Radio Frequency Identification (RFID) Indoor Parking Control System

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***Abstract*—**Frequency Identification (RFID) Parking Control System is a control and monitoring system designed for using at residential condominiums, gated communities, business parking garages, university parking areas, and hospitality or retail centers. In this study, a parking management system is designed using RFID technology along with wireless RF ZigBee to control and manage parking for mall workers. This system identifies each vehicle with a RFID-TAG/CARD using the mall worker card at the gate. The data will be exchange between the computer located at the gate and the sensors located at the garage through wireless RF ZigBee to clarify the empty parking place. Based on the data, the dynamic programming algorithm embedded in the system will determine the nearest parking location based on their entrance destination to the worker. The system can automatically monitor, guide and localize the nearest parking to the workers inside the parking space.

Keywords*—parking system, dynamic programming algorithm, Radio Frequency Identification (RFID), ZigBee.*

I. Introduction

When considering a large parking place i.e. at malls as case study, there may be hundreds of vehicles that is typically belong to the visitors, workers and employees at the mall. Monitoring and tracking the parking vehicle is very important, since it saves the time for drivers and decreases the cumbersome in the garage.

An RFID system consists of one or many readers which communicate with multiple tags by inquiring their identification [1, 2]. RFID has been playing an important role in various kinds of supply chain based industrial applications. RFID technology has been used for some time in parking lots. Siddhartha et al. [3] proposed a system which is shown to alleviate grid load during peak hours, take advantage of off-peak charging benefits, and generate revenue for the parking garage operator. A navigation method is proposed that minimizes the parking time, based on collected real-time vacancy information of parking lots [4, 5]. The proposed method leads to the introduction of an eco-friendly payment system using RFID technology, wherein no use of paper takes place. Automatic deduction of parking charge is taken care of on the server side, from users via RFID account and notification via SMS or Email is generated. By using navigation method, the user can get the shortest path to the selected parking zone to avoid congestion. Bandu et al. [6] presented a paper which deals with the modern sophisticated parking system with space management based on IR, RFID and Ultrasonic sensor network. In this system shortest path of the lot can be monitored, system helps us to prevent the vehicle from theft also used to model the space of the lot as per the width of the vehicle. Xiaolong et al. [7] designed a digital vehicle management system using RFID technology. This digital vehicle management system will enhance the utilization of parking space and help user check the availability of the parking space remotely since the system is connected to the Internet.

Zigbee technology is based on IEEE 802.15.4 standard for WSN that is being used in many commercial research applications today where it becomes an attractive solution for low power and low cost applications [8]. Many works [9-11], 10] have developed a unique solution by providing cost effective solution by using Zigbee technology in parking lot system technology. Instead of using and maintain cable that need to be installed at the ceiling of the parking lot, we developed a system that use wireless technology of Zigbee and it could notify the visitors of empty and non-empty parking lot.

In this paper, there are two systems are designed and developed to apply theses monitoring and tracking the parking vehicle easily and sufficiently. In the first system, RFID technology is used to control the garage gates. RFID based parking entrance system open the garage gate automatically based on the validation of RFID card. In addition, the wireless ZigBee stations to exchange the data between lots and the gate to inform about empty location in garage. In the second system, from the data that collected at the gates from ZigBee and RFID, the system tries to find the nearest empty parking location for the workers. The dynamic programming algorithm is use in this system to determine the nearest parking location from entrance to the workers. This indoor parking control system will bring many benefits to the workers and the parking lots management.

II. The Proposed System

Radio Frequency Identification (RFID) based parking entrance systems designed and developed can be divided into two parts:

A. Hardware part

The block diagram and garage layout of the proposed system are shown in Fig. 1 and Fig. 2. The system design is used in the proposed system, including the microcontroller sensor, sensors, data-acquisition, ZigBee transceiver, central processing and power units. Figure 3 and 4 are the circuit diagrams at ZigBee and RFID points.

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i) Microcontroller is a general purpose processor with no external components connected to it. Microcontrollers have on chip CPU, fixed amount of RAM, ROM, I/O ports, analog to digital converters, timers and counters. PIC 18f4620 offers the advantages, high computational performance, enhanced Flash program memory. PIC 18f4620 has the following features, reduce power consumption, Memory Endurance, Self-Programmability, Extended Instruction Set, Enhanced CCP Module, Enhanced Addressable USART and 10-Bit A/D Converter , where 18f4550 has an addition importance unit, it is USB module [12].

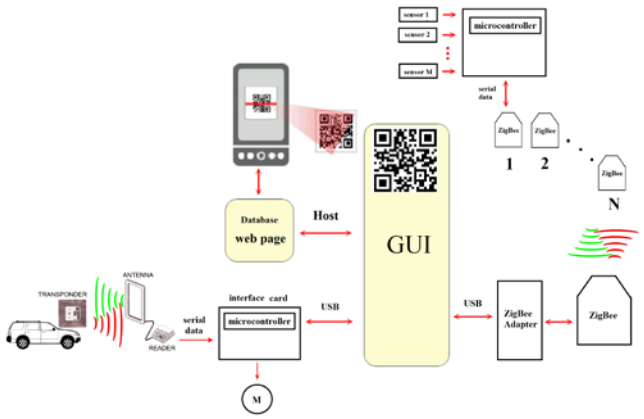

Fig. 1. The block diagram of the system.

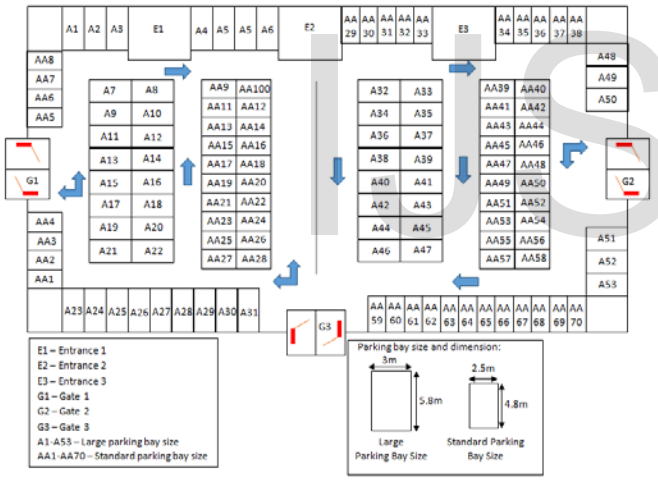

Fig. 2. The garage layout.

ii) ZigBee transceiver, ZigBee modems are one of the easiest ways to create a wireless point-to-point or mesh network. They have error correction, a reconfigured with AT commands, come in multiple flavors and can create a wireless serial link out of the terminals. The ZigBee radios can all be used with the minimum number of connections power (3.3V), ground, data in and data out (UART), with other recommended lines being Reset and Sleep. The system receives a Wi-Fi data from wireless ZigBee stations to mark the empty parking location. This data can be exchanged between the computer located at the gate and the sensors located at the garage spaces through RF wireless ZigBee technology [13, 14].

iii) The complete wireless receiver module is connected to a display unit through an USB port. Then the received RGB values are displayed through PC. Also, the corresponding color and the digitized values are displayed on the LCD in two columns.

iv) Radio-Frequency Identification (RFID) garage gate entry system is created by using RFID reader and its transponder; it is widely used for packing systems [15]. It aims to control the mall garage by a validation process for worker RFID-CARD card at the gates of entry and exit. This validation process is accomplice by comparing the incoming RFID data with database that contains information about allowed worker mall.

v) ICs, the TTL/74151 is a high speed 8-input Digital Multiplexer; it is used to read data from sensors. This Data Selector/Multiplexer contains full on-chip decoding to select one-of-eight data sources as a result of a unique three-bit binary code at the select inputs. The SN74x7 is a high sink current capable open-collector buffer. This device is high-voltage tolerant on the output of up to 30 V on the SNx407 model. The SN74x7 is also useful for converting TTL voltage levels to MOS levels.

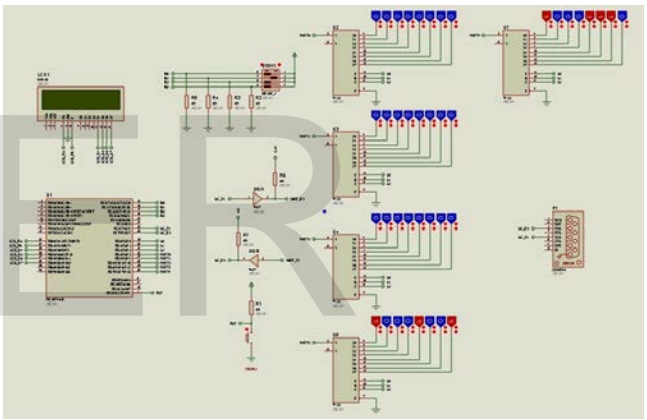

Fig. 3. The ZigBee circuit diagram.

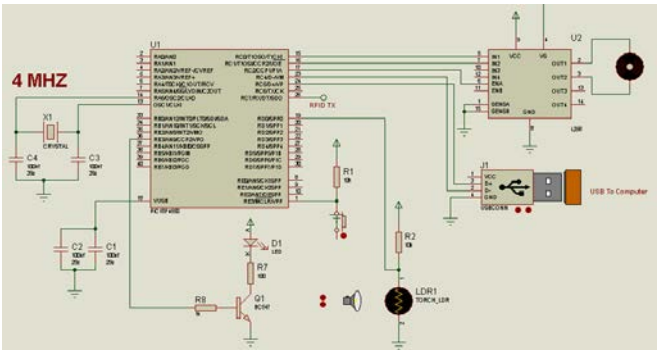

Fig. 4. The RFID circuit diagram.

B. Software part

The flowcharts are shown in Fig. 5 and 6 which represent the firmware of Zigbee and RFID circuits. An application for further signal processing and short distance recognition is used in the software package. The software is created by VB.NET. Fig. 6 is the flowchart of GUI at PC, it was written for sampling and data processing of received data from ZigBee and RFID to the PC.

Application flowchart describes the flow of data through information processing systems, a logic sequence, work or process of the program. Program must begin with routine for setting the analog, digital, parallel and serial ports. Flowcharting components include start and end points, processes, I/O operation, decision points and waiting periods. There is a block to read data from the RFID reader then send it over USB and process it. Another block to receive lots data from Zigbee, format and process it to detect the empty lots. The flow ended by display the status, events and messages on small LCD or GUI.

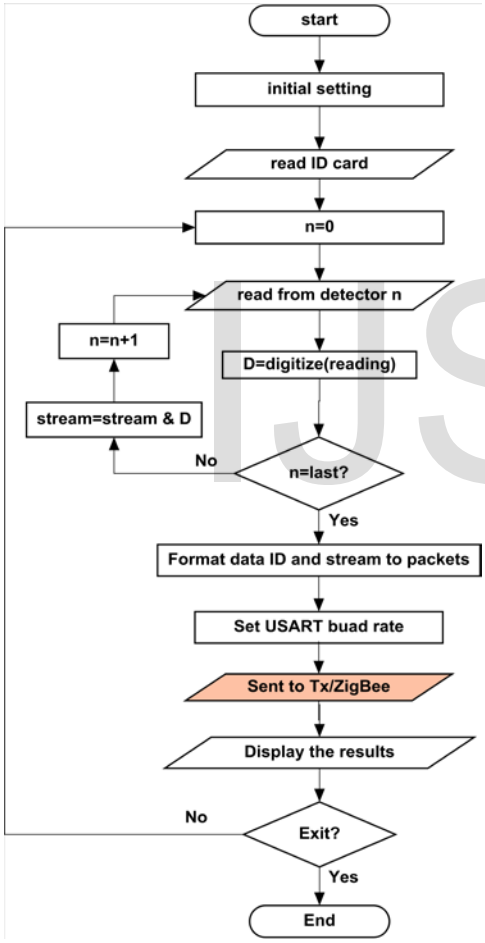

Fig. 5. The flowchart of the ZigBee circuit.

III. NEAREST EMPTY PARKING LOCATION SYSTEM

In this system the nearest empty parking location is determined for the worker at Gate g_i.

In the first, the mall workers' garage is transferred to undirected graph G (V, E), where V is the vertex (node) that represents the following elements Gate, Entrance, or Parking Location. The edge set E connecting pairs of vertices, which are unordered pairs of elements of V. The distance between each pair of nodes is represented as a weight of the edge between them. Secondly, the system applies a simple algorithm to determine the nearest parking place to the required entrance E_i, and then the shortest path from the Gate G_i to this nearest parking place is computed.

This algorithm can be divided into two steps. The first step; get the nearest parking place to the required entrance E_i, is determined by computing the minimum shortest path between all empty parking place and the entrance E_i. Then get the least short path between them to get the nearest parking place to the required entrance E_i. The second step gets the previous nearest parking place and computes the shortest path from this destination parking place to the Gate G_i.

The dynamic programming technique [16-18] is applied in this system to determine the shortest path between two locations in the garage. It works backward in the graph form destination to starting node (one of the gates). The algorithm can be listed in the table1.

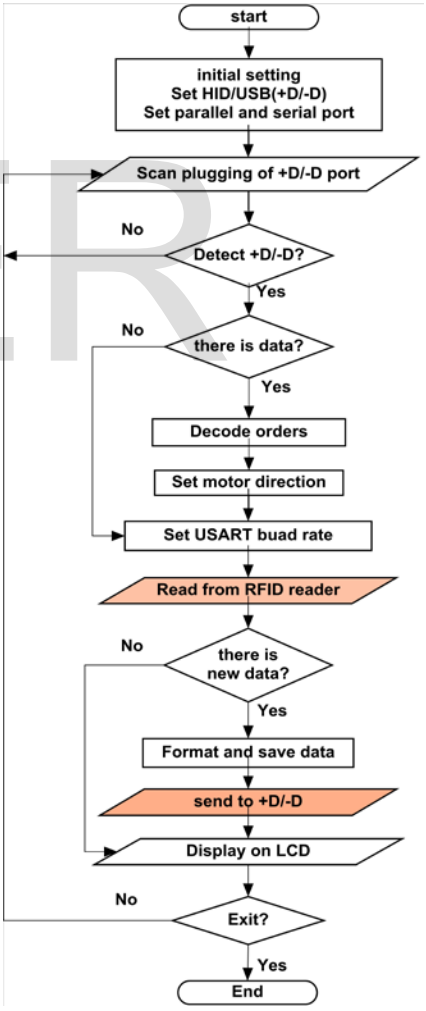

Fig. 6. The flowchart of the RFID circuit.

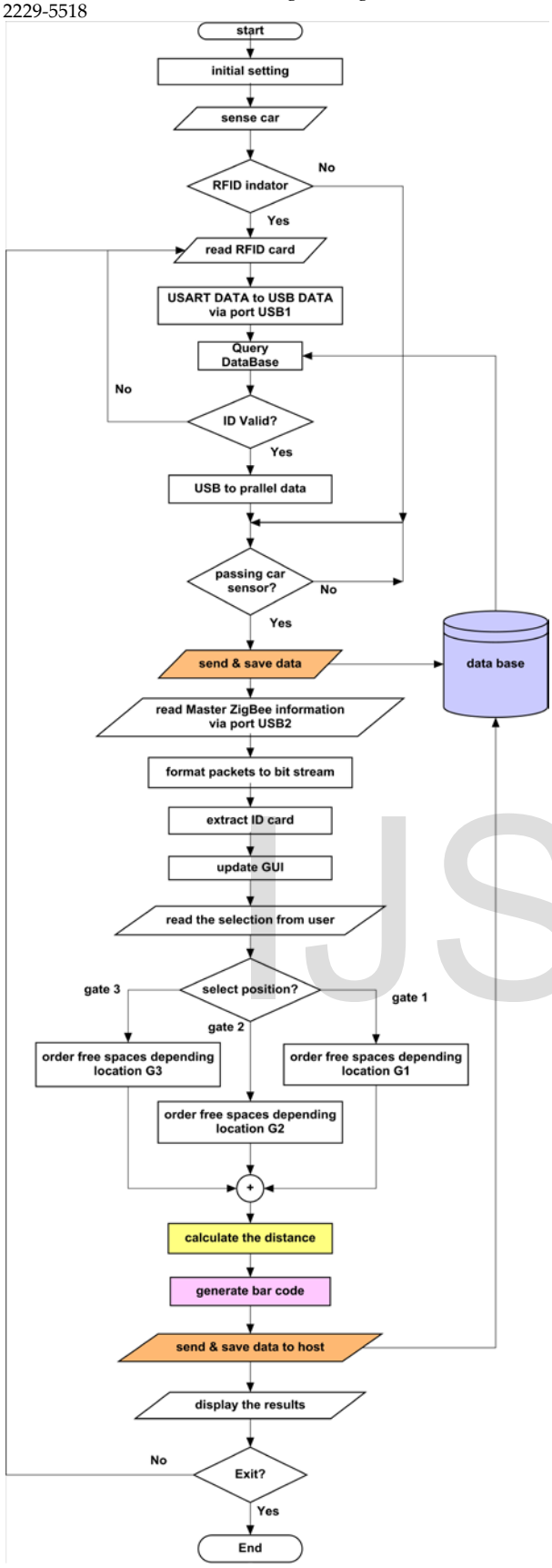

Fig. 7. The application flowchart.

TABLE I. THE ALGORITHM.

Input:
Undirected graph G = (V, E), where V is a set of Nodes and E is a set of weighted edges, with non-negative edge costs. Nodes in graph have three types; gate, entrance, parking place. An edge e(u, v) represents that vertices u and v are connected. Distance between vertex u and v is d(u, v), which should be non-negative.
Output:
Output: the shortest path from gate g_i to the nearest parking location from required Entrance E_i.
Process:
1- List all empty parking places ❑ Get all Empty Nodes of type Parking place 2-compute the shortest path between these parking places and the required Entrance E_i. ❑ For all empty location v in |V| ❑ starting at E_i and ending at v. compute (x_n the node at state n) ❑ $f_n(s, x_n)$ = immediate cost (at stage n) + minimum future cost (stages n+1) = $C_{S,Xn}+f^*_{n+1}(Xn)$, ❑ Return minimum $f_n(s, x_n)$ 3- Get the nearest empty parking place to the required Entrance E_i. ❑ Get the node $v_{nearest}$ that has the smallest distance to E_i among above all empty location v 4-get the shortest path between the $v_{nearest}$ to gate g_i ❑ Starting at $v_{nearest}$ and ending at gate g_i. compute ❑ $f_n(s, x_n)$ = immediate cost (at stage n) + minimum future cost (stages n+1) = $C_{S,Xn}+f^*_{n+1}(Xn)$, ❑ Return minimum $f_n(s, x_n)$

Consider the driver need to go to the node AA43 that represent an empty location from gate. There are two paths from these nodes to the gate 2, see Fig. 8. Dynamic programming technique is applied to obtain the shortest path from gate 2 to node AA43. The problem is solved recursively by working backward in the network from AA43. Let distance between node i and j is denoted as $d_{ij,}$ and $f_t(i)$ be the length of the path from node i at stage t. There two values, $f_n(AA41)$ from AA43 to AA41 and $f_n(AA45)$ from AA43 to AA45. In stage n-1, $f_{n-1}(AA39)=C_{AA39,AA41}+ f_n(AA41)$ and $f_{n-1}(AA47)=_{CAA47,AA45}+f_n(AA45)$ are computed. This process will be continued by selecting minimum path at any stage until gate 2. Finally, the minimum path between resulting paths (two paths in this example) is selected.

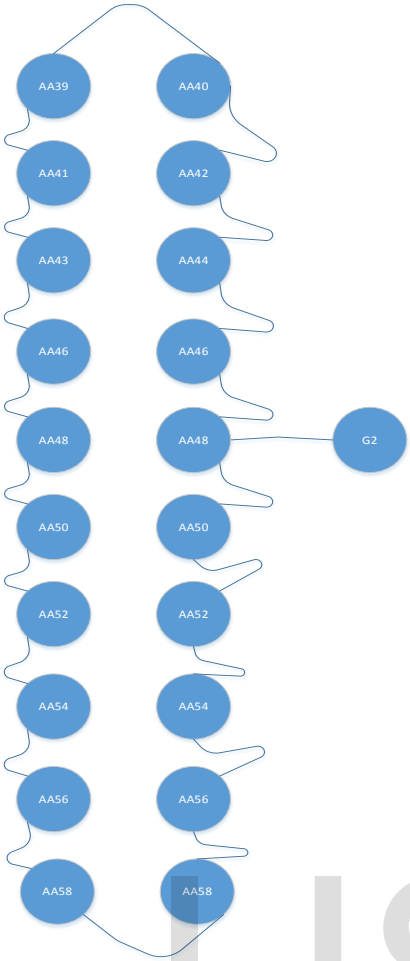

Fig. 8. The proposed paths of a garage part (G2).

IV. RESULTS

We implemented the complete hardware and load its suitable firmware and software code. The dynamic programming technique is applied. The final product implementation will be tested and succeed to sense and compute the short distance of empty lots for the selected region, Fig. 9 shows the running of our application.

Next, as shown in Fig. 10 and 11, the LCD indicator has printed up the ID of cards and the status of detectors of parking lots.

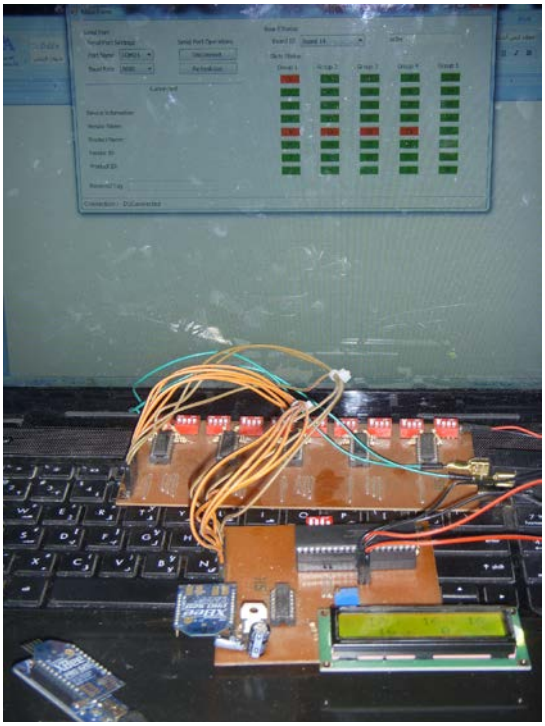

Fig. 9. The prototype of the system.

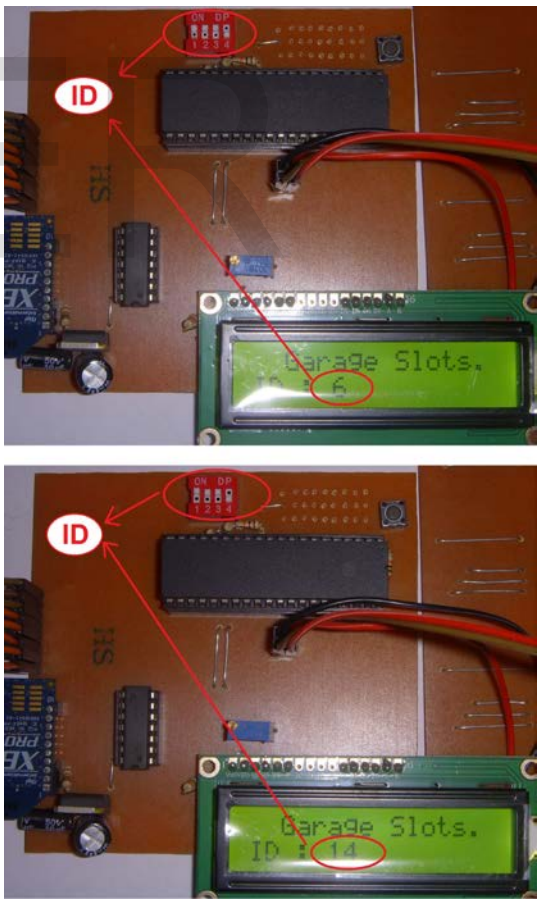

Fig. 10. The setting ID card.

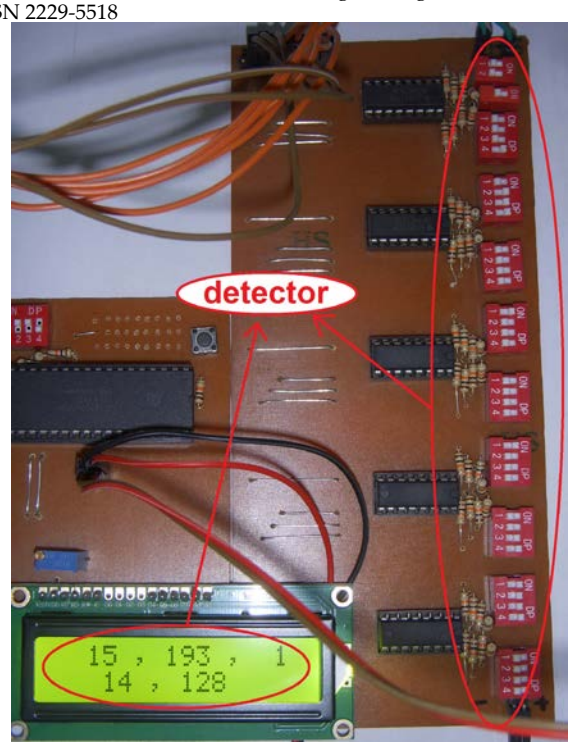

Fig. 11. The detectors result.

V. CONCLUSIONS

Indoor Parking Guidance System has been successfully developed and designed accordingly. This system will reduce the driver time searching for parking lot and the traffic congestion happen in parking area, since it able to recognize the status of lots and assigned the nearest parking lot from the mall entrance. The information is indicated on small LCD, and display on GUI of PC via ZigBee technology. The parking guidance system is designed based on the principle from Dynamic programming algorithm to calculate the nearest empty lot from each mall entrance. The design uses an RFID system to control of the opening a garage door depending to RFID cards validation, the RFID is used for especial lots which assigned to mall workers. The USB interface would allow for the user to add or remove tags and PC to receive data from ZigBees.

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