Real-Time Tracking and Environmental Monitoring System for Ice Trucks using IoT Techniques

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Abstract: - The problems faced by ice transporting entrepreneurs are the behavior of truck drivers in driving off the specified route and unnecessarily opening the freezing container door. Consequently, the dropping temperature inside the container of the ice truck damaged the frozen food transportation. For this reason, rotten frozen food because of transportation ruins the customer's trust. This research aims to present the design of location tracking, opening-closing container door counting system, and temperature monitoring system for ice trucks using Internet of Things (IoT) techniques. The real-time information is visualized via a web application for tracking and monitoring ice trucks

Key-Words: - Microcontroller, GPS tracking, IoT, Ice truck.

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1 Introduction

The behavior of driving off the route and unnecessarily opening the freezing container door of the ice truck driver causes temperature loss in the freezer container. This problem affects the quality of frozen food. Therefore, developing a location tracking system with an opening-closing freezer container door and temperature monitoring using the Internet of Things (IoT) for the ice truck increases the competition in the ice truck maker industry.

M.S. Ahmed (2021), [1], studied the design of a real-time monitoring system using an IoT platform. This paper suggested the IoT platform for a real-time system which includes the node, server, and communication protocol, Message Queuing Telemetry Transport. The real-time water quality management system uses an IoT platform, [2], to monitor and control water quality, such as pH, temperature, and turbidity, for home applications. The prototype system by the Nucleo Board Arm Cortex-M40 development board. Behzada et al. (2014), [3], designed and developed a low-cost vehicle tracking and controlling system using the prevailing cellular technologies. M. J. A. Baig et al. This technology includes Global Positioning System (GPS), Global System for Mobile Communication (GSM), and Microcontroller. The system used RF signals in a wireless sensor network to estimate the vehicle's location. J.F. Mendoza et al. (2017), [4], presented an embedded software architecture in microcontrollers for IoT in fog water collection. Mirza Jabbar, et al., (2021), [5], studied the design and implementation of a Peer-to-Peer (P2P) energy trading platform using ESP32-S2 Node-Red and MQTT protocol interface with a private Ethereum blockchain. The real-time monitoring and controlling of energy resources for remote locations with no internet access. V. Change and C. Martin (2021), [6], designed an Industrial IoT (IIoT) Arduino sensor system to record the temperature and location of ladle vessels for metallurgical purposes. The Arduino microcontroller connects to a K-Type thermocouple, Global-Positioning System (GPS) shield, a Real-time clock, and a Bluetooth module. Chinna Babu D. and Prakash V Carlos A. (2018), [7], designed real-time tracking and fuel monitoring which are implemented using IoT with Rasberry Pi. Hernández-Morales et al. (2022), [8], studied the design of an inspection system using IoT design for planting. This system contains a network processing unit and a low-cost application. Nawzad K. Al-Salihi (2021), [9], investigated the positioning tracking module of IoT and GPS using Arduino Uno and connected WIFI by ESP8266. Amit Kumer Podder (2021), [10], reported the smart AgroTech system using IoT to monitor urban farming parameters, i.e., the air humidity and soil moisture. This research presents the design and development of the location tracking and monitoring system using the IoT platform for the 1.65 x 2.25 x 1.66-meter ice truck, as shown in Fig.1. The temperature of the freezing container, the opening-closing state of the doors, and the speed of the ice truck are recorded on the SD card.

Fig. 1: Ice truck

2 Materials and Methods

2.1 Architectural Concept Design

The location tracking and monitoring system are designed for the ice truck using the IoT platform. The system has sensor nodes, e.g., door and temperature sensor, GPS, clock modules, and actuator nodes, e.g., magnetic sensor and active buzzer, an architectural concept design, as shown in Fig.2. The Arduino Uno R3 is used as a microcontroller to implement with the devices and transfer the data (location, temperature, door opening-closing status) to the NodeMCU V2 and recorded on SD Card. In the opening-closing container door monitoring, in the case the door is opened, the active buzzer module will be alert until the door is closed. The data is also delivered to an online database using Message Queuing Telemetry Transport (MQTT) via pocket wi-fi with IEEE 802.11 wireless communication standard. The real-time data is displayed on the Web application. The various module data and sensor statuses are displayed on the TFT LCD, which is interfaced with the Arduino Mega 2560 controller.

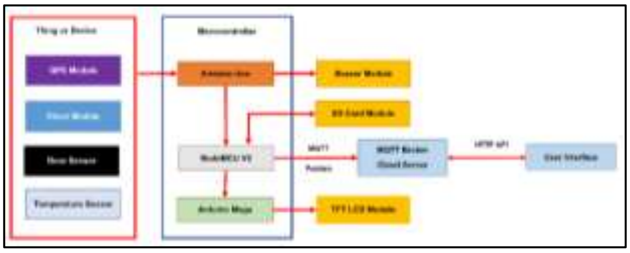


Fig. 2: Architectural concept design for local tracking and monitoring system

2.2 Experimental Setup

Input signals for Arduino Uno R3 consist of a GPS module as GPS Ublox NEO-7M has a 2.5-meter positioning accuracy, a 0.1-meter velocity accuracy, and 0.25 Hz to 10 MHz of signal frequency. In a Clock module as DS3231Real Time Clock, the discrepancy is at most two ppm (2 sec/1,000,000sec). The Door sensor as Magnetic Reed Switch BR-1021 has a detection distance value of 0 to 21 mm. The digital temperature sensor as DS18B20 has an error of ± 0.5 °C and an accuracy of -10 °C to +85 °C, as shown in Fig.3. The display module is used Inch TFT Color Screen M-320x480 with Kingston Memory Card Micro SD SDHC 2 GB, as shown in Fig.4. The NodeMCU V2 with Wi-Fi ESP8266 receives data and transfers it to the online Database. Fig.5 demonstrates the display module, sensors, microcontroller, location tracking, and buzzer module as an alarm signal and monitoring system. SD card is used Kingston Memory Card Micro SD SDHC 16 GB Class 10.

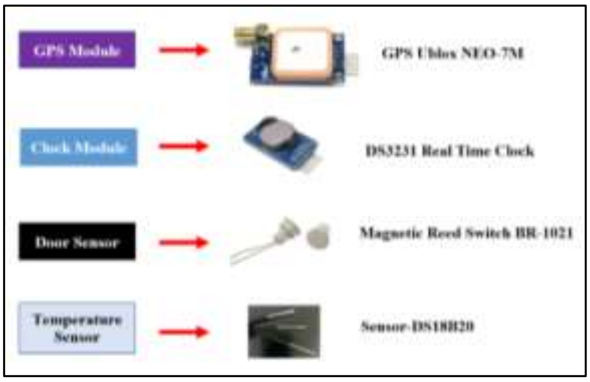


Fig. 3: Input module and sensors

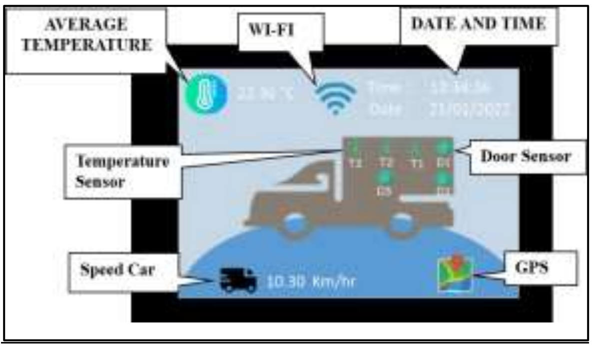


Fig. 4: Display module

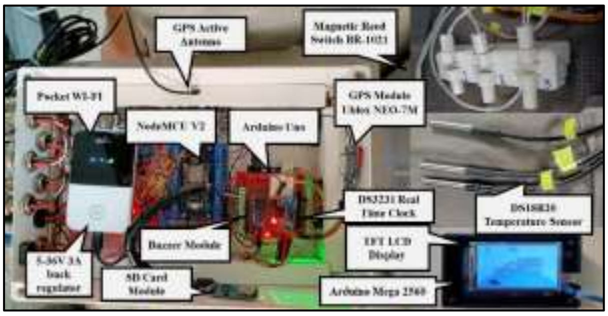
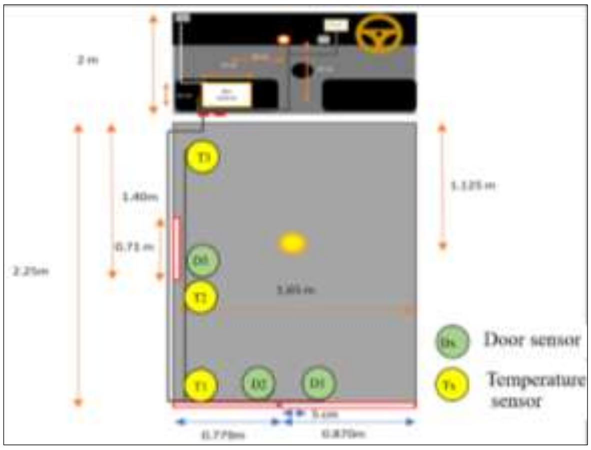


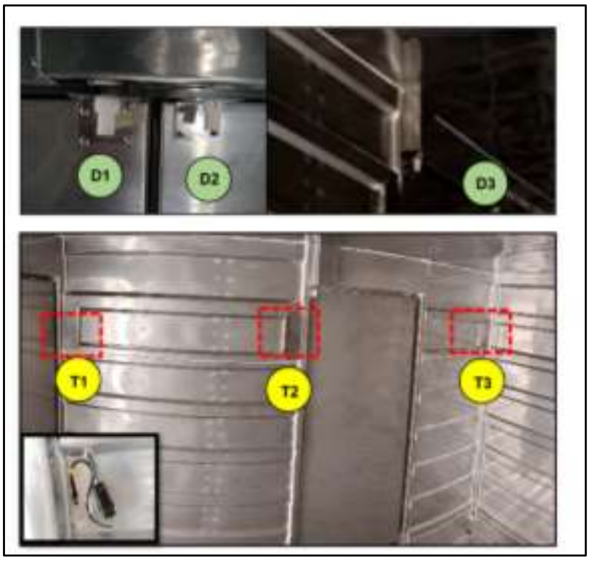
Fig. 5: Control box and sensors

2.3 Sensor Installation

Three door sensors, such as Magnetic Reed Switch BR-1021, were installed near the doors to detect door opening-closing status, and three digital temperature sensors, DS18B20 attached to the ice truck, as shown in Fig.6. 3.5-inch TFT LCD in the driver's cabin and the control box installed beneath the driver's seat.



a) Position sensor installation scheme



b) Position sensor installation at the ice truck

Fig. 6: Sensor installation

2.4 Programming

The GPS module, door sensor, clock module, and temperature sensor signal-receiving write C/C++ programs, and the internet connects via NodeMCU V2. MQTT delivered the data to the online database using IEEE 802.11 standards via pocket wi-fi. The information is displayed on the TFT LCD and the web application. There are three display sections, time duration and the number of door openings graph, and real-time temperature graph, route coordinate, speed, and opening-closing of doors location on the map, as shown in Fig.7.

Fig. 7: Web application display

3 Experimental Results

The two experiments verification for a location tracking and monitoring system.

3.1 Laboratory Tests

The temperature sensor test was performed in static calibration, random and sequential testing at 10 – 80 C with ±1.55 C overall error using the water bath test station, as illustrated in Fig.8. The magnetic reed switch BR-1021 is utilized to detect the steel door's opening-closing status. The distance between the head probe and the magnetic probe is effectively on/off in the 0-20 mm range.

Fig. 8: Water bath test station

The GPS Ublox NEO-7M module testing compared to coordinate on Google Maps must be within the acceptable limits of a 5-meter position error and 10 km/h speed error. The test considered the coordinates of 12 points around Hospital road, Suranaree University of Technology, as shown in Figure 9.

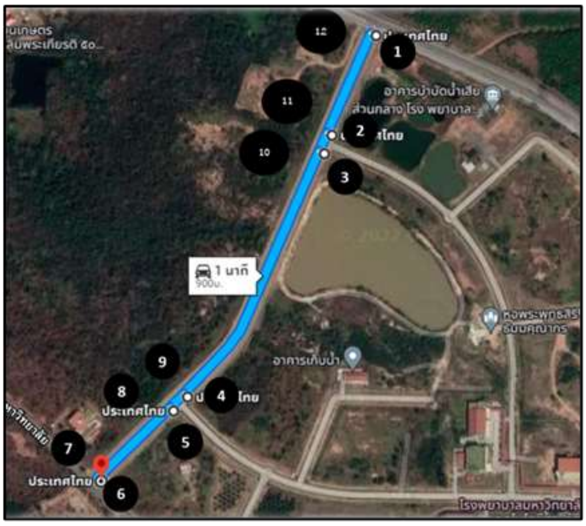


Fig. 9: GPS module testing Route

In the stationary position test, the highest position error was found at 3.25 meters at position 11. The moving position testing at a motorbike's constant speed of 30 km/h found the 30.98 km/h maximum speed and the 26.97 km/h lowest speed. The result has a maximum speed error of 3.03 km/h, as shown in Figure 10.

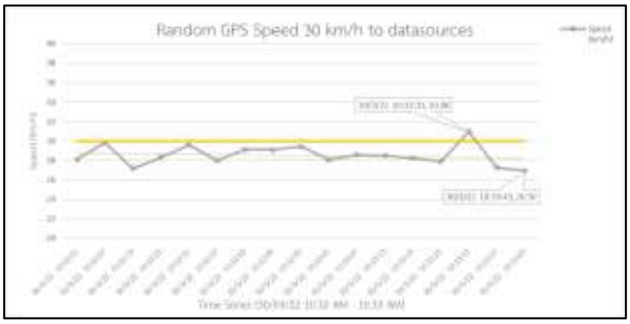


Fig. 10: GPS speed graph

3.2 Field Tests

Field testing of ice delivery driving location tracking and monitoring systems. The test location is around the university. as shown in Fig.11.

Fig. 11: Route and stopping positions of the ice truck

The monitoring system will display the temperature. Door open/close status, Wi-Fi status, and alerts on the TFT LCD are shown in Fig.12. The web application can illustrate each position's stop position and door status, as shown in Fig.13, 14. The data record of the SD card can save as a text file. In addition, the opening-closing status of each door is shown in Fig.14. The temperature profiles of the ice truck traveled as shown in Fig.15, and the speed profiles of the ice truck were recorded as shown in Fig.16.

Fig. 12: TFT display

Fig. 13: Location field testing on Web application

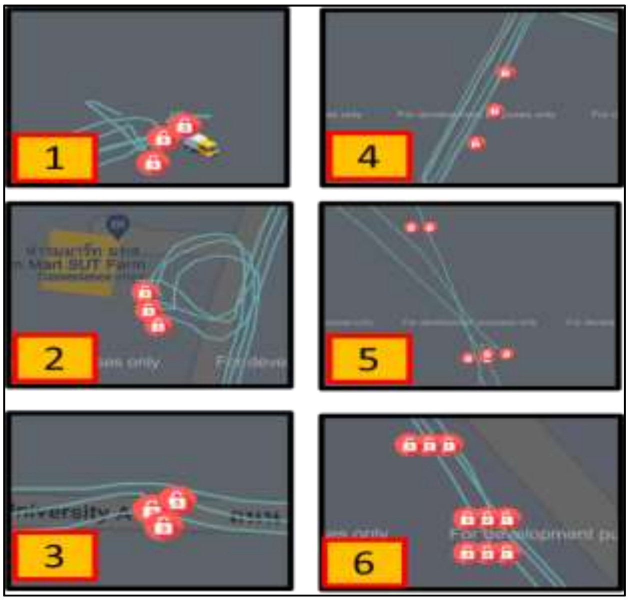


Fig. 13: Web application display of door opening-closing status

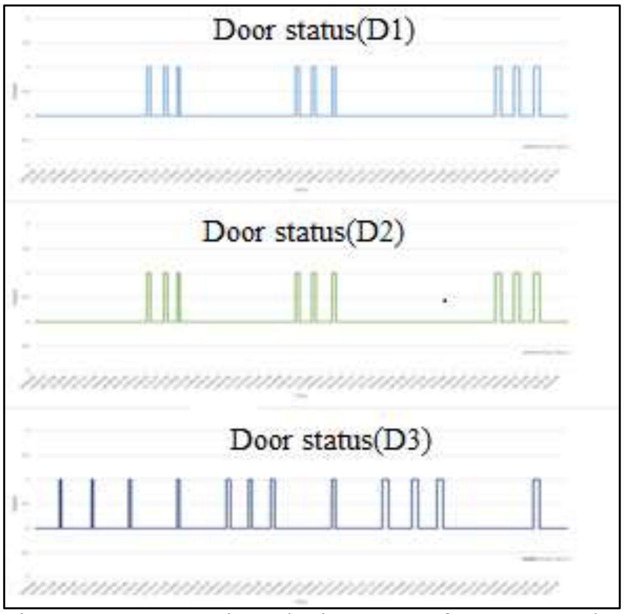


Fig. 14: Door opening-closing status from SD card

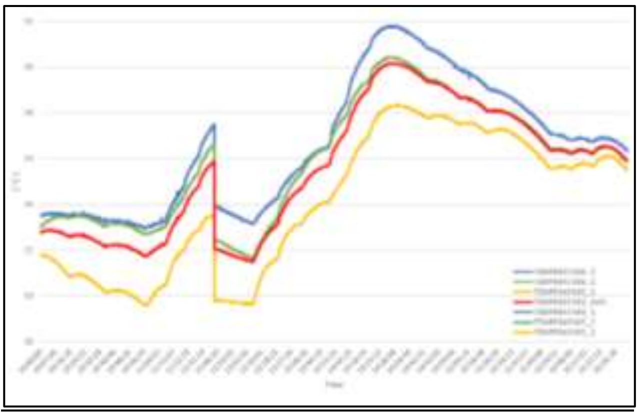


Fig. 15: Temperature profiles from SD card

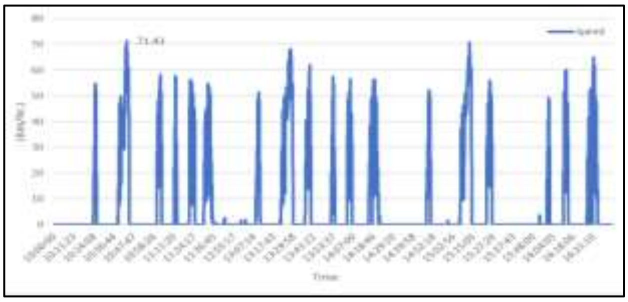


Fig. 16: Speed profiles of the ice truck from SD card

The Ublox NEO-7M GPS module testing records data to the SD Card module, compared with the location on Google Maps, found the 3.25-meter maximum position error. The sound alert system testing of the Active Buzzer module, when the door is opened, the buzzer is alarmed until the door is closed. The data is transferred from the measurement and data collection kit through the Pocket WI-FI wireless network to the server using the MQTT protocol. The data displayed via the web application is efficient. Recording results to the SD card ensures that the data will be recovered in case of online transmission is not possible.

4 Conclusion

According to the laboratory and field test results, the system can correctly display and notify the truck location, temperature, and opening-closing door status on the TFT color screen M-320x480 and the web application with all data recorded on the SD card. The low-cost real-time location tracking and environmental monitoring system of the ice truck using IoT techniques can increase the competition in the ice truck maker industry and provide the innovation for ice transportation services to be more efficient.

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