A proposed design of ANPR System utilizing short range wireless technologies

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Abstract:

This paper proposes the design of an Automatic Number Plate Recognition (ANPR) System utilizing short range wireless technologies. One of the aims of this paper is to discuss the cost and power efficiency of the proposed system while communicating information from the road side units (RSUs) to the control center using short range wireless technologies. The paper proposes the use of ZigBee (IEEE 802.15.4) to transfer information which will reduce the overall cost of the system and enables it to be developed and deployed in developing countries where cost and power are major factors in the design of any system. Furthermore, this paper also discusses the suitability of ZigBee for special outdoor systems like Intelligent Transportation Systems where wireless communication can be affected by various factors like distance between wireless modules, communication at high density traffic areas, effect of weather and interference of other radio signals on wireless communication.

Keywords:

Wireless Communication, Automatic Number Plate Recognition, Intelligent Transportation Systems, Wireless Channel Effect

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1. Introduction:

This research is an effort to develop a low power and cost efficient ANPR (Automatic Number Plate Recognition) system using short-range wireless technologies. ANPR is a system in which the image of the vehicle is captured using High Definition cameras installed at the road [1]. The image is used to detect the vehicle type (car, van, bus, truck, and bike etc.), its color (white, black, blue etc.), its name/model (Toyota Corolla, Honda Civic etc.) and then this image is processed using segmentation and OCR techniques to get the vehicle registration no. in the form of characters. After extracting the required information from vehicle number plate, this information is sent to the control center for further processing.

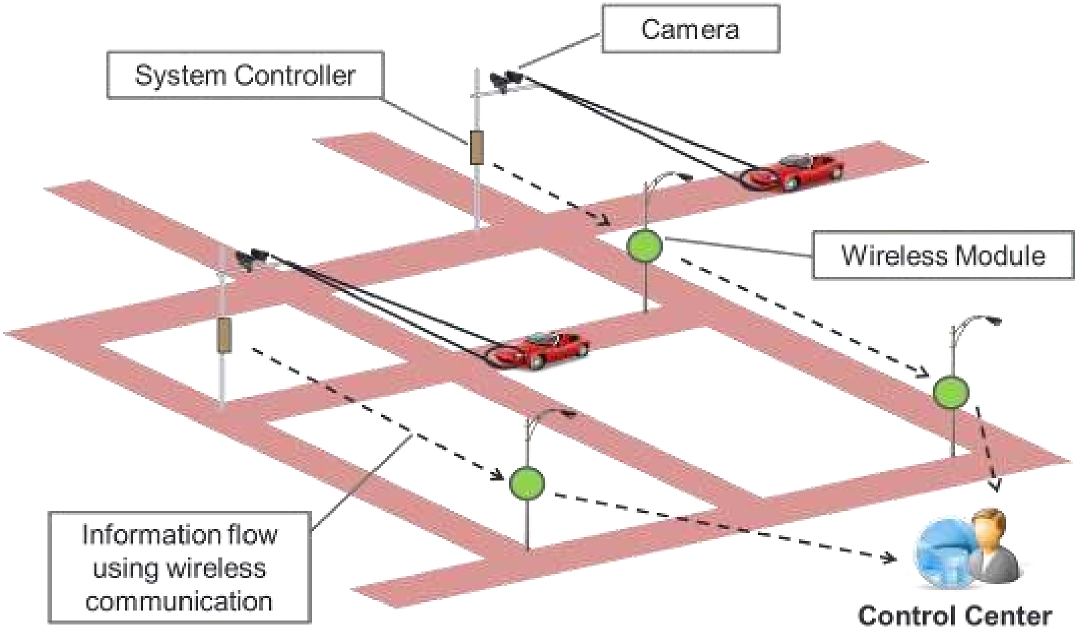

Figure 1: Proposed System Model for ANPR System

Figure 1 shows the proposed system model for ANPR System. In this proposed system, cameras are mounted on the roads. Two images of the vehicle are captured by these cameras (frontal and back image of the vehicle). A System Controller is mounted on the pole which processes these images instantly. As soon as the images are processed, they are sent to the control centre using ZigBee wireless module mounted with System Controller. Multi-hop communication [2] is used to transmit data from RSUs to control centre. The information received at the control centre can then be processed further to take appropriate actions.

The proposed system is very comprehensive in nature; however this paper deals with only the communication part of the system. The major aim of the paper is to study the performance of ZigBee in Intelligent Transportation Systems where sensitive data is expected to be the transferred from road to the control centre without large delays.

2. Literature Review:

João Paulo et al. [3] presented techniques to use low power CMOS for storing and sharing of information in a shared network. Their application "CMOS-SRWSN" can be used in cars for communication and entertainment. This in-vehicle wireless communication also removes the hassle of wires.

Mirjana Stojilović et al. [4] discussed various techniques for developing an antenna for collecting sensor readings and transmitted it using cellular technology. Their study showed that sensor can communicate with both RF and cellular technology. Comparison of various techniques shows that RF switching scheme is the best design for such systems.

S. Savazzi et al. [5] introduces a method of wireless connecting the sensors to collect the data about natural disasters like earthquake. The method presented in this paper creates a wireless sensor network in which each sensor can connect to other sensor wirelessly. The data gathered by the sensor can then be transmitted to the central location wirelessly. This reduced human effort and hassle of wires.

Digi White Paper [6] gives an overall understanding of ZigBee, its architecture, protocols, topologies and transmission frequencies. This paper also describes the Personal Area Networks (PAN) and how ZigBee can connect with other personal devices to create a PAN.

Razi Iqbal et al. [7] explain the use of ZigBee in Intelligent Transportation Systems. They conducted various experiments to measure the range of wireless communication on various types of roads, e.g., straight and curve. Furthermore, they performed various experiments to show how ZigBee signals are affected by solid surfaces like buildings and rough surfaces like trees.

3. Proposed System Model:

One of the core objectives of this paper is to evaluate the efficiency of short range wireless technology, ZigBee in Intelligent Transportation Systems. Figure 2 shows the proposed arranged of a system that is used for performing various experiments to collect data and analyze the behavior of ZigBee in transportation Systems. The proposed system enables transmission of information wirelessly up to 1 KM.

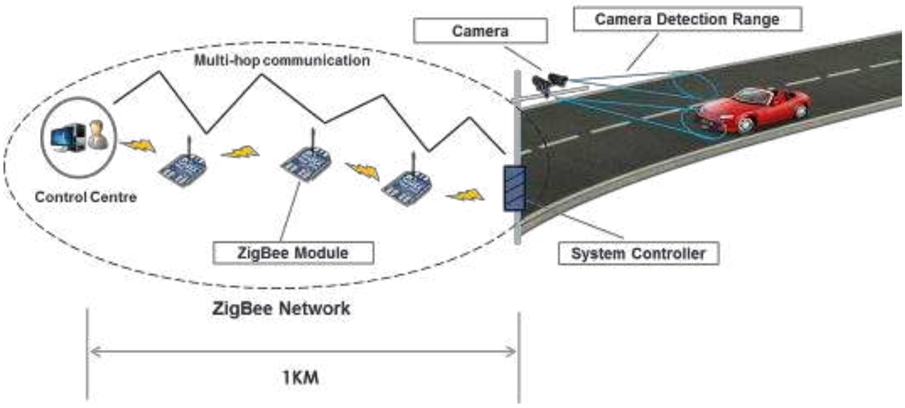

Figure 2: Proposed Technical System Model

As illustrated in Figure 2, the information is sent using ZigBee, wirelessly to Control Centre. The wireless modules used in this project (XBee Pro) have a good range of around 1.5 KM for data transfer. However in order to overcome the issues of data loss, high error rate and hindrance at the road because of heavy traffic, multi-hop ZigBee communication is used. In a multi-hop communication, the data is sent to multiple modules and they create a network cloud for sending and receiving data to and from the modules. So for this purpose ZigBee Host, ZigBee clients and ZigBee relays modules are used for transferring data from road side units to the control centre wirelessly.

The use of wireless modules for transferring information can be beneficial in decreasing the cost of the system, reducing power consumption and hassle of wiring from road side units to the control centre.

4. Factors affecting wireless communication:

In order to develop a sustainable outdoor system, it is essential to measure the efficiency of its components against various factors. To measure the efficiency of ZigBee, Received Signal Strength Indicator (RSSI) is checked against various factors. RSSI is the strength of a radio signal. It is measured in dBm and its value ranges from 0 to -120 dBm. The closer the value to 0, better the signal.

4.1. Distance between modules

As mentioned earlier, ZigBee modules are low range modules, so if communication is to be done at large distances, multi-hop communication is required. In order to deploy the modules in the open environment, we modified Friis equation [8] to calculate the distance between the modules. Below is the equation used for calculations:-

$$R = \frac{10^{(P_t+G_t+G_r-P_r)/20}}{41.88 \text{ x } f}$$

P_r = Transmission power of sender
P_t = Sensitivity of receiver
G_r = Antenna gain of sender
G_t = Antenna gain of receiver
f = Frequency
R = Transmission Range

Several experiments were performed to calculate the distance between the modules by keeping the RSSI value between -40 to -70 dBm.

Table I: Variations in RSSI at different distances between modules

Distance (m)	RSSI (dBm)	No. of Bits	Error %
10m	-45	96	0 %
20m	-48	96	0 %
30m	-52	96	0 %
40m	-57	96	0 %
50m	-66	96	0 %
80m	-69	96	0 %

100m	-84	96	10%

Table I shows the value of RSSI at different distances between the wireless modules. Number of bits in this case is kept constant. It is evident from the table above that increase in the distance between the modules, decreases the value of RSSI and hence the signal. Furthermore, increase in the distance between the modules can increase loss of packets and hence error in communication.

4.2. Communication at high density traffic area

Wireless technologies are prone to data loss at areas where there is lot of congestion e.g. houses, humans, vehicles and other materials like trees etc. In order to make the communication of wireless modules efficient in specific areas it is very important to check the area for feasibility of installation. One of the major factors in this regard is the height of the modules. The modules should be installed at a suitable height so that there is no interference as far as humans and vehicles are concerned. Several experiments were performed to measure the efficiency of the modules at various heights.

Table II: Variations in RSSI at different heights

Height (m)	RSSI (dBm)	No. of Bits	Error %
1m	-55	96	0 %
2m	-48	96	0 %
3m	-42	96	0 %
4m	-40	96	0 %
5m	-37	96	0 %

Table II above shows the results of experiments performed to check the efficiency of wireless communication at various heights. Results show that better the height, less are the chances of hindrance from objects like humans and vehicles etc.

4.3. *Effect of weather on wireless communication*

In Intelligent Transportation Systems, wireless modules are expected to be deployed in the outdoor environment. Hence it is important to measure efficiency of wireless communication against various environmental factors like weather etc. In order to measure the efficiency of ZigBee against various weather conditions and temperatures, several experiments were performed.

Table III: Variations in RSSI against different weather conditions

Temperature (c)	Weather Condition	RSSI (dBm)	No. of Bits	Error %
43c	Hot Sunny	-49	96	0 %
40c	Humid	-50	96	0 %
27c	Heavy Rain	-61	96	2 %
29c	Drizzle	-53	96	0 %
26c	Windy	-56	96	0 %

Several experiments were conducted in different weather conditions to gauge the effect of weather conditions on wireless communications. Table III above shows that weather has minimal effect on wireless communication.

4.4. *Effect of Interference of other wireless technologies*

In this multi-wireless technology environment, several various signals are available in the air. These signals operate on various frequency bands. However, many wireless technologies operate on similar frequency bands due to their unlicensed nature. Presence of different wireless signals can affect the communication. In order to gauge the efficiency of ZigBee in the presence of its peer wireless technologies like Bluetooth, RFID, Wi-Fi and GSM, several experiments were conducted. Table IV below shows the results of conducted experiments in this regard.

Table IV: Effect of Interference from other wireless technologies

Technology	Frequency	RSSI (dBm)	No. of Bits	Error %
Bluetooth	2.4 GHz	-53	96	0 %
Wi-Fi	2.4 GHz	-52	96	0 %
GSM	900 MHz	-55	96	0 %
RFID	13.56 MHz	-52	96	0 %

As shown in the table above, the RSSI value of ZigBee is not much affected by the presence of other peer technologies in the surrounding. However, the communication can be affected by significant increase in the numbers of devices nearby.

Conclusion:

The paper presented the design of an Automatic Number Plate Recognition system based on short range wireless technology, ZigBee. The presented system is a very comprehensive system; however, the scope of this paper is to check the eligibility of ZigBee for use in Intelligent Transportation Systems by gauging the efficiency of ZigBee against various factors like distance between the modules, communication at high density areas, effect of weather on wireless communication and effect of interference of other wireless technologies. Several experiments were performed to measure the efficiency of ZigBee for use in Intelligent Transportation Systems and the results show that ZigBee is well suited for transportation systems in developing countries due to its low power consumption and cost effectiveness.

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