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Environmental monitoring based on traffic management

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Abstract

A significant amount of research work carried out on traffic management systems, but intelligent traffic monitoring is still an active research topic due to the emerging technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI). The integration of these technologies will facilitate the techniques for better decision making and achieve urban growth. However, the existing traffic prediction methods mostly dedicated to highway and urban traffic management, and limited studies focused on collector roads and closed campuses. Besides, reaching out to the public, and establishing active connections to assist them in decision-making is challenging when the users are not equipped with any smart devices. This research proposes an IoT based system model to collect, process, and store real-time traffic data for such a scenario. The objective is to provide real-time traffic

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1. Introduction

The sustainability and smartness of the smart city concept rely on the technologies adopted to improve the people's quality of life. The smart city governance is one significant aspect of smart city initiatives, which will facilitate the planning techniques for better decision making [11,14]. One of the key elements of the smart city governance framework is the public value generated out of the smart services provided [15].

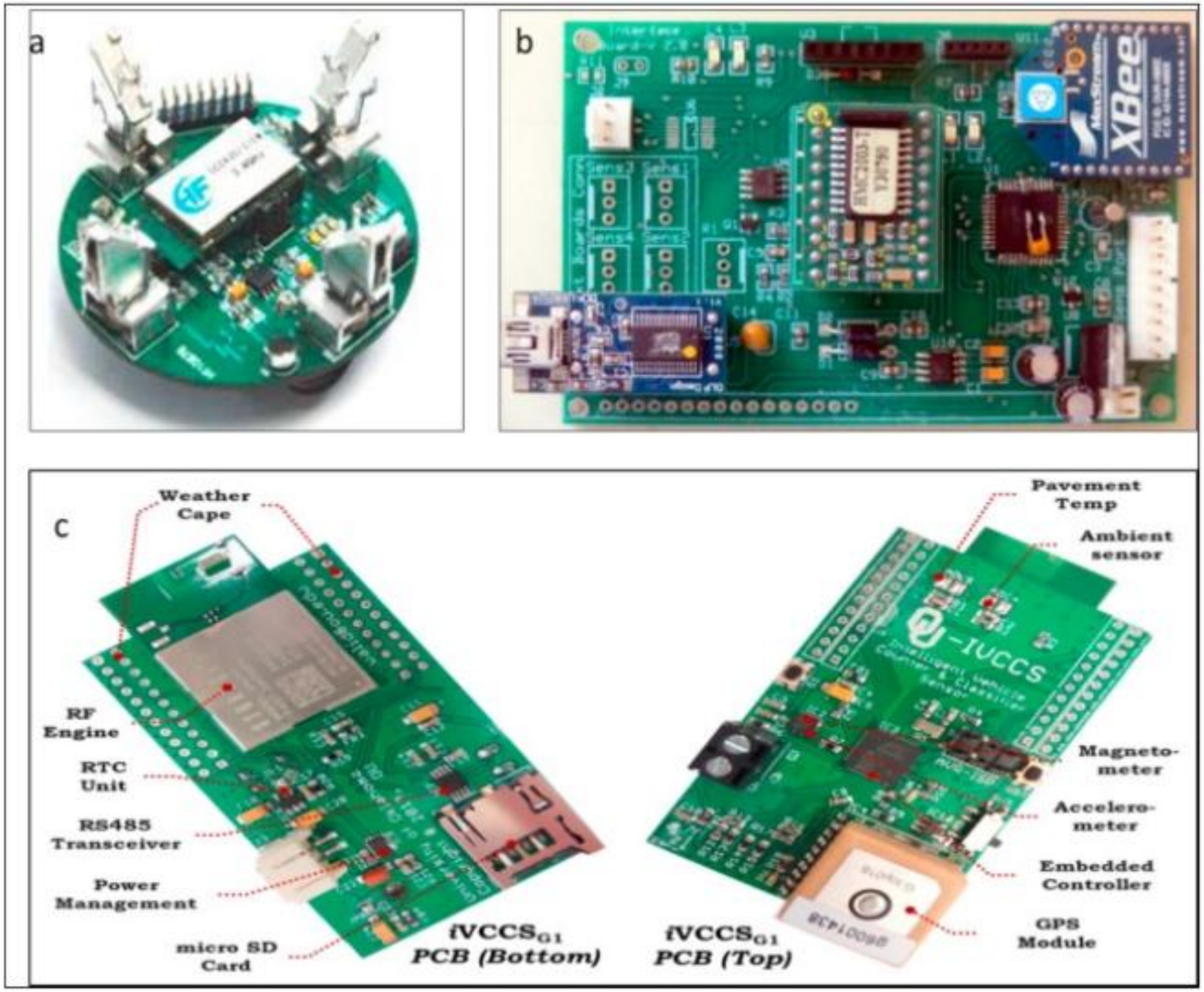
Smart traffic infrastructure is an essential component of smart city initiatives because traffic congestion is a severe issue that grows along with city development. Smart traffic management includes intelligent transport systems with integrated components like adaptive traffic signal controls, freeway management, emergency management services, and roadside units [34]. Such systems collect real-time traffic data and take necessary measures to avoid or minimize any social issue created as part road congestions [21]. For example, access to real-time traffic maps will assist the residents in selecting appropriate route to save time and effort.

2.1. Real-time traffic updates

Real-time traffic monitoring systems play a key role in the transition toward smart cities. A considerable amount of literature has been published on intelligent traffic management systems based on the IoT paradigm [25,56,60,61]; Z [38]. Autonomous traffic sensing is at the heart of smart city infrastructures, wherein smart wireless sensors are used to measure traffic flow, predict congestion, and adaptively control traffic routes. Doing so effectively provides an awareness that enables more efficient use of resources and infrastructure.

2.2. Wireless sensors for vehicle data collection

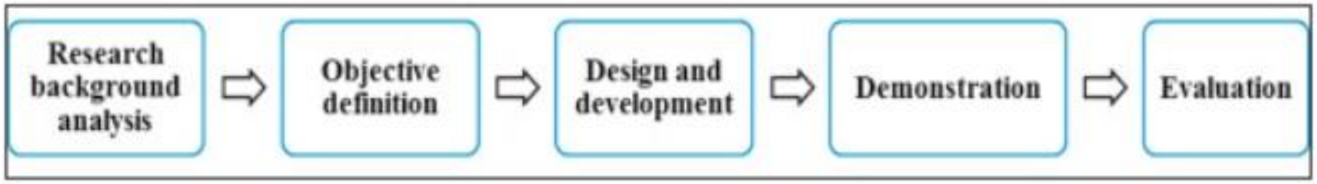
This section presents the review of sensors that are used for vehicle detection and classification. The sensors used in intelligent traffic monitoring systems can be on-road sensors or in-vehicle sensors. The on-road traffic sensors can be again classified into two types: intrusive and non-intrusive. The intrusive sensors are paved on the road and are costly compared to non-intrusive sensors. The intrusive sensors provide accurate information; however, they are questioned for the expenses in terms of installation. maintenance, repair costs [22]. The maintenance of such sensors requires road lane closures and traffic disruptions.



a
b
XBee
c
Weather Cape
RF Engine
RTC Unit
RS485 Transceiver
Power Management
micro SD Card
iVCCS$_{G1}$ PCB (Bottom)
iVCCS$_{G1}$ PCB (Top)
Pavement Temp
Ambient sensor
Magneto-meter
Accelero-meter
Embedded Controller
GPS Module

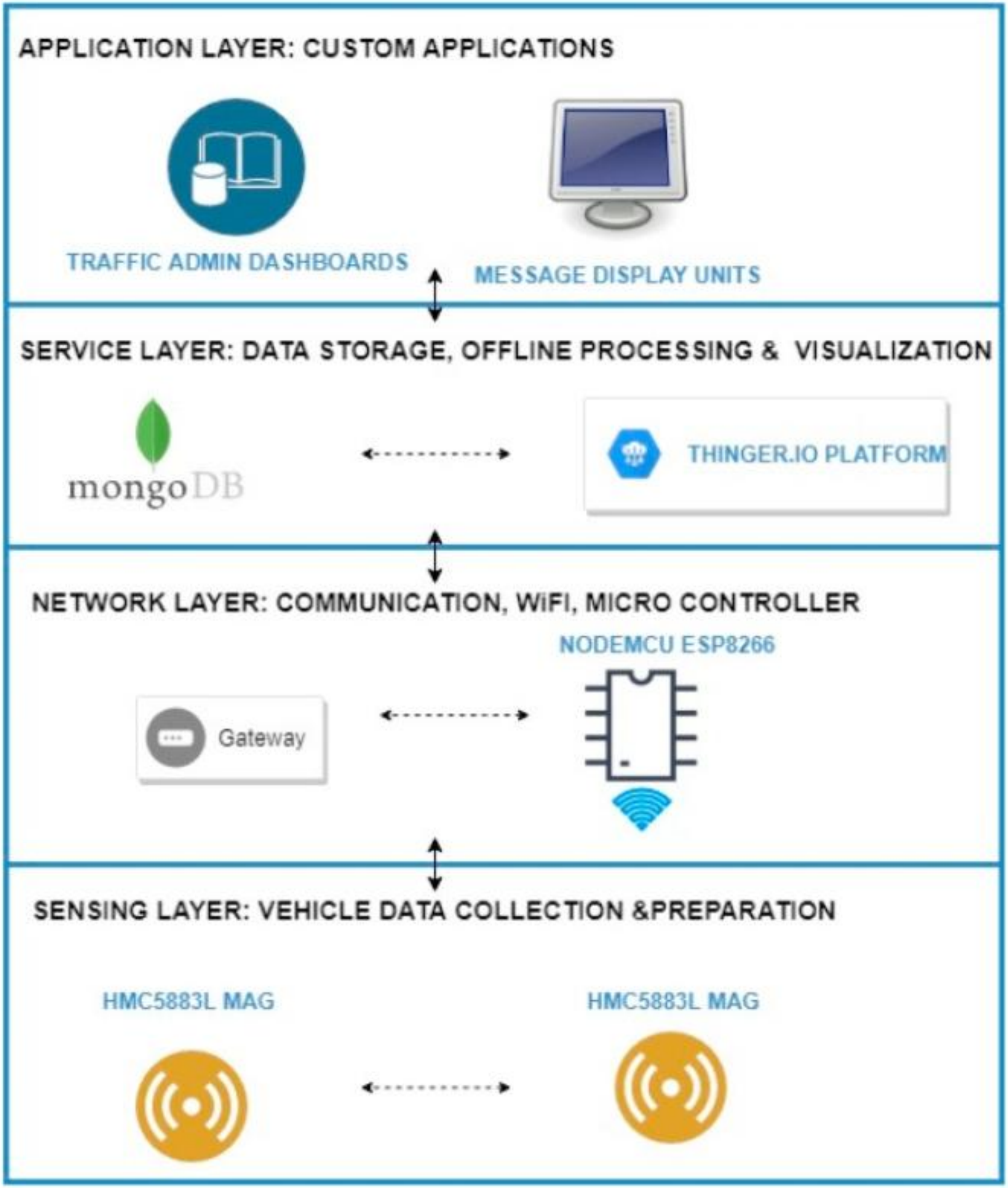
3. The research methodology

A robust research methodology is essential to achieve the research objectives. This research work is carried out in five main phases according to design science research methodology [49]. The five phases are given in Fig.2: (i) research background study, (ii) objective definition, (iii) design and development of artifacts, (iv) demonstration to show how the artifacts resolve the problems, and (iv) final evaluation.



4. System design and development

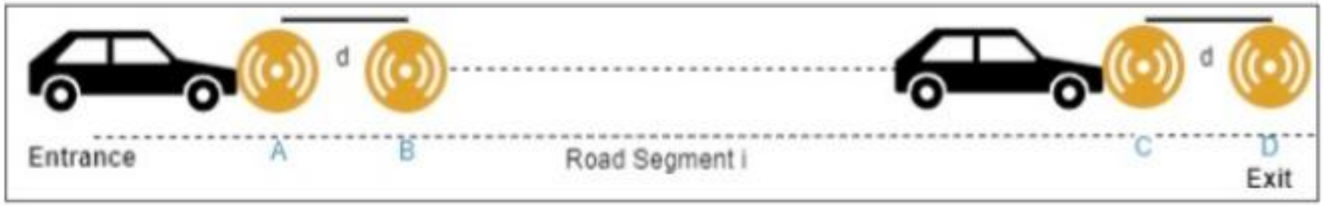
This section discusses the proposed system model, different software and hardware components required, and algorithms to implement the proposed system. The proposed system communication model is presented in Fig. 3, which has components installed at the roadside and a cloud-based central server. The roadside setup includes sensors and message boards. The sensors and boards will be installed between two road segment intersections. The central server includes data storage, cloud services, and interfaces. The components can communicate with each other using WiFi.


APPLICATION LAYER: CUSTOM APPLICATIONS
TRAFFIC ADMIN DASHBOARDS
MESSAGE DISPLAY UNITS
SERVICE LAYER: DATA STORAGE, OFFLINE PROCESSING & VISUALIZATION
mongoDB
THINGER.IO PLATFORM
NETWORK LAYER: COMMUNICATION, WiFI, MICRO CONTROLLER
NODEMCU ESP8266
Gateway
SENSING LAYER: VEHICLE DATA COLLECTION &PREPARATION
HMC5883L MAG
HMC5883L MAG

4.3.3. Road occupancy and growing queues

The traffic congestion measures are mostly based on parameters such as speed, time and delay, reliability, service, space, etc. The road space occupancy is one such measure to determine the growing traffic queue and Fig. 7 (b) shows the flowchart on how to determine the road congestion using occupancy measure. Fig. 8 illustrates how the road occupancy measure is calculated.

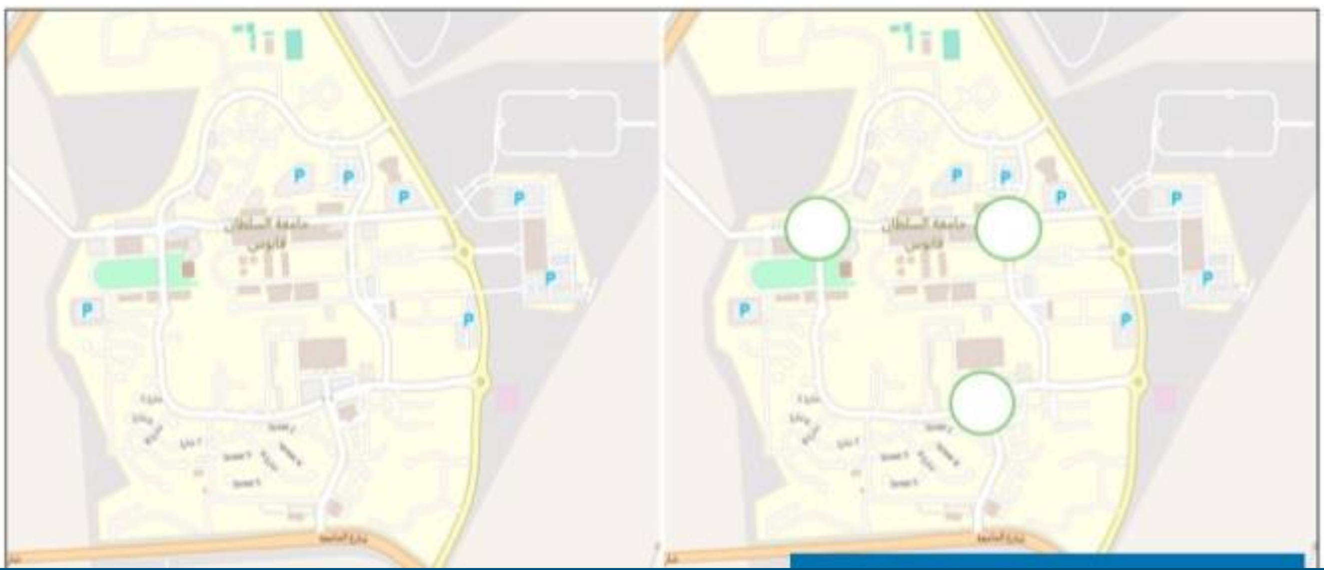
The VPL is estimated by the sensors when the vehicle crosses the sensor nodes, the physical length is added to the road occupancy measure and subtracts the length when the vehicle departs at exit points as in Fig.8. When sensor C detects a vehicle, sensor node D will estimate the physical length and send it to sensor B. The microcontroller associated with sensor B holds the occupancy measure and sends real-time traffic updates.



6.1. Selection of message board location

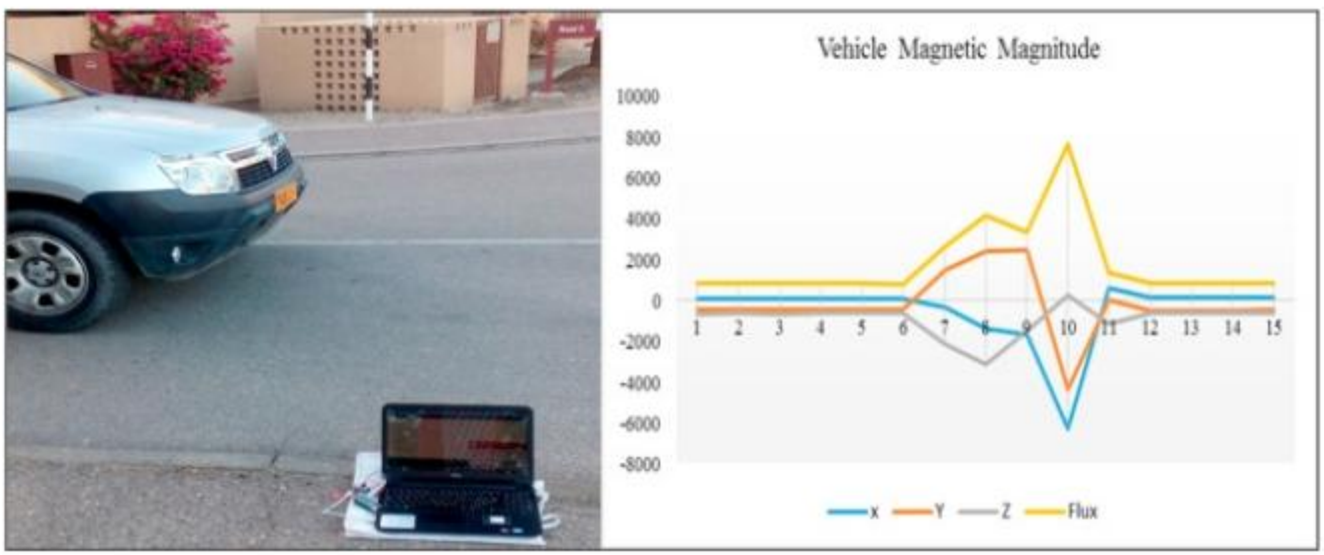
The map of the university is downloaded from the OpenStreetMap website. The OSM files are converted and loaded to MongoDB and the pictorial view is presented in Fig. 11. The original map is on the left and expected junctions are marked on the right. The accuracy of the map processing script is measured through precision and recall metrics. These metrics are used to evaluate the effectiveness of information retrieval. Precision %= (Number of relevant junctions retrieved/Number of junctions retrieved) * 100%

Recall %= (Number of relevant junctions retrieved/Number of relevant junctions in the map) * 100%



6.3. Dashboards

The communication between sensor node B and Thinger. io has been established to build the dashboard and store real-time traffic data for the future. A simple dashboard to find the occupancy of road A, B, and C at different timings is given in Fig. 12 (see Fig. 13).



References

[1] Z.A. Almusaylim, N.Z. Jhanjhi
Comprehensive review: privacy protection of user in location-aware services of mobile cloud computing
Wireless Pers. Commun., 111 (1) (2020), pp. 541-564
Google Scholar ↗

[2] V.T. Arasan, G. Dhivya
Measuring heterogeneous traffic density
Int. J. Civ. Environ. Eng., 2 (10) (2008), pp. 342-346
Google Scholar ↗

Thank you