2,3,4}} \sum_{k=1}^{N} \sum_{j=1}^{8} w_j q_j(k)$$

s.t.

$$q_1(k+1) = \max[q_1(k) + t_1(k) f_1^{1-k} - t_1(k) c_1, 0] + t_2(k) f_1^{2-k} + t_3(k) f_1^{3-k} + t_4(k) f_1^{4-k}$$

$$q_2(k+1) = \max[q_2(k) + t_1(k) f_2^{1-k} + t_2(k) f_2^{2-k} - t_2(k) c_2, 0] + t_3(k) f_2^{3-k} + t_4(k) f_2^{4-k}$$

$$q_3(k+1) = \max[q_3(k) + t_1(k) f_3^{1-k} + t_2(k) f_3^{2-k} + t_3(k) f_3^{3-k} - t_3(k) c_3, 0] + t_4(k) f_3^{4-k}$$

$$q_4(k+1) = \max[q_4(k) + t_1(k) f_4^{1-k} + t_2(k) f_4^{2-k} + t_3(k) f_4^{3-k} + t_4(k) f_4^{4-k} - t_4(k) c_4, 0]$$

$$q_5(k+1) = \max[q_5(k) + t_1(k) f_5^{1-k} - t_1(k) c_5, 0] + t_2(k) f_5^{2-k} + t_3(k) f_5^{3-k} + t_4(k) f_5^{4-k}$$

$$q_6(k+1) = \max[q_6(k) + t_1(k) f_6^{1-k} + t_2(k) f_6^{2-k} - t_2(k) c_6, 0] + t_3(k) f_6^{3-k} + t_4(k) f_6^{4-k}$$

$$q_7(k+1) = \max(q_7(k) + t_1(k) f_7^{1-k} + t_2(k) f_7^{2-k} + t_3(k) f_7^{3-k} - t_3(k) c_7, 0) + t_4(k) f_7^{4-k}$$

$$q_8(k+1) = \max(q_8(k) + t_1(k) f_8^{1-k} + t_2(k) f_8^{2-k} + t_3(k) f_8^{3-k} + t_4(k) f_8^{4-k} - t_4(k) c_8, 0)$$

$$\sum_{i=1}^{4} t_i(k) = C, \quad k = 0,1,\dots,N-1$$

$$T_{\min} \le C \le T_{\max}.$$

$$t_{i\_\min} \le t_i(k,N) \le t_{i\_\max}, i = 1,2,3,4$$

$$q_j(k) \le \alpha_j, \quad i = 1,2,3,4, k = 1,2,\dots,N$$

where C , $T_{\min}$ and , $T_{\max}$ represents cycle time, lower and upper bound for the cycle time respectively. The term $t_i(k,N)$ stands for the green signal time variable of each lane over N-step horizon. It can be written as

$t_i(k,N) := [t_i(k) \;\; t_i(k+1) \;\; \dots \;\; t_i(k+N)]^T, \; i = 1,2,3,4$. For each step the horizon, summation of green times is equal to cycle time which may vary between a lower and upper value. Each green time values also has minimum ($t_{i\_\min}$) and maximum value ($t_{i\_\max}$) which is fixed over the horizon. The summation of the minimum green time values assumed to be equal or less than $T_{\max}$, also summation of the maximum green time values assumed to be equal or greater than $T_{\min}$ for feasibility concerns. The queue lengths are constrained by α_j $i = 1,2,3,4$ for each lane in the current intersection (spillback constraint for multi-intersection case).

The objective function includes weighting parameters w_j which assigned to the each lane. For each lane it has a default value of $w_j = 1$ for which the objective becomes minimizing the total queue length. The weighting parameter w_j may be set regarding different criteria's (maximum or average delay, priority of one lane, emergency vehicle passing etc.), then the optimization objective also change depend on assigned weighting parameter values.

3. 결 론

We proposed a system using RFID for traffic data acquisition and suggested a decentralized traffic control model 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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