- CE200L-2_E02-6
- An Internet of Things (IoT) Based Automatic Vehicle Counting and Traffic Forecasting using Raspberry Pi
- BOLANDRINA, Leslie M.; CAMPOS, Joshua C.; DE GUZMAN, Jerrete Patrick B.
- Civil Engineering
- Link for Materials: https://drive.google.com/drive/folders/1vVIue3teadnAFsPcaQN-FZhLZKhxie8T?usp=sharing
- Evaluation Link: https://bit.ly/SCEGEProposal1Q2122

An Internet of Things (IoT) Based Automatic Vehicle Counting and Traffic Forecasting using Raspberry Pi

By:

Bolandrina, Leslie M. *(2018103955)*
Campos, Joshua C. *(2016142268)*
De Guzman, Jarrete Patrick B. *(2018100249)*

Bachelor of Science in Civil Engineering
Mapua University - Intramuros, 2021

A Civil Engineering Thesis Submitted to the School of Civil, Environmental and Geological Engineering in Fulfillment of the Requirements for the course

THESIS 1 (CE200L-2)

Mapua University
October 2021

Table of Contents

CHAPTER 1

The Problem and its Background

Introduction

Traffic congestion has always been a significant problem in the Philippines, especially in urban areas with dense populations. Aside from congestion, environmental and accident-related problems due to saturated roads have become a problem of concern in these areas. Road Traffic is caused by the increased numbers of vehicles as the population rapidly increases. There has been inequality in the development of road infrastructure in contrast to the growing number of automobiles. By considering the current transportation system in the country, the likelihood of arriving on time to destinations is always delayed.

One way of reducing traffic congestion is by means of traffic forecasting wherein you will know the real-time forecast of information about the flow of traffic based on data such as traffic flow, number of vehicles, and average traffic speed. This will enable commuters to be able to know what time they would expect heavy traffic to avoid travelling during that time period. Using software such as Matlab, Python, and more, engineers nowadays can simulate the traffic flow based on the data gathered in tools such as cameras and wireless devices that are commonly used in traffic monitoring today. In addition to that, the Internet of Things (IoT), a system of interconnected computing devices that can transfer a series of data through a network without the need of human interaction is a new trend that is helpful in gathering, tracking, monitoring and interpreting data.

There are various ways to control traffic congestion that are already present in the transportation sectors today such as traffic-light management, the use of CCTV in monitoring road conditions, improvement of services, construction of new infrastructure and enforcing road traffic laws. However, the above-mentioned methods are systematic operations that involve techniques and processes that consume a lot of time in evaluating traffic needs. Traffic management requires precise control of the process involving traffic prediction, and road monitoring to be able to produce efficient, fast, and reliable data on time to be able to provide good services and solutions. Traffic management generally involves monitoring of actual traffic situations and controlling the flow with respect to speed and volume counts to ease movement of vehicles without experiencing congestion to increase the safety on the road

Traffic congestion seems like a never-ending problem for the people and is usually one of the major limitations that affects the overall performance of the road transportation system. The researcher aims to provide data for other mitigating measures in reducing the traffic. Along with this, traffic forecasting would be done in the paper as well. This is possible through traffic monitoring using cameras for vehicle counting and raspberry pi for holding and storing the data during the conduct of the study. The data gathered would be interpreted using MatLab for precise vehicle volume count and traffic forecasting. Lastly, the researcher also wants to encourage other engineers, especially those who are in line with Transportation Engineering to consider or engage in this type of study to expand more knowledge on the current trend in Internet of Things (IoT) and how it will help and provide ease in the transportation sector.

Statement of the Problem

The general objective of this research is to develop and apply the Internet of Things to the transportation sector particularly on traffic management by forecasting the traffic flow utilizing Internet of Things. The specific problems that the research wants to address are:

1. To identify components of IoT applications applicable to traffic monitoring
2. To determine the different contingencies that can be applied based on the implementation of IoT in the transportation system particularly on the traffic monitoring.
3. To assess the utilization of the IoT application as implemented to the traffic monitoring.

Keywords: Internet of Things (IoT), Smart Transportation, Traffic Monitoring, Traffic Forecasting, Sensors

Objectives

The general objective of the study is to aid in traffic management by forecasting the traffic flow using cameras and a traffic monitoring algorithm The forecasting of traffic flow would be done by the use of a camera to record real-time video and a time series algorithm will aim to create a traffic data report in relation to Smart Traffic Management System and Internet of Things. Traffic monitoring would be done to ensure that the objective of producing accurate data is met. The specific objectives of the research are:

1. To create algorithms to count the number of cars on 32nd Street, Bonifacio Global City, Taguig, Metro Manila, Philippines from 3:00 p.m. to 5:00 p.m., Monday to Sunday.
2. To forecast the volume of traffic on the succeeding weeks based on the weeks of monitoring and compare the result and accuracy of forecast.
3. To provide traffic data and suggestions for traffic insight.

Hypotheses

This paper is entitled "An Internet of Things (IoT) Based Automatic Vehicle Counting and Traffic Forecasting using Raspberry Pi" that will submit to an outcome based on the hypothesis below:

H0. There is no significant difference when applying IoT in traffic management specifically in traffic monitoring and forecasting.

H1. There is a significant difference when applying IoT in traffic management specifically in traffic monitoring and forecasting.

Significance of the Study

Having enough knowledge about the systematic operation of traffic flow, transportation engineering is a further step in attaining the stability of traffic. Transportation plays a great part in the continuous growth in the economy by providing accessibility to every needs of the people. It also helps in generating employment and better access to healthcare which are essential to economic development.

Being able to provide accurate traffic forecasting for the future enables commuters, road users and pedestrians to access places in a safer and faster way possible without experiencing delays. It plays an essential role in the development of transportation structures. It also plays as the basis for traffic revenue forecasts in the financial viability of a transport project. Lastly, it provides data for current and future average daily traffic and design hour volume. The study's findings will benefit different sectors that include the following:

Transportation Sector - The outcome of this thesis will provide information that could reduce or eliminate the traffic congestion brought by the increasing number of vehicles on urban roads. Having enough information regarding this matter will help the transportation sector mitigate the current and future saturation problems in traffic. As a result, this paper will provide significance to provide a faster flow of vehicles, goods, people and provide growth in the community.

Public Transportation Users - Passengers on PUV's and railway face difficulties and difficulties because of the change in public transportation. Passengers on public transit will have a better grasp of the traffic congestion that may develop in the time of pandemic owing to the data that is being studied. Having this said, commuters will benefit from this by being able to manage their trip time, the availability of PUVs and as well as choosing the time that they will commute considering the traffic condition.

Smart Transportation - The data that will be gathered in this paper will provide recommendations that will help in managing traffic congestion. Reduced traffic congestion will help in lessening pollution and energy consumption, contributing to a more sustainable development.

Traffic Monitoring - Simulation and prediction provided by this study will help in monitoring the traffic and future flow of traffic in the specific place in order to establish future plans.

Scope and Limitations

This study covers the application of the Internet of Things to Traffic Congestion Management. The collection of data will come from the traffic count along 32nd Street in BGC during peak hours. The study will be conducted between 3:00 PM and 5:00 PM, from Monday to Sunday in any two consecutive weeks from November to January as this will be the quarter where the researchers will conduct their data gathering. The target of this study is the vehicles passing by at the road specified. The scope of the study is limited to the traffic data that the researcher will gather near the road. The vehicles which do not pass the specified road and exceed the given time frame are not within the scope. The study would be done by the utilization of a camera to determine the number of vehicles often passing along 32nd Street. The study will only be conducted at the north bound of the road. To increase the accuracy of the traffic count, the researchers will use an algorithm to forecast the traffic condition.

Definition of Terms

- Algorithm - A well-defined logic written in software used in analysis for databases, artificial intelligence, operating systems, and computers.
- Average Daily Traffic (ADT) - It is the traffic volume traveling through a location or portion of a road in both directions over a period, divided by the number of days in the period and factored to provide an estimate of traffic volume for an average day of the year.
- Internet of Things (IOT) - A system of interconnected computer equipment, mechanical and digital machines, objects, animals or people with unique IDs and the capacity, without human to human or human computer contact, to transmit data over a network.
- MatLab - A fourth-generation numerical computing analysis and programming language.
- Peak-Hour Factor (PHF) - It shows how constant the traffic volume is during peak hours.
- Raspberry Pi - A series of single-board computers used as an input or output to control electronic components for physical computing and exploration of the Internet of Things.
- Sensors - Devices that can detect exterminating information from a certain object through signals that can be distinguished by machines and humans.
- Smart Transportation - The utilization of developing new technology makes it easier, cheaper (for both the city and the person) and safer to move around a city. Traffic

Congestion - An increasing demand for road network utilization is generally described by slower speeds, lengthy of travel, and greater queueing.

- Traffic Forecasting - A future estimation of the numbers of vehicles or people that will use a specific transportation at a specific time and date.
- Traffic Simulation - It is a mathematical modeling of transportation systems through an application in computer software or model that is necessary in transportation planning.
- Transportation System - Facility comprising essential means and equipment for passenger or cargo transport.

Thesis adviser Approval:

ENGR. GEOFFREY CUETO

Name and Signature

ENGR. ERICSON D. DIMAUNAHAN

Name and Signature

CHAPTER 2

Review of Related Literature

Traffic management is part of a compound extent of civil engineering. This part of the paper shows the significant contribution of traffic forecasting in traffic congestion management, especially in urban areas using new technologies such as cameras, algorithms, and the Internet of Things. Related literature and Related studies from previous studies will serve as justification and support in the study that the researcher will be conducting and their basis for the theoretical framework. The specific concepts that will be found in this chapter are subject to Internet of Things, Smart Transportation, Traffic Monitoring, Sensors, and Traffic Forecasting. Related literatures include journals, write ups, and articles that are either unpublished or published in forms of book and magazines. Detailed explanation will be provided in relation to this paper.

Internet of Things (IoT)

It is said that the Internet is a ground-breaking invention and is constantly evolving for new applications, making it for everybody's use. Today, we currently observe human-human or human-device communication, but the Internet of Things (IoT) promises a bright future for the Internet in which communication is machine-machine (M2M). The Internet of Things (IoT) promises to connect everything in our environment through a shared infrastructure, providing us control over the things around us and keeping us informed about their status (Singh, 2016).

The Internet of Things (IoT) has drawn attention by giving a vision of a worldwide infrastructure of networked physical things that enables anytime and even anywhere connectivity for anything, not only just for any one person. According to Madakam(2015), the Internet of Things will transform real-world objects into intelligent virtual items in the future. The Internet of Things (IoT) aims to bring everything in our environment together under a single infrastructure, providing us control over our surroundings and keeping us informed on their status.

The Internet of Things is a global network of heterogeneous intelligent items networked via the Internet to control the real physical world. Nonetheless, there are still obstacles in intelligence, autonomy, security, privacy, and interoperability that must be resolved for this emerging paradigm to succeed (Valencia, 2018). IoT poses both challenges and opportunities. It is possible to give ease to an individual's life, e.g., are sensors in transportation and even mapping

the most efficient route for an individual to pass through. Having this said, there are still some issues about safety and privacy.

Smart Transportation

According to WSP(2021), Intelligent Transportation Systems (ITS) are a collection of cutting-edge information and communication technologies that are used in transportation and traffic management systems to increase the reliability, safety, efficiency, and sustainability of transportation networks, as well as to reduce traffic congestion and improve driver experiences. A great example of a smart transportation application is that road network performance can be monitored and adjusted in real-time. Endless possibilities can be done using smart transportation by having a clear and studied strategy, providing convenience to the public while ensuring safe hands.

Greater inclusion of modern automobile technologies is frequently considered part of the development of emerging technologies, resulting in several benefits. However, given research that shows induced travel by early adopters of developing car technologies and services and mixed effects in transit use and active transportation, the final consequences of such benefits are uncertain (Kelley, 2019). Some of the things that could determine its implementation are its geographic scope and characteristic of the area. Another thing that affects this is the population to its demographic characteristics and adaptation to transportation technologies.

Knowing the advantages and convenience of smart technology, other countries such as the Philippines are implementing it. ITS is an information and communications technology (ICT) system that applies to road transportation, including infrastructure, vehicles, users, and traffic and mobility management, and is utilized to connect to other types of transportation. That being said, according to the statement of MMDA Chairman Danilo Lim from the article written by (Galvez, 2019), this ITS will connect cities and even other concerned agencies by providing a more efficient traffic management system that will address the traffic congestion problem and make the MMDA operations' "seamless" in the next three years.

Traffic Monitoring

Traffic monitoring takes account of the vehicular speed, type, and count. Shobana (2019), stated that vehicle classification and size that are acquired by Vision -based video monitoring

systems are some parameters for traffic monitoring. This can be done via sensor, camera or actual surveying in the site. By traffic monitoring, we can then apply any solutions to an existing problem in the vicinity through the information we have acquired. It can also provide benefits in project planning by giving the data needed in the traffic impact assessments. Having the data provided through traffic monitoring can also help us predict the traffic flow using software such as PTV Vissim, MatLab, etc.

Sensors

According to Shobana (2019), sensors can be used for traffic monitoring and information systems connected to vehicle classification are used to estimate traffic on the road. These sensors would register the data to the cloud. IoT would then help improve the control and management of the traffic system. However, we must keep in mind that each system employs a variety of technologies, sensors, and other components such as infrared sensors, radio frequency identification tags, cameras, Big Data, Zigbee, and Bluetooth, among others.

Traffic Forecasting

Intelligent transportation systems heavily depend on high quality traffic forecasts to serve better performance and the detection of traffic congestion based on internet of vehicles are gaining numerous interests for study. (Wang, et al., 2019) According to Wang, Yang, et al., (2019) Accurate and timely forecasting of passenger traffic is one part of intelligent traffic control and management. Traffic data volume in the society increases rapidly, along with the random and nonlinear systems of traffic which still is a problem of concern in the field of transportation. Incorporating the Internet of Things (IoT) will improve the accuracy and time consumption in calculating traffic forecasts. It can also improve the scheduling of traffic planning during peak hours especially in transport stations and places with large passenger traffic.

Review of Related Studies

This part of the paper is administered to published studies that are linked to this research. These are works that focus on Internet of Things, Smart Transportation, Traffic Monitoring, Sensors, and Traffic Forecasting. These previous studies provide a clearer understanding toward the subject of this thesis. Provided are correlation methods and application of the process that will serve as a viable basis for future output.

Internet of Things (IoT)

Internet of Things (IoT) is a medium utilized to be clever, wiser, and more informative everyday communication. IoT continues to rise, and some researchers are currently reviewing it. Different approaches, platforms, and applications are being presented and developed to help society. The study conducted by Murad developed utilizing the SLR methodology or systematic literature review, surveys are carried out on the concerns associated with IoT use in the development of public transportation intelligence. The proposed design offers a solution to challenges of real-life by developing powerful ideas and sharing them. The result from the study shows that up to now the IoT use has tended to prioritize safety in the prevention of road accidents but has still not discussed how intelligent transport systems can be designed to minimize congestion and reduce wasted time for passengers through the integration of bus programming, bus presence, and payment efficiency.

A comparable evolution surrounding transport may be noticed in discussions that go from sustainable to smart cities, where a change in discussions may be recognized. IoT is a new revolution that has turned conventional ways of life into a high-tech form of existence. The IoT-based difference results from smart cities, smart houses, pollution control, conserving energy, smart transport, and intelligent industries. IoT has been using smart devices and the Internet to give new solutions to those company, community, and government-industry concerns and problems worldwide. IoT gradually becomes a significant component of our lives that may be felt throughout our lives (Kumar, Tiwari, & Zymbler, 2019).

The central infrastructure of a smart city has been seen in IoT (Internet of Things). However, the IoT technology contributions regarding smart cities' administration, development, and enhancements are still not documented. Finding the importance and the essence of complex components of IoT technology in a city was also done by a poll with around 200 experts. The

survey findings show the main points and critical aspects for the success of a smart city (Park, del Pobil, & Kwon, 2018).

A study made by Kumar et al. (2017), the Internet of Things is state-of-the-art technology with a broader viewpoint on solutions to technical difficulties. IoT is an exemplary manifestation of ICT related to the specific application. There are few sensing devices with nano and micro-size electromechanical equipment in IoT, whatever the application. This assists in data collecting, and the wireless technology is used to transfer to the cloud via the Internet. In the transport and logistics business, the Internet offers several options. This includes different applications or demands of a transport system. IoT cars may be monitored about movement, position, operation, stop, or at any danger, etc. The IoT technology allows sophisticated monitoring of all these factors.

IoT (the Internet of Things) is the inter-networking model based on identified, sensed, networked, and computerized systems enabled by the technological stack to provide seamless access to intelligent services and applications between physical and digital objects. The potential of the IoT allows a variety of applications to be developed. Smart homes, smart cities, Smart Healthcare, Smart Traffic, Logistic, etc. are used for IoT-based solutions in several vertical sectors. Causevic, Colakovic, and Haskovic studied several options f or IoT logistics and supply chain management services, including tracking vehicle fleets, monitoring, control of commodities, location-based services, etc. The result of the study is that to track items and monitor them in real-time, the application requires positioning, sensing, transmission, and calculation capability. Several technologies such as sensor technology, hardware, software and cloud platforms, technology for communications, placement, power, energy storage, and security methods are necessary to provide such features. Since IoT solutions require a new technological stack, we have offered insight into potential technologies to develop the proposed solution.

Smart Transportation

According to El Dafrawy (2015), intelligent transportation is a web-based GIS routing application for industrial and logistical applications. He had said that the main idea behind the smart transportation application is that the system will consist of various elements such as vehicles, wagons, and boxes to transport goods, batteries to power the cars, operation centers to park and recharge the batteries, and distribution centers to receive orders for delivery.

Public administration and municipalities face a difficult task in managing a sustainable urban development that provides the ideal living circumstances for residents. Smart cities are now widely regarded as a successful urban strategy for increasing people's quality of life through technology in urban areas while increasing environmental quality and providing better services to citizens. Graber (2016) stated that Mobility is a crucial part of this new approach to urban development. Transportation has several adverse effects and problems on city quality of life, including pollution, traffic, and congestion.

To provide travel efficiency, GPS was created. This GPS became a key in terms of real-time transportation applications. However, one problem is that vehicle tracking data from GPS receivers are prone to measurement inaccuracies (Zhao, 2017). The assessment of GPS receiver data reliability is neglected, especially in an actual scenario and in the phase following data transfer but before information identification.

The use of intelligent transportations is significantly increasing, revolutionizing the way transportation and infrastructure operations are conducted. Xie (2018) stated that the widespread deployment of smart, connected sensors and things, combined with artificial intelligence (AI) and big data analytics, can help us gather better understanding, make real-time and even predictive machine learning, and develop better plans to improve innovative transportation safety, efficiency, and serviceability.

Transportation is not only concerned with the travel pattern of humans but also freights. Logistics takes part in the transportation system, and with that being said, numerous challenges are being experienced in this aspect. Smart transportation was a proposed answer to solve problems such as delays in the transportation of freight or cargo. Azab (2016) stated that the customers' main concerns are the selection of trucking firms, miscommunication, and a lack of information flow, whereas the primary concern is resource utilization irregularities. As a solution to that, they made a web-based prototype to illustrate the essential features and functionalities to improve communication in both B2B and B2C scenarios (B2C) that reduced the processing time in the logistic problem, improved customer satisfaction, and enhanced resource utilization in the trucking companies.

Traffic Monitoring

Urban traffic networks are often over-saturated due to rapid development in urban cities and traffic flow observation during different periods become a hotspot of studies to provide accurate measures in addressing congestion problems. Traffic monitoring is a field that is well recognized in taking part in identifying the causes and effects of road accidents, road planning and congestion (de Souza-Daw, et. al., 2016). In addition to these, road users, freight and transportation sectors depend on the roads for faster movement where traffic monitoring is a key to predict future actions.

Traffic monitoring systems oversee the collection of traffic data including flow information, vehicle density, and speed that is a significant part of the Intelligent Transportation System (ITS). Countries where most metro cities are still suffering traffic congestion problems experience travel delays, pollution issues due to emission created in traffic jams, fuel wastage, and death due to traffic related accidents. (Nagmode & Rajbhoj, 2017)

The research by Tulay, et. al (2019) supported that Traffic monitoring systems these days are operated with traditional systems that are wired and expensive and utilization of passive and signal embedded sensors can make a big difference in keeping track of traffic conditions The different systems that are adapted nowadays includes inductive loops, video -based systems, RADARs, magnetic sensors, etc. The current process in traffic monitoring is expensive and requires 24 hours of human monitoring to check the status of the roads. To solve these concerns, Nagmode & Rajbhoj (2017) stated that intelligent road traffic management systems can be done by Internet of Things (IoT) and network of wireless sensors to provide real-time traffic monitoring. IoT allows things to communicate with each other without the need of human control in collecting, storing, and interpreting the data they collect. It is also the latest approach in ITS that rapidly captures wireless technology application and telecommunication.

Traffic congestion became increasingly serious and traffic violations increased each day affecting the economic and social development of the affected place. The existing systems in monitoring traffic are widely applied worldwide and are usually through inductive coil sensors layer on the road to collect data and so on. (Hong, 2019)

Traffic Forecasting

Data services and on-demand suggestions are increasingly becoming more essential in mobile life as the number of mobile users and applications grows. Shao, et al (2016) proposed a prediction technique of user traffic density and personal interest based on real-time mobile traffic data and wireless location information which is based on the wireless personal communication network. To assure quality and push service, the service provider might deliver specific information to target consumers based on the forecast. Then run a simulation with real traffic data from a network service provider surrounding Tsinghua University to see how accurate the forecast is. The simulation results show that integrating traffic data and position combination, may considerably enhance the rate of effective suggestion.

Pengzhi, et al. (2009) conducted a thorough research of important technologies such as the use of wireless sensor networks in traffic monitoring networks, traffic flow forecasting using a gray forecasting model, and traffic congestion control. The researchers present a scheme that uses wireless sensor networks to monitor city transport vehicles and have designed a traffic monitoring system based on wireless sensor networks that is applicable to all types of city environments, based on the features that wireless sensor networks have no space constraints, flexible distribution, mobile convenience, and quick reaction. Researchers may use the system to track major routes that are frequently blocked, determine the time-varying law of traffic congestion, and then focus on monitoring them to drastically decrease investment and achieve high efficiency. The researchers utilize the Adaptive GM (1, 1) Model for traffic flow forecasting, which features a real-time rolling prediction for city traffic and produces improved forecast results. The researchers developed Traffic Random Early Detection (TRED), a traffic flow congestion management and scheduling algorithm for traffic networks, based on a mature congestion control method for computer networks. It was utilized for real-time traffic scheduling by the researchers, and it has opened a new approach to analyze and solve traffic congestion control issues.

Boonsrimuang et al. (2007) presents a study about Traffic Forecasting and Navigation Assistance System through Web Application that offers drivers with route planning advice information. The Traffic Forecasting and Navigation Assistance System (TFNAS) is made up of a survey car with a GPS module that reads traffic data and sends it to the TFNAS Center over the internet. The GPS database and traffic information processing system are both located in the TFNAS Center. It collects real-time GPS data, assesses traffic density, and delivers guidance

information for the most efficient route with the shortest arrival time to Front-end Devices, such as SmartPhones, PDAs, and Laptops, through Web Browser.

Everything that might impact the flow of traffic on the road is considered part of the traffic environment, including traffic signals, accidents, rallies, and even road repairs that can produce traffic congestion. A motorist or rider can make a sensible decision if they have previous information that is very close to approximation about all the mentioned issues above and many more everyday life events that might impact traffic. It also aids the development of driverless cars in the future. Traffic data has grown tremendously in recent decades, and we've progressed to big data ideas in transportation. This fact urged the researchers to pursue a solution to the traffic flow forecasting problem based on traffic data and models. Because the amount of data available for the transportation system is enormous, properly forecasting traffic flow is difficult. The researchers planned to utilize machine learning, genetic, soft computing, and deep learning techniques to analyze huge data for the transportation system with a lot less complexity in this project. In addition, Image Processing techniques are used in traffic sign identification, which aids in autonomous vehicle training. The proposed algorithm not only outperforms current algorithms in terms of accuracy, but it also enhances the dataset's complexity. The researchers also intend to connect the web server and the application. Also, the algorithms will be upgraded to achieve a considerably better level of accuracy. (Mahrishi, et al., 2020)

The Internet of Things (IoT) is a network of interconnected devices, such as sensors and smart gadgets, that have processing, sensing, and communication capabilities that can communicate with one other and a central console through the Internet. Any data network's operational and management functions rely heavily on network traffic prediction. For IoT networks to offer dependable connectivity, network traffic prediction is also more important. Traffic prediction has been successfully implemented using an artificial neural network (ANN). In the study of Koucheryavy, et al. (2019), they use Time Series NARX Feedback Neural Networks to forecast IoT traffic time series using a multistep ahead prediction method. The performance functions MSE, SSE, and MAE have been used to assess the estimated error of a prediction technique, as well as another measure of prediction accuracy, the mean absolute percent of error (MAPE).

Sensors

Smart traffic control and car theft detection solution includes inputs to a range of devices including Light Detection and Ranging (LIDAR), Passive Infrared Scope (PIR), 360 camera devices, pinhole and laser sensors, and other devices. In the proposed system, all devices are working together to identify inadequate parking and monitor the parking situation by imposing a penalty on a driver of the car shortly. The identification and unintentional state of the car also aids the authorities by very rapidly studying the recorded data. (Umare et. al., 2019)

Safety and congestion are two things that have led industrialized countries to embrace intelligent systems of transport (ITS). The highly difficult patterns of traffic and infrastructural lacks, which prevent these systems from applying successfully in Southeast Asian countries like Vietnam. The first is that motorbikes are the main vehicles for Southeast Asian countries instead of passenger automobiles by far. Furthermore, the condition of roads differs considerably from place to place. This leads to numerous difficulties of transport, including congestion and accidents. The suggested system includes a collection of sensors including a temperature sensor, moisture sensor, GPS receiver and two motorbike mounted catadioptric cameras. The two catadioptric cameras capture a 360° street view that looks at the environment. A unique reverse mapping approach allows spherical panoramic pictures to be flattered without creating blank pixel areas. All sensor and video information are used in Vietnam to identify dangers and model road users. The data aims to promote driver awareness through education and route planning to boost road safety research on rider interactions. (Souza-Daw et al., 2016)

The system of traffic management is regarded as one of the main aspects of a smart city. Traffic congestion is commonly visible on roadways with the fast expansion of population and urban mobility in cities. A smart traffic management system using the Internet of Things (IoT) is suggested to address numerous difficulties for controlling transport on roadways and to support authorities in effective planning. To improve traffic flow on roadways a mix of centralized and decentralized approach is utilized, and an algorithm is created to effectively manage different traffic circumstances. The system uses cameras and sensors to regulate the traffic signaling density. The traffic density is predicted by another Artificial Intelligence program to help reduce traffic congestion in the future. Furthermore, during traffic congestion RFIDs are also utilized to prioritize urgent vehicles such as ambulances and fire brigades. Smoke sensors are also part of this system for detecting this circumstance in the event of fire on the road. (Javaid et al., 2018)

The present traffic system is not dependent on the traffic density in many locations, and each route is given a predetermined period. This causes traffic congestion related to huge red-light delays and road scheduling in a city that must fluctuate but in fact not during peak hours. These old methods are not flexible and can no longer sustain traffic in unforeseen circumstances or in an accident and are hence inefficient. Different sensors with their virtues and demerits can be utilized to calculate the density of the traffic. Ultrasound Sensors are utilized together with image processing, which operates on a system in Raspberry Pi calculating the driver density and allotting time to various traffic levels dynamically. This in turn helps to improve signal control and efficient traffic management, therefore lowering the likelihood of a collision. Real-time data may be gathered, saved and controlled on a cloud utilizing Internet of Things (IoT). These data may be utilized to understand any failure of the sensing equipment as well as to evaluate the signal duration case for further research. (Naga et al., 2018)

Currently, traffic jams have recognized urban life as a major concern. Suffering from increasing cars has passed a tolerance limit through bad infrastructure, especially slow traffic management. To improve the functioning of the fixed traffic system, Rahaman e t al. presented a new approach based on a smart sensor network. The suggested traffic control system is utilized to provide cars with radio frequency identification technology (RFID) and low power wide area network (LoPWAN), Wireless Sensor Network (WSN), low-area network (LAN) etc. Experimental findings reveal that in vehicles, when vehicle counting is flawless up to a speed of about 12500m/s, the suggested method has 98.26% accuracy. In comparison to the Integrated Virtual Collaborative Conferencing System (iVCCS), which cost $11.83 per node, the suggested solution is cost-effective. The entire system will be thoroughly disciplined and systemically managed via the Internet of Things (IoT).

Synthesis and Justification

Understanding and controlling the movement of traffic, not only vehicles but also people is one of the most important areas in the field of civil engineering, especially in the transportation sector. Today, transportation is a significant factor in the economy of a country, alongside logistics and transportation management. The analysis of transportation operation, according to studies and literature, is one of the key parts of having a stable economy. The speed in mobility directly impacts the abundance in the economy. The keywords that were chosen in this paper are linked in

transportation engineering, which are the specialization of the researcher. The keywords are identified as Keywords: Internet of Things (IoT), Smart Transportation, Traffic Forecasting, Traffic Monitoring, and Sensors. Related Studies and literature are compiled and reviewed to relate to current studies based on the mentioned keywords. Most of the references are conducted outside the Philippines, and it all focuses on managing traffic congestion specifically in urban areas where high volume of vehicles and commuters are experienced. The general belief is that the Internet of Things (IoT) can be a breakthrough in the field of transportation when it comes to traffic management. The ease and speed of this emerging technology can bring a solution to the problems that cause transportation related problems.

This study is important because it presents data that can be used in future studies to provide a faster and efficient mode of transportation in the Country. Although recent research is relevant and provides more of the precedent of the current study, this paper focuses on the Philippines, especially in BGC, Makati. It will provide local study and analysis to the change IoT may bring in terms of the public transportation system and how it links to managing traffic congestion.

Theoretical Framework

The research enables further understanding of traffic congestion and the factors that contribute to it such as traffic flow, number of travelers, number of vehicles and time of travel. This subject widely relates to traffic monitoring and planning, which is significant in addressing the saturation problem in the road. The analysis and traffic simulation using Internet of Things that will be provided by this study is in line with the purpose of reducing the problems in traffic congestion.

The paper will be useful for future references when considering the use of IoT in transportation especially in traffic monitoring in urban areas. This would be relevant since the research is aligned with transportation engineering that will satisfy the objection of smart and sustainable transportation. Traffic simulation and forecasting will be provided in this study that may serve as future basis and improvement and development. Recommendations and representation will be provided for future ventures. Since these ventures in the emerging technology require specific work, the researcher is probably going to engage with future projects on their specializations.

Thesis adviser Approval:

ENGR. GEOFFREY CUETO

Name and Signature

ENGR. ERICSON D. DIMAUNAHAN

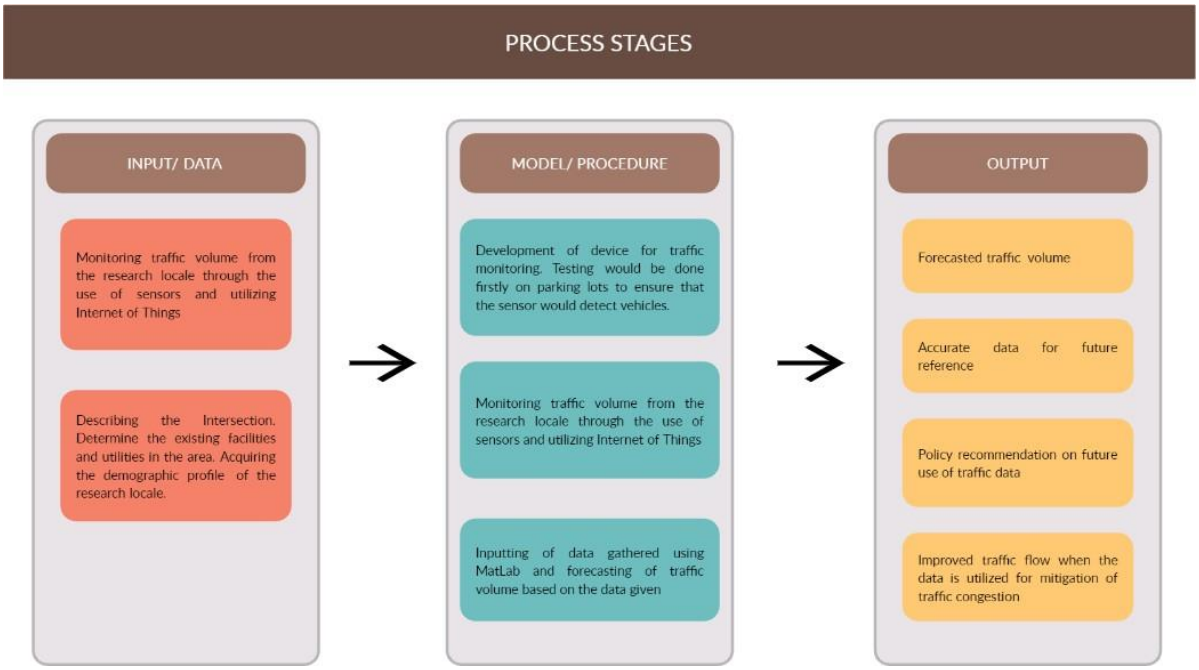
Name and Signature

CHAPTER 3

Methodology

In this part the researchers describe the techniques done for the study such as data collecting, assembling of the necessary equipment for data gathering, analyzation of data, and interpreting. This section of the study would improve the manner in making the research be described in detail by describing each progression done to complete the research. This part would also help the readers to be enlightened on what materials and data gathering procedures were used.

Conceptual Framework



PHASE 1: INPUT/ DATA

This phase explains how to choose the parts that affect the issue and the variables that will be included in the review that will be created later. This first stage will include reviewing related studies and literature, analyzing papers, and acquiring necessary information from articles, journals, and manuals. We also determine what are the potential factors that cause congestion in the area by determining the facilities and demographic profile in the area as well as the necessary information in the road itself. This stage is divided into two sections, each of which describes each

action and analysis performed in-order to understand the topics at hand. The output of this phase will be used to create the model and process that will be later be used in the second phase.

Step 1: Collecting relevant data to define Internet of Things, Smart Transportation, Traffic Monitoring, Traffic Forecasting, and Sensors and analyzation of its relation to one another

This step includes all the related readings, written works, and reviews of major papers that are relevant and can help us understand and analyze other data for the next step. A portion of the articles and data that have previously appeared and been used can be re-read and kept for the information necessary for this phase. Most of these papers will be gathered from reliable sources on the internet. Articles, journals, and manuals may contain relevant information that can aid study. Other documents that may exist and be discovered by the researcher will also be included if they are significant to the study's results. The technique and data collection will take place in the researcher's home, with the help of Mapua E-Libraries and Scopus. Other materials can be found on reliable and legitimate websites on the internet. The approach to be used in this phase is online research.

Step 2: Describing the Road. Determine the existing facilities and utilities in the area. Acquiring the demographic profile of the research locale.

The chosen research locale for the study is along 32nd street, Bonifacio Global City, Taguig, Metro Manila, Philippines. The road where the congestion is observed would be observed and be given description. Knowing the factors that might affect the traffic congestion in the area is critical for the study. Existing facilities such as store boutiques, quick service restaurants, grocery stores, hospitals, and other facilities or buildings must be considered since this may be one of the factors that triggers the congestion in the area. Other factors such as the demographic profile of the area must also be considered. Having the knowledge of the area would make the

study easier and understandable for the researchers to know what are the factors that contribute to the congestion.

Figure 1: 32nd Street, Bonifacio Global City

Figure 2: 5th Avenue, Bonifacio Global City

Figure 3: Intersection of 32nd Street and 5th Avenue at BGC

PHASE 2: MODEL/ PROCEDURE

In phase 2, the device that would be used by the researchers to monitor traffic would be created. The model would also be generated based on the gathered resources. Observation and monitoring of traffic would be done as well to get the necessary data for the forecasting. Once data is acquired, forecasting of traffic volume would be done using the software MatLab.

Step 3: Development of devices for traffic monitoring. Testing would be done firstly on parking lots to ensure that the sensor would detect vehicles.

In monitoring the traffic, the device must be firstly completed and made. The device that would be used would be assembled by the researchers. The tool specification for the device that would be used in the study are as follows: Camera, Predator Helios 300 Laptop, and Raspberry Pi 1. To test if the device is working once assembled, it would be tested in a parking lot where vehicles are stationary. Once the device is found working, it would be then tested in a busy street this time to see if it can detect multiple moving vehicles at once.

Step 4: Monitoring traffic volume from the research locale through the use of sensors and utilizing Internet of Things.

Once the device for monitoring the traffic is completed, it would be then deployed in the research locale, along 32nd street, Bonifacio Global City, Taguig, Metro Manila, Philippines.

Monitoring of traffic would be done from Sunday to Monday around 3 to 5:00 pm. The observation period would be done for 2 weeks to ensure that the data gathered would be enough for the forecasting. The data gathered during the monitoring would be stored in the cloud and be then used for the traffic forecasting.

Step 5: Inputting of data gathered using MatLab and forecasting of traffic volume based on the data given.

Once the data gathering procedure is already completed, the necessary data would then be put in MatLab to be coded for traffic volume forecasting. MatLab would be used as software for the research as it is one of the available software the researchers have and is compatible with the raspberry pi. Evaluation of the data would be done in this step as well.

PHASE 3: OUTPUT

The last phase would illustrate the result from the gathered data. Results would be checked again by the researchers to ensure the accuracy of the traffic forecasting. Evaluation of results would be done in this phase as well. The results would also be interpreted by the researchers in this phase to be explained further and make it clearer to the readers.

Step 6: Forecasted traffic volume

This would be the result of the traffic forecasting done using MatLab software. The forecasted traffic would be checked for its accuracy and credibility. The results would be then compared by real time comparison or manual counting for proofing of accuracy.

Step 7: Accurate data for future reference

Once the accuracy of the data and forecasted result is confirmed, the research can provide a reference for future reference for other researchers. The accurate data produced would serve as the data for creating mitigating measures that will reduce traffic flow.

Step 8: Policy recommendations on future use of traffic data

With the use of the data produced, the researchers can provide a general mitigating measure to address the present issue in the research locale. The results produced would provide a guide and provide information in-order to do so.

Step 9: Improved traffic flow when data is utilized for mitigation of traffic congestion.

The forecasted data can be used by other researchers as a basis or reference in their study. The location where the research is conducted can contact the researchers to provide the forecasted

data in-order to make improvements in the research locale. Since the conducted study would yield accurate data and can be used, it can also be deployed in other areas where traffic congestion is a problem.

Research Design

This paper will use a quantitative research approach, in which the researchers will conduct an observation intended to provide an appropriate framework for this study. The researcher aims to measure the volume of vehicles passing along 32nd street, Bonifacio Global City, Taguig, Metro Manila, Philippines between 3:00 pm to 5:00 every day for two weeks. The entire procedure will be done using a camera device pointed along the road for vehicle counting. The numbers and scales will help the researchers identify the time and day when vehicle volume on the specific place is highly saturated. Data gathered will then help the researcher forecast the future weekly flow of vehicles and traffic of the place. The major objective for conducting a quantitative study is to acquire consistent and reliable information by evaluating the numerical values, which will help researchers find a faster way of forecasting traffic to avoid congestion. A faster way of computing and data gathering will be done with the help of the Internet of Things.

Research Setting

The study will take place at Bonifacio Global City. Many individuals recognize Bonifacio Global City (BGC) to be a high-end and wealthy district. There are seven major access points at BGC which are: access from the North and West through Kalayaan Avenue which connects it to the North Gate and the Kalayaan Flyover, access from Taguig in the West via EDSA through McKinley Road and to the McKinley Gate; the three main entrances (Upper East Gate, Sampaguita Gate, and Lower East Gate) from C-5 highway in the East; and from the airport through the Villamor Airbase to the South Gate by Fifth Avenue and Lawton Avenue. The study will be conducted near the North Gate of BGC specifically along 32nd Street.

Figure 6: Google Earth View of 32nd street, Bonifacio Global City

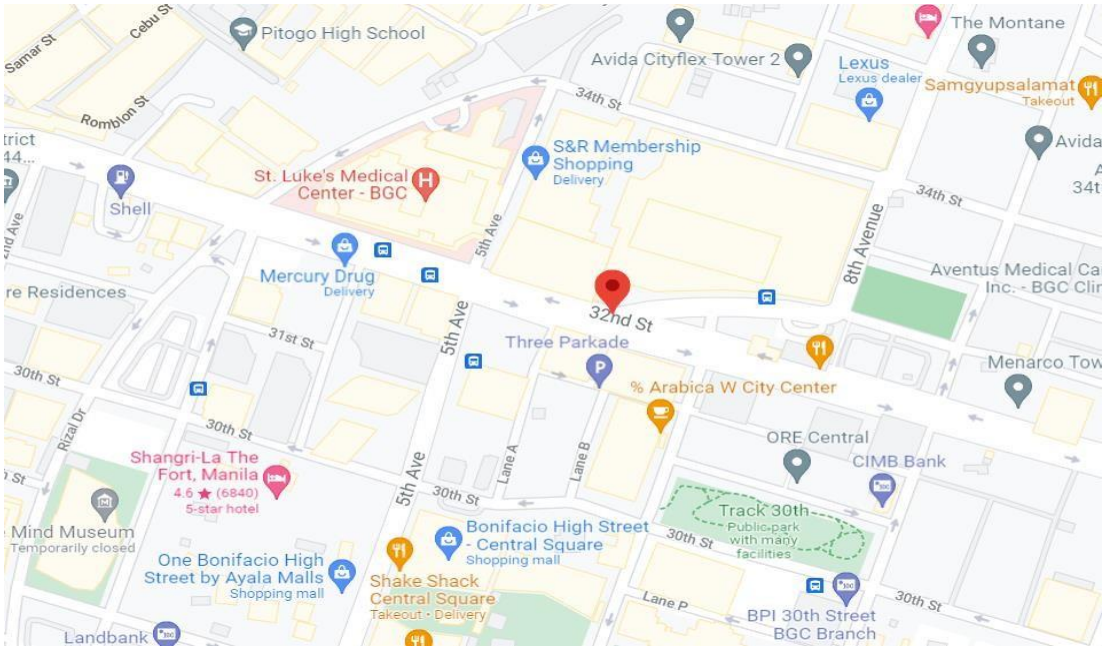
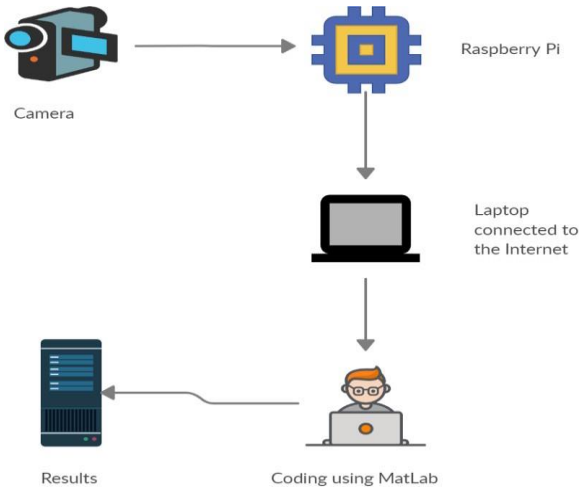


Figure 7: Good Street View of 32nd street, Bonifacio Global City

The researchers concentrated on the key background and objectives of the study. The research focuses on the development and use of the Internet of Things to the transportation industry, specifically on traffic management through traffic flow forecasting. The Internet of Things (IoT) is a network of physical objects that are connected and exchange data with other devices and systems over the internet using sensors, software, and other technologies.

Data Gathering Procedure

The procedure for gathering all the information required is partitioned into three stages which are as per the following: gathering and inputting of data, modeling the instrument to be used in the gathering of information, and lastly the evaluation of the data gathered to create a traffic forecast in the specific place of conduct. In this part, the number of vehicles that have been gathered over two weeks of monitoring will be used to forecast the future flow of traffic in the specified place. The accuracy of evaluation will be tested after two weeks prior to the date of data gathering. Majority of the data that will be collected on site, from vehicles passing along 32nd street, Bonifacio Global City, Taguig, Metro Manila, Philippines for two consecutive weeks between 3:00 pm to 5:00 pm from Monday to Sunday. There will be no respondents needed in this study since it will use the number of vehicles passing through the place of study at a certain period. After gathering all the data needed in traffic forecasting, the researchers will tally and evaluate the results by applying the statistical statement that they will be using in this study.



Data Gathering Instruments

For the purpose of this paper, the data collection method that will be used is observation through the use of a camera which aims to observe and count the ongoing number of cars at a specific place and time on a highway surrounding. The main advantage of using a camera for observation is that it provides a faster and easier way to record and visualize the scenario and provides detailed information about the natural flow of the vehicles. The collected data through video recordings will be analyzed using a qualitative approach because the numbers of vehicles that will be observed will be coded to numerical data. By then, the researcher will be able to collect all the necessary data when it comes to traffic forecasting among the selected roads in Bonifacio Global City, Taguig, Metro Manila, Philippines. The researchers drafted the codes and algorithms based on the resources gathered from the Review of Related Studies and the Review of Related Literatures. The criteria in choosing the best algorithm that is applicable and manageable were considered during the research. Lastly, the procedure and instruments that will be used are validated beforehand with engineers and consultants prior to being used in the gathering, analysis, and interpretation of the data.

Statistical Treatment for Data

The statistical treatment in the study will be based on the quantitative observation done by automatic counting using video camera and raspberry pi. Algorithms will be used for counting the volume of vehicles going along a specific road and time. The data that will be gathered will validate the researchers' study. The phases of data gathering are as follows:

The computation for Average Daily Traffic (ADT) for the specific time of the research study will be as follows:

$$ADT = \frac{1}{n} \sum_{i=1}^{n} VOL_i$$

Where:

VOL_i = Vehicle volume in the specific time of day

n=number of days/weeks

The conduct of the study will be done between 3:00 pm to 5:00 every day for two weeks, when vehicle peak hours will be expected. The researcher will consider Peak-Hour Factor (PHF) in forecasting the future traffic flow along 32nd Street in BGC. PHF is the ratio of the volume occurring during the peak hour to a maximum rate of flow during a given period within the peak hour. Fifteen (15) minutes of period flow is used for maximum rate of flow.

$$PHF = \frac{HV}{(\frac{60}{15}) V_{15}}$$

Where:

PHF= Hourly Volume

V_{15}=Maximum 15-minute volume within the hour

Thesis adviser Approval:

ENGR. GEOFFREY CUETO

Name and Signature

ENGR. ERICSON D. DIMAUNAHAN

Name and Signature