Chapter 15

Kernelized Electronic Road Pricing (KERP)

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Abstract

Every year, Malaysia produces a lot of new vehicles in supporting the transportation demand which lead to the economic growth. However, the increasing of number of the vehicles on the road contributes to the heavy traffic congestion. In addition, implementation of traditional toll collection system causes the traffic to become slower during peak hour. Consequently, the road users waste a lot of time waiting for the long queue during traffic congestion, hence lots of fuel gas will be released to the air which may affect the environment. Therefore, we propose Kernelized Electronic Road Pricing (KERP) to reduce the traffic congestion at busy area such as Penang Bridge by implementing open toll system and road pricing scheme. In this project, radio frequency identification (RFID) is used to detect the vehicles entering the bridge. The sensor will detect the vehicles entering the bridge without having to stop at the toll entrance and automatically deduct the toll fees. The KERP system will analyze the rate of car passing the bridge in specific hours and display the price that must be paid before entering the bridge based on the vehicle class and specified road pricing rate. The system provides monitoring function by detecting invalid card or insufficient balance card and capturing vehicle’s plate number that exceed the speed limit. The road pricing rates will be calculated using algorithms of Kernel Function which is used to classify the data of vehicle classes and time range in order to determine the pricing rate periodically. The road users are encouraged to enter the bridge during non-peak hour by offering lower pricing rate during non-peak hour. Overall, KERP can minimize traffic congestion and reduce time travel for the user. Besides, it can manage the user’s travel planning by offering a road pricing scheme.

Introduction

Malaysia is one of the countries that implements conventional toll collection system in the expressway areas such as North–South Expressway, Shah Alam Expressway, Johor Bahru Eastern Dispersal Link Expressway and Penang Bridge. The traffic flow especially at the entrance and exit of the expressway is slower during peak hour as the number of road users that use the expressway to shorten the travelling distance are higher compared to normal hour. Usually, the peak hours are ranging between 7 to 9 o'clock in the morning, 1 to 2 o'clock during lunch hour and 5 to 7 o'clock in the evening. At the toll plaza, which is located at the toll entrance and exit, the expressway users need to wait for their turn to pay the toll fees either using Touch 'n Go or SmartTAG. The gate barriers at the toll plaza will be opened once the user has paid for the toll fees. Sometimes, when the users did not have sufficient balance in their Touch 'n Go card, the alarm will be sounded and they need to wait for the toll worker to clear the insufficient fees. This situation especialy if it occurs during peak hour will increase traffic jam and extend more traveling time.
In order to reduce traffic jam at certain period of every year, PLUS Expressways Berhad (2018), one of the national highway concessionaries will always release the Travel Time Advisor (TTA) earlier to the public during festival seasons. Using TTA, the road users are suggested to plan their journey using expressways based on particular location such as from north to south region and specified days and time in order to decrease the traffic congestion and accident cases during festival. Indirectly, the road users are also encouraged to use the expressways during non-peak hour by offering discount for the toll fees.

Electronic Road pricing is basically a scheme of fees that is charged to the user directly for the road services in congested road areas. The scheme is implemented in highly densed country such as Singapore and Hong Kong in order to encourage the road users to travel during non-peak hour (Rouhani, 2016). The road users will be highly charged during peak hour to encourage them to use alternative road ways rather than the main expressways. This mechanism can reduce the traffic congestion and educate the road users to avoid using expressways during peak hour.

This study is inspired by state-of-the-art road pricing schemes in the developed countries in order to reduce the traffic congestion problem in busy cities like Penang. The proposed system, Kernelized Electronic Road Pricing (KERP) is based on the Penang Bridge by implementing open toll system which is without the gate barriers for speeding up the journey to enter the Penang Bridge or exit to the main land. It can optimize usage of the road network by encouraging drivers to consider alternative roads to reduce traffic congestion during peak hour.

**Proposed Implementation**

Rather than using conventional toll system with the gate barrier, the proposed system, KERP implements open toll system with gantry to display the toll pricing and vehicle information at the toll plaza. Firstly, the vehicles that entering the bridge are required to installed the SmartTAG inside their vehicles to allow the detection of the Touch ‘n Go (cash card) when the vehicles crossing the gantry area. The vehicle will be detected at the gantry without having the gate barrier that can slower down the vehicle speed. Then the system will detect the valid card and deduct the toll fees via the SmartTAG. The system will send a notification of the card balance to the user through short message service (SMS).

Basically, KERP is divided into two parts. The first part is the prototype system which is developed to represent the proposed implementation of KERP as shown in Fig. 1(a). Inductive loop is installed underground to detect the vehicles crossing the gantry area. The LED display at the gantry will display the current road pricing based on particular range of time and additional commertial advertisement. The radio frequency (RF) signal will detect the SmartTAG inside the vehicles in order to deduct the toll fees based on the current road pricing. The closed circuit television (CCTV) camera is used as security measure that will operate 24 hours a day to monitor the vehicles on the road and the additional automated enforcement system (AES) camera is also installed at the gantry to monitor the speed of the vehicles that entering the Penang Bridge.
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The second part is the proposed calculation of road pricing scheme. The road pricing will be changing according to specified time range and type of the vehicle classes as shown in Fig. 2(a). When a vehicle is passing through the RF signal, the system will automatically calculate and display the toll fees based on the vehicle classes (Class 1 to Class 7) and pricing rate which is calculated based on range of time (Normal, Peak Hour and Non-Peak Hour) as listed in Fig. 2(b). Using KERP system, the pricing rate will be calculate using algorithms of kernel function which is a method for classification. In this system, it will be use to classify two features which are the input data of vehicle classes and time range when the vehicle is detected in order to determine the pricing rate of the detected vehicle. The toll fees will be automatically deducted based on the pricing rate on the time the vehicle was detected. the vehicles that entering the Penang Bridge.

The prototype system has been developed to represent the actual implementation of KERP. Fig. 3 shows the system operation starting from the detection of the vehicle by using passive infrared (PIR) sensor. Selected microcontrollers are connected to the PIR sensor and radio frequency identification (RFID) reader is used to detect RFID tag that attached to the vehicle that entering the toll entrance. An LCD display will show the information of pricing rate and a monitoring camera will view the vehicle that passing the sensor area as figured in Fig. 1(b). A global system for mobile (GSM) module is connected to the microcontroller in order to send a message to the user to notify the cash card balance.
Conclusion

KERP is proposed to reduce the traffic congestion at Penang Bridge using open toll system and road pricing rates. The KERP sensor will detect the vehicles entering the bridge without having to stop at the toll entry and automatically deduct the toll fees. The proposed system can reduce the waiting time without having to slow down the vehicle using the open toll system. The system will provide monitoring function by detecting invalid card or insufficient balance card and capturing vehicle’s plate number that exceed the speed limit. Notification will be sent to the user to notify the balance of the cash card for entering Penang Bridge through SMS. The proposed system can be implemented by having an actual pilot testing at Penang Bridge and enhanced with added value of e-wallet to automatically top-up the cash card in real-time manner.

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References


