Program: Smart Cities: Livable Philippines

College of Engineering, Adamson University

Executive Summary

Smart Cities: Livable Philippines is a program dedicated to the development of urbanized communities here in the Philippines. As a start, the City of Dasmariñas wash chosen to be the implementation site to help its increasing economic growth in terms of developing its traffic flow infrastructure through technological solutions. The program is composed of three (3) major projects, each tackling different areas of traffic congestion and to ensure the well-being of the population. The projects are

1. SmarT LiSA (Smart Traffic Lights System with Analytics) that aims to improve traffic lights systems which are static in nature that caused large delay times in the traffic flow. It would enable smooth traffic flow by allowing the roads with higher traffic density to give first priority. The first priority will also be given to emergency vehicles so that why can experience smooth traffic not impeded by the traffic lights.

2. TaNuod: Traffic Analytics Intelligent Urban Surveillance System - This project pertains to an intelligent urban surveillance system aiming to solve high traffic volumes and increased crimes in the City of Dasmariñas, specifically consisting of Artificial Intelligence-based subsystems.

3. Smart MAIA (Monitoring of Air Quality using IoT and Analytics) -This project is based on the IoT and cloud computing technology and will be primarily aimed at monitoring the air quality to help in developing plans for pollution control.

General Objectives

The general objective of this program is to develop smart and innovative solutions to traffic problems and promote the well-being of the citizens in urbanized cities. The projects aim to integrate the use of technology to be able to solve these problems.

Specific Objectives

In terms of addressing the issue of traffic and the promotion of the citizen's well-being the following objectives are:

1. To develop a smart traffic light system that would help alleviate the traffic congestion problems in areas experiencing heavy traffic, such as intersections.

2. To develop an intelligent urban surveillance system aiming to solve high traffic volumes and increasing crime rates

3. To develop a smart air quality monitoring system that would help in minimizing the air pollution on urbanized cities.

Rationale/Significance

The City of Dasmariñas in Cavite is at the forefront of leading other cities to be "smart." It is known to be the "University Capital of Cavite", and is one of the most competitive cities in the country in terms of economic growth. However, as the economy rises, there are some challenges that need to overcome. The result of a rising economy is a rise in population, and as the population increases come traffic congestion, public safety, and pollution. These problems could hamper the growth of the city. Traffic congestion has cost the economy quite heavily in terms of the movement of goods and delivery of services, increased vehicle operating costs, and otherwise productive man-hours consumed as travel time. The negative impacts of traffic congestion on public health and the environment can be quantified and translated to economic costs in the long run. With the partnership of the local government unit of Dasmariñas, the proponents want to help this city to be able to solve these problems so that they could continue to grow and prosper.

The researchers want to tackle the problem of traffic congestion and the citizen's well-being. This is also aligned with the UN Sustainable Development Goals which are to ensure healthy lives and promote well being (3), and make cities and human settlement inclusive, safe, resilient, and sustainable (11). The researcher would want to incorporate advanced technology to make this possible. There are many ways to advance the city and make it "Smart" to support and help its citizens.

Methodology

Over the course of the program, the four projects will be developed simultaneously. The general methodology for this project includes 4 main parts, Design, Prototype Development, Analysis, and Full-Deployment.

1. Design - In this stage, the researchers are involved in research and planning. Relatedlitereatures are needed to be examined to know the best practices and what has been done in the past. From this, the researchers would plan the final design criteria of the project. Tools such as hardware and software are also identified in this stage. This would produce a well-designed system that is innovative and targets the set objectives.

2. Prototype development - After formulating the final design, the researchers are now ready to implement it. The implementation process is a cycle of creating, testing, and analyzing. The created initial prototype needs to be tested first in terms of its function. Then there is a need to analyze the test results to know if there are any problems in the prototype development or any design improvements. These steps are repeated until the prototype matches the desired design parameters.

3. Analysis - Analysis here include simulation of the prototype, this could be done first in the laboratory before deploying in the actual site. Analysis of the whole system behavior through a set of defined parameter changes is to be examined. At this point, the researchers expect that it would work smoothly in the simulation, if not this would help them prepare some interventions when being deployed to its intended environment.

4. Full-deployment - Installation of the final prototype is performed in this stage. The full system is expected to be running smoothly. If there are any complications, re-adjustments shall be made. Also, maintenance will be taught to personnel who will operate and troubleshoot the system after the turn-over. It is expected that a full operational system is the output of this stage.

Project #1: SmarT LiSA
(Smart Traffic Light System with Analytics)

Project Description

The Smart Traffic Light System with Analytics (SmarT LiSA) is an advanced traffic light systems where the decision of stop, ready and go is base from the traffic density data it processed. The process includes recording and analyzing past and present data, and gives out right decision to alleviate traffic congestion. The systems includes a network of near-by traffic lights that makes the system aware of what are the traffic situations on nearby roads. This enables the system make important decisions on prioritizing the most congested roads. Also, the on-road sensors gives out accurate information about traffic density which is critical in decision making. In this type of system, there would be an ease in traffic congestion that is caused by waiting for a traffic light. Also, due to the control of near-by traffic lights, their operations will be in-sync with each other, making it possible for emergency vehicles will be given priority and experience smooth traffic.

Significance

Within one of the priority area of the United Nations Sustainable Develop Goals 11 – Sustainable Cities and Communities, this research will tackle about the importance of human mobility. Philippines, has been identified to be one with the worst traffic problems. The problem arises not only in Metro Manila, but in other urbanized cities as well. The source of the problem can branch out to many different areas like, poor traffic rules and regulation, poor road infrastructure, lack of road traffic awareness among drivers, commuters, and pedestrians, and so on. The project wants to deal specifically with the poor road infrastructure, especially on roads were traffic lights are so close to each other and not in-sync. Traffic becomes heavy in those areas especially in intersection. In this type of conventional traffic lights, the waiting time piles more and more, when they are not in sync. Thus, optimization of this traffic lights are needed to develop. Traffic lights should not be static but dynamic and can adapt to traffic density changes.

RRL

The transportation systems in smart cities aim to make public transportation enticing than private cars and decongest traffic flows [2]. To develop public transport, additional infrastructures are deployed by some cities, like road widening, additional trains, and bus stations. The challenging problem is how to decongest traffic in cities, especially on large intersections, where thousands of cars pass by every day. One solution to this problem is the optimization of traffic lights.

Traffic lights are responsible for traffic flow inroads. They play a vital role in controlling traffic especially in intersections and increasing road safety not just for the cars but for pedestrians crossing the streets. With this, we could look at how traffic lights are being controlled, they can be fixed-time controlled or dynamic control. For the fixed time they are the conventional type of traffic lights where a fixed time was set when changing between the lights, and dynamic controls employ a sensor to adapt to traffic conditions [3]. Dynamic traffic lights are currently used in smart cities, and many studies have been conducted to make them smarter and reliable. A study by Kafi et.al. [4] surveys traffic light system with a wireless sensor network to adjust the time duration of changing lights depending on traffic information being given by the on-road sensors or on-vehicle sensors. Another study by Srivastava et.al. [5] also uses a wireless sensor network for data collection and made a simulation for real-life traffic scenarios. These two studies made

the dynamic traffic light smarter in a sense of data collection from sensors. Another study by Younis et.al. [6] used the concept of cyber-physical systems to develop algorithms to be used in real-life systems. It also uses on-road sensors to gather data and then use those data for traffic light decisions. These systems made the conventional traffic light smarter, however, the lack of autonomous control on communication among traffic lights is lacking.

General Objective

The project aims to develop a dynamic traffic light system that uses on-road sensors to detect traffic density and inputs from other nearby traffic lights to create priority roads to decongest on heavy traffic areas.

Specific Objectives

1. To develop on-road sensor nodes capable of detecting the number of cars in a specific area and reports back the data read wirelessly to a central processing unit

2. To develop a wireless network of traffic lights that is able to exchange information with each other.

3. To develop an algorithm that would utilize past and present data from sensors and input from nearby traffic lights to create a decision priority

Methodology

The researcher will take the following steps in developing the project:

1. Data gathering form actual traffic flow.

The researcher will gather traffic flow data from areas identified that experience heavy traffic and with traffic lights that are installed close to each other. This can be performed by developing and installing sensor modules to the concerned areas then record their readings. The sensor will measure the average waiting time and traffic density in terms of the number of cars per area.

2. Creating the traffic simulation environment

From the data gathered, a traffic simulation environment will be created. The simulation environment has real-life parameters that can be extracted from the collected data. The simulated environment is the virtual representation of the areas identified.

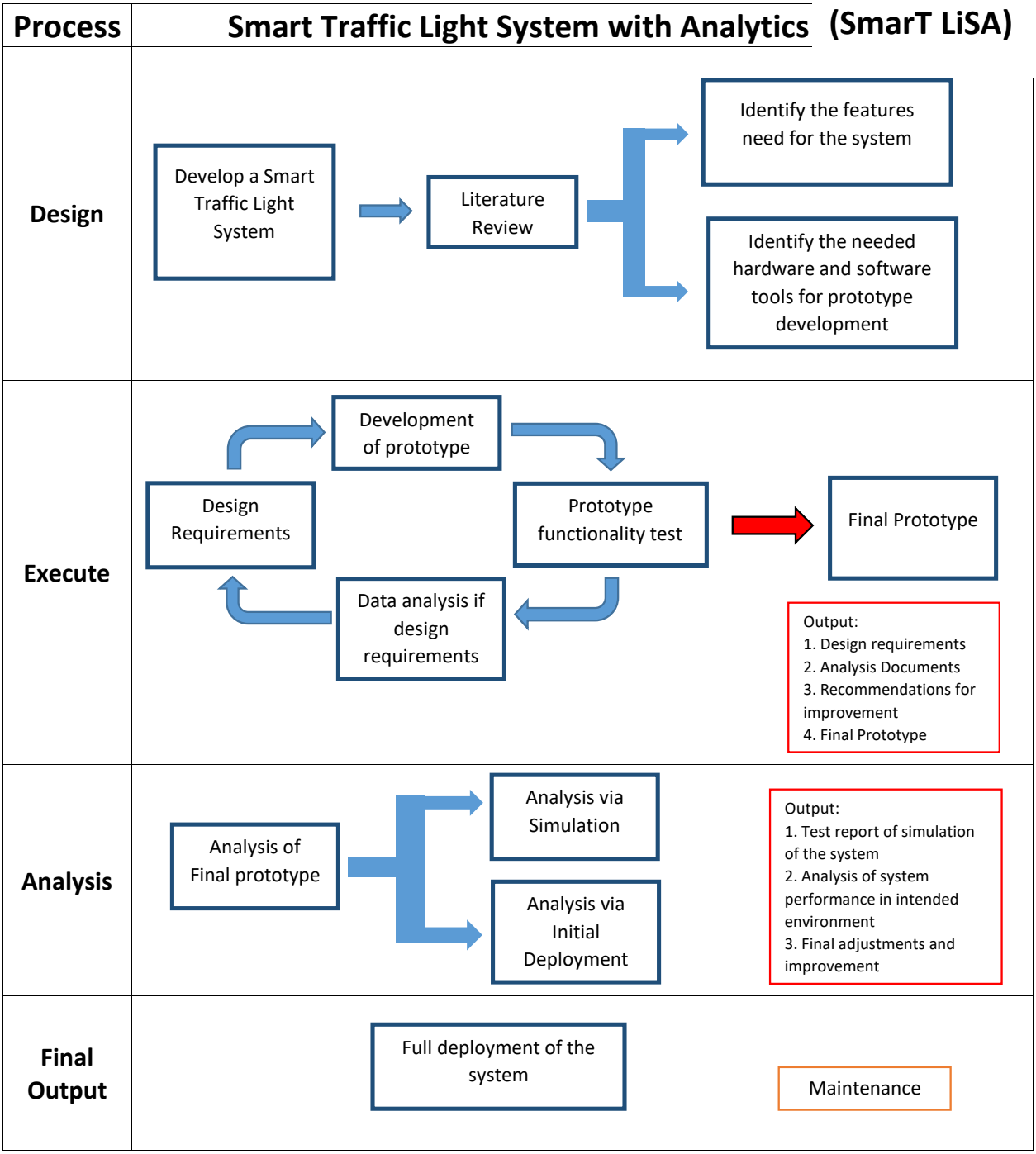
3. Developing the decision algorithm

When the simulated environment is ready, the researcher will develop the decision algorithm and apply it in the simulated environment. This process would take a lot of readings from prior literature and books related to traffic flow study and machine learning. The goal of the developed algorithm is to decrease traffic congestion through its learning capability by controlling the traffic lights.

4. Evaluation and application to the physical system

If the developed algorithm shows a good result in the simulation through various evaluation methods, it can now be applied to the real physical traffic light system. This will also undergo analysis and evaluation.

Theoretical Framework



The development of the system starts with a more in-depth literature review to know best practices and needed improvement of past works. This would give the researchers ideas on what are the features needed based on the set objectives. Also, at this step, a preliminary design can be sketched so that hardware and

software tools can also be identified. After this, the essential parts of the development are complete, it is now ready for execution. The prototype will now be developed based on the set design requirements, this process is a continuous process of creation, testing and analysis until the desired outcome is met. The researchers would use the identified hardware and software tools to create the prototype, then it is needed to test its functionality if it behaves as it was intended to. Analysis of the test may say if there are things to improve or it is ready for deployment. The output of this process is the final prototype that has met all the design requirements. At this point the prototype has only undergone functionality tests in the lab, it requires to be tested on its intended environment. Simulation can be used in this step so that any minute adjustments can be done before deploying to the real world. In this step, software tool and data gathering techniques are to be used to full simulate the intended environment. When everything goes smoothly in the simulation, it can now be ready to be deployed in the physical world. The system still needs to be assessed if the target objectives have been met and adjustments or improvement can be applied until the whole system is ready for a full deployment. Lastly, maintenance is needed for the system, even if the system is fully automated, in time mishaps can occur. Training of the right people to maintain and troubleshooting the system is needed so that the system would continue to work.

Proposed measures to address possible implementation issues and gaps

In the initial deployment of the system, few adjustment and improvement are expected to be seen, even if the system behaves perfectly in the simulation. This is to be expected because there are factors that the researchers cannot control. Hence, in the time of initial deployment, analysis of the system should be implemented. This will give the researchers ample time to adjust some functions to fit in the physical environment. Also, simulation even if not perfect, can help predict the problems that will arise form physical deployment. This would help plan and formulate possible actions to prevent and solve those problems.

Outputs

Publication

The researchers expected at least 2 conference paper submission and 1 journal publication for this project. The conference papers to be submitted would be about the development of the on-road sensors, and the traffic light network. The final journal paper would be about the whole system implementation.

Patent/IP

The system and the devices developed is expected to be patented. The researchers have done its literature review to add novelty in this project. The novelty would at least make this project a utility model or if there is an inventive step developed during the study then this could be a fully patented technology.

Product

Expected products to this project are the on-road sensors and the traffic light system. If ever successful on its initial implementation at Dasmariñas, Cavite, then other cities might adapt this project and its products.

People Service

Even though the SmarT LiSA is fully automated, maintenance and troubleshooting are needed. Hence, training of personnel to operate, maintain and troubleshoot the system would be given to those people who are willing to earn and be of service to the community.

Place and Partnership

The study is targeted to be implemented on one of the "Belt of Cities" of Region IVA, which is the Dasmariñas City. With their initiatives to go modern and smart, the project would be a great help towards that goal. Also, local industries are expected to gain in this project. We plan on asking for support for supplies and materials if ever needed to the development of the project.

Policy

In terms of policy, the project visualize the future where every traffic light system are dynamic and not static. We hope that some policies can be drafted so that this would come to fruition.

Potential Outcomes

Here are some potential outcomes of this project

1. Alleviation of traffic congestion caused by traffic lights when there are heavy traffic on the road.

2. Ease of flow or traffic when there are traffic light that are close to each other.

3. Emergency vehicles are not perturbed by traffic lights and can experience smooth traffic flow.

Potential Impacts

Social Impact

Study shows that traffic lights can cause traffic. Due being static with fixed amount of time to stop and go, are frustration of motorist on. Also in the Philippines, because of poor urban planning, every intersection has traffic lights causing a funnel within a funnel of heavy traffic. Heavy traffic causes the nation to lose millions of peso. As this project suggest, when traffic lights became smart and dynamic, this problem could be alleviated. When traffic congestion decreases, the public would welcome public transportation which means less number of private vehicles on roads. This will lead to lesser number of cars on the road and eventually lesser to no congestions.

Economic Impact

Traffic problems cause a large economic impact via loss of millions of Pesos. The main culprit is the time wasted on the road than being productive somewhere else. This is the economic impact this project wants to reduce. With the project targeting the poor traffic infrastructure of traffic lights, the traffic congestion will decrease, thus saving time on the road. This domino effect will lead to boost in the economy of the city.

Target Beneficiaries

These are the target beneficiaries:

1. Motorists/Commuters – by alleviating traffic congestion, they are the people whole would greatly benefit in this project. They will decrease their time spent on roads due to traffic and use that saved time on more productive ways.

2. The community – with lesser traffic congestions, the community can go wherever they want in a lesser amount of time. This would bring the community to engage with each other more and create new opportunities. Also, the project would create jobs to help operate, maintain and troubleshoot the system.

3. The city – the project will help the city in terms of traffic problems and a boost in the economy. The city will be a template on how technology can solve this problem and bring tangible positive results to the city.

Sustainability Plan

After the full deployment of the project, the researchers would like to turn over the operation, maintenance and troubleshooting to the local government unit. The researchers will help to train the right people to be able to help in sustaining the project.

Limitations of the Project

The project is limited to the following:

1. The project will not cover an entire city for the full deployment, it is limited 3-4 traffic lights in one major road.

2. The project will control only the stop, wait, and go of the traffic lights and nothing else.

3. The project will not cover to fully solve the traffic problem.

List of Risks and Assumptions

Some of the risks are:

1. Some of the hardware needed are not available in the Philippines and needed time to procure overseas.

2. There might be difficulty in installation and possible theft.

3. There would be some events in the government that would delay the full deployment of the project.

Some assumptions are:

1. The prototype development will be developed on time and all of the hardware needed are not faulty and working 100%.

2. The devices were installed properly.

3. The government prioritizes the project for installation and deployment.

References

References

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Project #2: TA-Nuod
(Traffic Analytics Surveillance System)

1 Project Information

We proposed a project entitled: ***TaNuod: Traffic Analytics Intelligent Urban Surveillance System***. This project is under the R&D Priority Area under **Emerging Technologies** and **Smart Cities** and falls under the UN SDG Goal 3 on **Good Health and Well-being,** and Goal 11 on **Sustainable Cities and Communities**. This project will be led by **Engr. Dylan Josh Domingo Lopez**, faculty of the Computer Engineering Department of Adamson University.

The project will be developed from August 10, 2020, to August 10, 2021.

2 Executive Summary

The City of Dasmariñas is becoming one of the epicenters of urbanization but faces challenges in terms of urban mobility especially in traffic management and public safety. As urban sprawl is observed in Dasmariñas, we can observe high traffic volumes passing through the city and high urban crime rates. Solving these challenges will significantly improve traffic flow and pedestrian safety. To address these challenges we propose to:

1. *Have an ICT CCTV Surveillance plan.* This will establish the surveillance backbone of the city enabling all related integrated systems.
2. *Integrate a traffic flow and composition analytics tool*. This will aid in traffic management decision-making for future policies and programs.
3. *Integrate a pedestrian flow monitoring system with hand gesture-based recognition alerts.* This will aid citizens in requesting emergency responses without verbal or physical contact.

4. *Integrate street violence recognition systems in Areas of Interest*. This will aid in remote crime alerting and reporting.

Adamson University's College of Engineering produces world-class professionals and engineers capable of leading Philippine innovations in the 4th Industrial Revolution. Our Adamsonian team is trained and educated in computational and applied Artificial Intelligence and Smart Cities, also having several experiences in developing Computer Vision and CCTV-based recognition systems in the Philippines and Taiwan.

It is with great pleasure to be at the forefront of developing engineering initiatives for smart cities for our country. With the help of the Department of Science and Technology, we can envision and build a better and modern society for the Filipino people together.

3 Project Summary

This project pertains to an intelligent urban surveillance system aiming to solve high traffic volumes and increased crimes in the City of Dasmariñas. Specifically consisting of Artificial Intelligence-based subsystems such as (1) a data analytics platform for traffic flow and Traffic Composition using object tracking/detecting and optical flow algorithms; (2) a pedestrian flow monitoring system using face/human detection and optical flow algorithms with a hand gesture recognition system for visual cue emergency report; and (3) a street violence recognition system using a two-stream architecture for action recognition.

Furthermore, the project will also aim to simulate the deployment of related surveillance technology and the aforementioned subsystems. Finally, the project is expected to produce an ICT management plan for surveillance technology considering the underlying subsystems

4 Significance / Rationale

TA-Nuod will not directly solve traffic management and public safety issues, nor lessen crime rates. As with any analytics tools or systems, our project and its underlying subsystems will aid in the decision-making process of concerned parties. Specifically, this will aid in analyzing traffic flow and Traffic Composition that might be useful for road-widening projects, traffic rerouting, traffic congestion forecasting, and other transportation-related urban management tasks. The project can also aid in human/ citizen behavior analysis and crime prevention in public spaces which can be useful in planning social events, emergency routes, and crime investigation routines. Generally, this project will aid in achieving UN

Sustainable Development Goal 11 on Sustainable Communities and Goal 3 by creating reliable and safe public and private transportation systems and further creating better liveable urban spaces for the people.

5 Literature Review

Transportation is among the primary services and needs in modern urban infrastructure which allows users and citizens mobility. Security is also among the need of users and citizens as also seen in Maslow's Hierarchy of needs. With this, we can envision a modern society that is intelligent enough to provide secure urban spaces and efficient transportation services.

The Philippines ' transition to develop smart cities is not far from reality. For analyzing needs for smart cities we must first determine the key areas for improvement at an urban level. In the case of the City of Dasmariñas, there are perceived challenges in their transport infrastructures/services [1] and public safety [2]. These challenges can also be perceived as opportunities in planning modern and intelligent urban services, from which we can perform the Plan, Detect, React and Analysis cycle for smart city frameworks [3].

Surveillance systems such as with the use of closed-circuit televisions (CCTVs) are vital in addressing these challenges in the modern infrastructure perspective. Utilizing CCTV networks can pave ways in a seamless transition to improved security performance, costs, and policies to the integration of emerging technologies such as Artificial Intelligence (AI) [4]. Although the use of CCTVs is already commonplace in the Philippines, we have not maximized its use. In 2016, a student from Adamson University was stabbed 18 times near his home and died shortly after, no one responded immediately and the entire scene was recorded [5]. Implementing intelligence with these CCTVs will prevent these kinds of incidents and minimize the labor of barangay officials and maximize their monitoring efficiency.

Integrating AI has already boomed in the 21st century. Some of the uses cases developed countries have ventured for better urban management are pedestrian monitoring, anomaly detection, and traffic monitoring. The safety of pedestrians is vital for urban space livability. Pop from INRIA [6] utilized object detection for pedestrian recognition using Faster RCNN and SSD. Similarly, Kim et al [7] utilized Random Forests for faster detection of pedestrians applicable for real-time use. Intelligent surveillance systems can also be utilized for crime prevention such as with the works of Ha et al [8], in which they utilized Motion Co-occurrence Feature. Another implementation is by Lopez and Lien [9] which utilized two-stream architectures and complex action decomposition to determine violence in CCTV cameras. Furthermore, intelligent surveillance systems can be used in traffic monitoring. Vehicle detection can be achieved using

object detection such as with Lorencik et al [10]. Traffic intensity measurement can also be achieved through object detection with the Macroscopic Traffic models as seen in the work of Gani et al [11]. Although these implementations utilize machine learning and deep learning models in solving our perceived challenges, they can be further improved using state-of-the-art technologies for better urban implementation. A system to consolidate these technologies for a city-scale implementation is also needed for an efficient and effective smart city service.

6 General Objectives

This project aims to aid in traffic management and public safety in the City of Dasmariñas through solving challenges in increased traffic volume and urban crime. Further aiming to develop an urban ICT management plan regarding surveillance systems and related technology for the city.

7 Specific Objectives

To achieve our main objective we must specifically:

- Design an ICT management plan for the implementation, operation, maintenance, and sustainability of the CCTV system of Dasmariñas City.
- Develop a traffic flow and composition analytics tool integrated with the surveillance system using object detection, object tracking, and optical flow algorithms.
- Develop a pedestrian flow monitoring system with the surveillance system capable of determining hand gestures as a visual cue for emergency reporting using human detection, optical flow algorithms, and hand gesture recognition.
- Develop a street violence recognition program for areas of interest using two-stream action recognition.

8 Methodology

This project comprises several subsystems and underlying activities that need to be achieved. The following procedures must be done:

A. TA-Nuod for Vehicle Traffic

1. Video data gathering of traffic flow.

Videos will be gathered from different routes at the City of Dasmariñas. Key scenes from these routes such as regular traffic conditions, light traffic congestion, heavy traffic congestion, and standstill traffic will be collected as raw data.

2. ***Video data cleaning and labeling***

Video frames will then be extracted from the gathered videos at a sampling rate of eight (8) frames per second. Data cleaning will be carried out by deleting frames that do not contain any vehicles. Once data has been cleaned, vehicles in the frames will be labeled using an image annotating tool such as LabelMe, LabelImage, or Supervisely. Vehicles will be classified into specific types of vehicles (i.e. Jeepneys, UV express, tricycles, private cars, shuttles, buses, trucks, etc.). These annotated images will be consolidated into a vehicle dataset.

3. ***Develop a neural network for vehicle detection***

A convolutional neural network as the object detector backbone (i.e. YOLO, SSD, FasterRCNN, etc) will be selected. The annotated/labeled images will be converted to the annotation formats applicable to the object detector. The dataset would then be split into training, validation, and testing sets. Transfer learning from the MS COCO dataset will be used to shorten the training time and heighten the base accuracy. A model will be produced after training the dataset consisting of the model schema and weights. The trained model will then be tested using the test partition of the dataset.

4. ***Develop an algorithm for determining traffic flow and composition.***

Once the object detector is passed the model accuracy needed, it will be integrated with the optical flow algorithm to determine traffic flow. A graphical user interface (GUI) will be developed to determine the number of vehicles, their types, and the traffic flow for an area of interest.

5. ***Unit testing the subsystem***

Once integrated successfully, TA-Nuod for Vehicle Traffic can be tested through other sample videos, mock-environments, and the actual environment for user acceptance.

B. TA-Nuod for Pedestrian Safety

1. Video data gathering of human flow.

Videos will be gathered from different public spaces at the City of Dasmariñas. Scenes from these spaces for every hour will be collected as raw data. Additionally, scripted fighting scenes in areas of interest will also be recorded for violence recognition.

2. Video data cleaning and labeling

Video frames will then be extracted from the gathered videos at a sampling rate of four (4) frames per second. Data cleaning will be carried out by deleting frames that do not contain any pedestrians. Once data has been cleaned, pedestrians in the frames will be labeled using an image annotating tool such as LabelMe, LabelImage, or Supervisely. Aside from human annotations, specific hand-gestures for emergency (i.e. crime-related, health-related, and operations-related)

For violence recognition data, the raw videos will be run through an optical flow algorithm to get the equivalent optical flow video. Frames from the original video and the optical flow video will be extracted at a sampling rate of twelve (12) frames per second. Data cleaning and labeling will also be performed for the RGB frames and optical flow frames but instead of labeling humans, actions will be labeled. These action classifications include: standing, walking, running, waving, slapping, grappling, punching, kicking, and melee weapon attacking.

3. Develop a neural network for violence detection

A convolutional neural network as the object detector backbone (i.e. YOLO, SSD, FasterRCNN, etc) will be selected. The annotated/labeled images will be converted to the annotation formats applicable to the object detector. The dataset would then be split into training, validation, and testing sets. Transfer learning from the MS COCO dataset will be used to shorten the training time and heighten the base accuracy. A model will be produced after training the dataset consisting of the model schema and weights. The trained model will then

be tested using the test partition of the dataset. The human detection model will be re-trained if the testing f1-score is lower than 88.00%. The violence detection model will be re-trained if the testing recall is lower than 80.00%

4. ***Develop a system for monitoring pedestrians, emergency alerts, and, violence detection***

Once the object detectors are passed the model metrics needed, they will be integrated into a single system. A GUI will also be developed for the TA-Nuod for pedestrian safety for areas of interest.

5. ***Unit testing the subsystem***

Once integrated successfully, TA-Nuod for Pedestrian Safety can be tested through other sample videos, mock-environments, and the actual environment for user acceptance.

C. ICT Management Plan

1. ***Determine Points-of-interest***

A key aspect of implementation for surveillance technology is determining the points-of-interests (POI) or areas of interest (AOI). These POIs will be determined using geographic analysis and traffic congestion analysis. The POIs will usually be intersections or routes that have high traffic congestions and pedestrian density.

2. ***Design a CCTV Network Architecture***

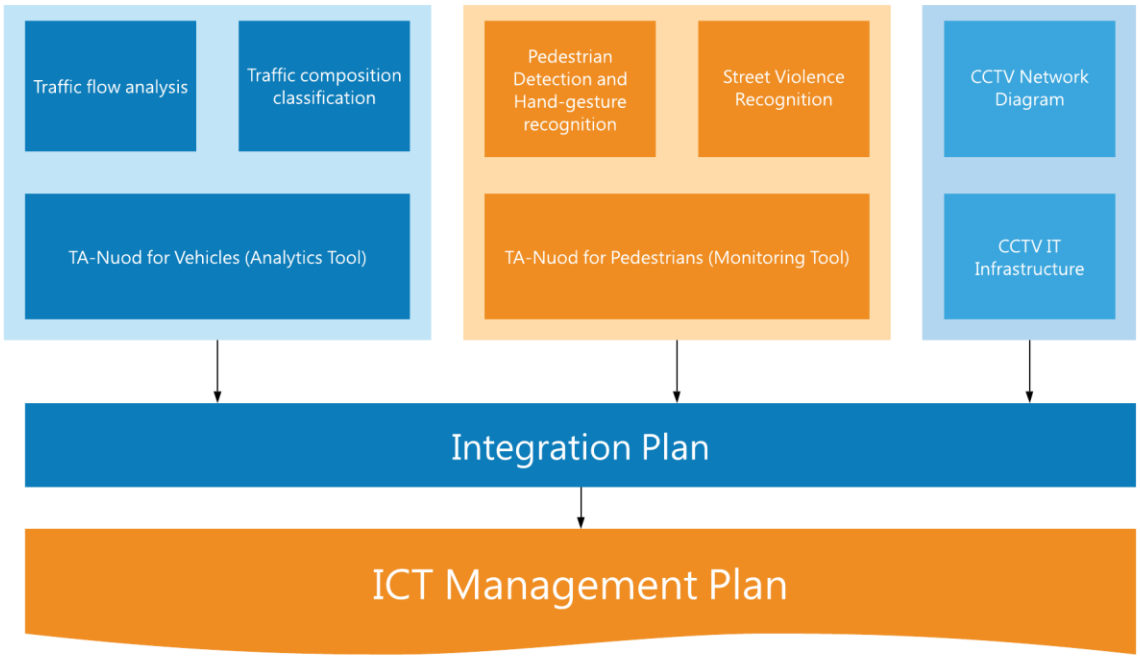
A network architecture for the surveillance system can be drafted once the POIs are determined. This will aid in determining the distance of access points and edge devices. Aside from planning the placement of surveillance cameras, edge computing will be considered in the design to appease network traffic and computational complexity at core computing devices.

3. ***Network Architecture Simulation***

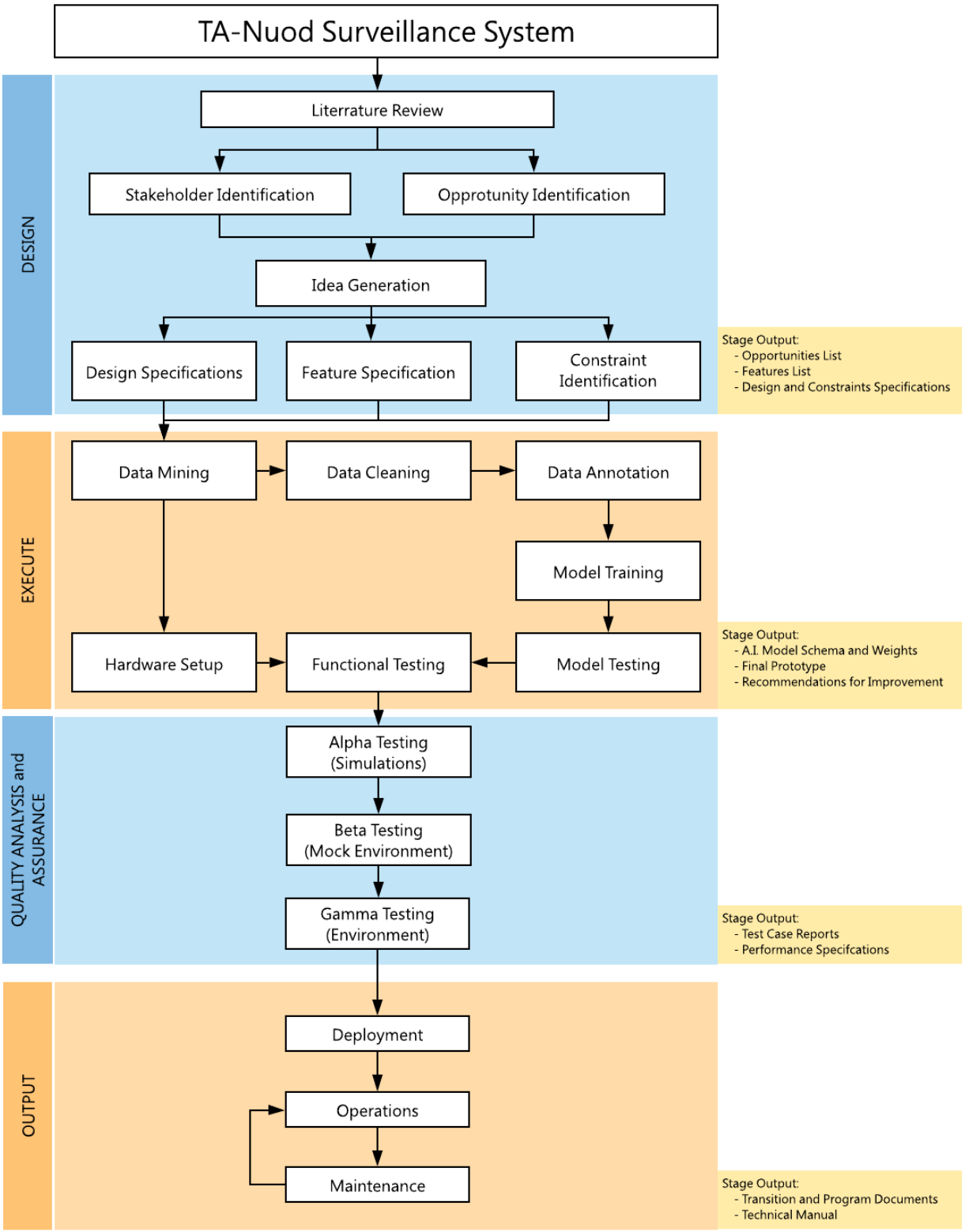
The designed network architecture will then be simulated using a network simulation software for the city-level. This will further aid in data traffic management and material cost projections. Security recommendations will also be determined upon performing simulations.

4. Subsystem Integration Plan

Once the simulation tests are complete, further integration and implementation plans can be documented. The integration plan will include suggested installation, operation, and, maintenance routines for the entire system.



9 Scientific Basis / Theoretical framework



The development of the system starts with an intensive literature review and case studies about smart cities and the implications of surveillance systems in traffic management. This will help in determining the stakeholders involved and problems/ opportunities that can be addressed. With further brainstorming and use of idea generation methods, the features and constraints of the system can be identified as well as the design and specifications for hardware, software, and network subsystems. After the design stage, we can then proceed with the execution of the project development. The project development will follow the software development lifecycle with the integration of the CRISP-DM framework. The execution stage requires the specifications from the design stage which will direct the data mining requirements in which it is cleaned and annotated. AI models can then be trained evaluated which can be subjected to functionality tests with the designed hardware. At this stage, the final prototype can be produced along with the AI model weights and schema. After developing the prototype several series of tests will be done for verification and quality assurance. Alpha testing will be done using simulation software to analyze ideal situations. Afterward, Beta testing can be done in a mock-environment that can be done in the laboratory and/ or at a selected area at the target site. Upon the success of the Beta test, the gamma test can then be run in several areas in the target site, if successful the system can then be deployed. The deployment of the system marks the final stage of the project. Expected outputs should be technical and operations documents for technology transfer and transition as well as a manual for operation. The system should be ready for operations with the continuous and dynamic upgrade and maintenance.

10 Proposed measures to address possible implementation issues and gaps

The perceived issues and gaps for implementation and their corresponding measures are:

- ***System/ Service downtime***

  If the system and or apps for command centers fail, a technical support team must be active for system queries. If there will be critical issues on-site or remote maintenance can be made.
- ***Device theft or breakage***

  To increase the sustainability of the edge devices, security measures can be made such as a specific policy, routines, or technical solutions (i.e security feature updates/upgrades)

- ***Misdetections and misclassifications***

Even if testing evaluations have high metric scores, the system can still have rooms for errors due to data variability or the introduction of never-before-seen data. This can be solved with reporting of misclassified or misdetected cases and perform model updates for the systems.

- ***Operations and maintenance***

  Training and lectures can be done as well as transition management documents for general cases of operations and maintenance such as complex software, hardware, or network issues.

11 Expected Outputs (6Ps)

11.1 Publication

At least 2 conference paper submissions and 1 journal publication are expected to be produced for this project. The conference papers to be submitted would be about the development of computer vision applications for traffic management or ICT systems for smart systems. The final journal paper should pertain to the whole system implementation.

11.2 Patent / Intellectual Property

The system, subsystem applications, and devices developed are expected to be patented. An extensive literature review has been done to add novelty to this project. The GUI of the applications can also be applied for Industrial Design. The novelty would at least make this project a utility model or if there is an inventive step developed during the study then this could be a fully patented technology.

11.3 Product

Expected products to this project are the surveillance management system for vehicle analytics and pedestrian safety specifically the software applications to be developed. Once successful in implementing at the City of Dasmariñas, other cities might consider adapting the surveillance system and its underlying applications.

11.4 People Service

The TA-Nuod Surveillance System still requires monitoring personnel at a minimum. Training can be provided to citizens to produce jobs for maintenance personnel for system repairs. Opportunities for the technical support team at the local government level can also produce jobs for entry-level to the professional level.

11.5 Place and Partnership

Several public and private partnerships can be promoted through this project such as network and IT infrastructure companies and especially the City of Dasmariñas as part of the "Belt fo Cities" of Region IV-A. We also further push partnerships within the city to promote local production and ease of repair.

11.6 Policy

The TA-Nuod System provides necessary descriptive analytics for the decision-making body. We hope that this system aids in the development of service-related policies such as traffic management and public safety. In a wider sense, we hope that this system aids in urban attractiveness, DRRM-related, and ICT adoption or Digitalization policies.

11.7 Potential Outcomes

The perceived implications and outcomes of this project are:

- Implementation of a command structure in traffic and pedestrian monitoring based on the ICT system;
- Development of high-quality data for commercial, institutional, and academic analysis;
- Proposal for traffic management and public safety guidelines, policies, and/or ordinances that leads to a decrease in traffic congestion, better road construction, route planning, and citizen safety; and
- Increase crime and emergency response time.

12 Potential Impacts

12.1 Social Impact

Aside from solid waste management, traffic management is one of the most visible changes that can be observed by people in terms of urban development. Upon the success of this project and the proper development of guidelines, policies, and/or ordinances the people can have more trust in the government and the policies that they make. Developing a surveillance system also increases the sense of safety of the people in public spaces as well as lowering crime knowing someone is watching them. In general, this project will aid in improving the city's efficiency and attractiveness.

12.2 Economic Impact

Transportation services such as roads are the lifeblood of the economy. By making traffic more efficient logistic supply chains can greatly improve for all sectors as well as a more productive and time-efficient workforce. Indirectly, investing in the city would be more attractive due to better transportation. Although this project would high initial investments, this project can open new doors for cost recovery activities such as justifiable fines due to traffic or urban violations, electronic road pricing, or congestion charges. Furthermore, there would be decreased labor costs for the barangay-level officials since there would be less need for people monitoring the surveillance system.

12.3 Target Beneficiaries

The target beneficiaries for this project would include but not limited to:

1. **Transportation Service Users** – these would include drivers and commuters in which alleviating traffic congestion would decrease their average travel time which will increase their productivity.
2. **The community** – these would include non-users of the road infrastructure service but are the inhabitants of the city. Less traffic congestion may contribute to lesser noise pollution and atmospheric pollution. Walking or strolling would not pose fear and anxiety.
3. **Enforcement** – these would include barangay officials (i.e tanods), MMDA officers, and other related enforcement agencies. Less traffic congestion may contribute to lesser noise pollution and atmospheric pollution. Walking or strolling would not pose fear and anxiety.
4. **City Legislation** – these would include the policy-makers of the LGU. The availability of high-quality data can aid them in the development of policies, guidelines, and/or ordinances.

12.4 Sustainability Plan

After the deployment, the project will be turned over to the respective LGU department for operation and maintenance. The project team will provide necessary training and education to responsible stakeholders, a transition management plan as well as an operations manual will also be provided. Upon transfer the LGU will have full autonomy over the system, further updates and upgrades will be upon the discretion of the LGU however the project team will establish a partnership as a consulting board. The generated ICT plan will be transferred to the LGU as their property and implementation will be under their discretion.

12.5 GAD Score

9.32

12.6 Project Limitations

The project is limited to the following:

1. The project's TA-Nuod for vehicle traffic analytics will not cover all routes but only cover two (2) intersections of a major road.
2. The project's TA-Nuod for pedestrian monitoring will only cover two (2) streets for pedestrian monitoring and violence detection.
3. The system management for the whole project will only be implemented to only one command center.
4. The project will not directly solve traffic and public safety challenges.

12.7 Risks and Assumptions

Some of the risks of this project include:

1. Unavailability of needed products in the country or does not meet the required standards, thus will be forced to procure overseas leading to delays due to shipping and added costs.

2. There might be difficulty in installation and possible theft or breakage due to force majeure.

3. Delays in implementing the project in the city due to unforeseen events negatively impacting the institutional, local, or national level.

Some assumptions of this project are:

1. The prototype development will be developed on time and all devices are available in the country preferably in Dasmariñas and they are not faulty.

2. The devices were installed properly, not stolen, and not broken due to force majeure.

3. No events occur that will negatively impact the institutional, local, or national level.

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Project #3: Smart MAIA
(Monitoring of Air quality using IoT Analytics)

Project Description

Smart Air: IoT-Based Air Quality Monitoring is consist of an air quality sensing device and a web-server. The application will be developed based on the IoT and cloud computing technology and will be primarily aimed at monitoring the air quality. Smart Air will efficiently monitor the air quality and will transmit the data to a web-server via LTE in real time. Smart air will be composed of a microcontroller, pollutant sensors and an LTE modem. The device will be designed to measure the concentration of aerosol, VOC, CO, CO_2, and temperature humidity to monitor the air quality. Cloud computing will also be used to store all the data and to serve as the resources for further analysis of air quality. The application will employ big data analytics approach to study, evaluate and predict air quality.

Significance

Air is one of the most essential natural resources for the existence and survival of the entire life in this planet. Almost all forms of life including plants and animals need air for their survival. All living organisms specially humans need good quality air which is free from harmful gases to continue living. According to the World Health Organization, 90 percent of the population now breathes polluted air and air pollution is the cause of the death for 7 million people every year. The health effects of pollution are very severe that causes stroke, lung cancer and heart disease. Air pollutants are also proven to have a negative impact on humans and the earth's ecosystem as observed in the recent global air pollution problems like ozone depletion. The project purpose is to precisely collect accurate and reliable data for air quality monitoring.

RRL

Monitoring and preserving air quality is one of the most essential activities in many industrial and urban areas today. The quality of air is adversely affected due to various forms of pollution caused by transportation, electricity, fuel uses etc. The deposition of harmful gases including carbon dioxide, nitrous oxide, methane etc. is creating a serious threat for the quality of life in smart cities[1]. J. Srishtishree,et.al[2] stated that air pollutions is becoming an invisible killer. Air pollution levels, particularly in cities are the most alarming threats posed to it residents. The study focuses on using sensors for the pollutants that are coming from vehicular emissions that posed some serious effects on human life. Sensor readings are then processed using deep learning algorithm to forecast pollutants to aid city administrators in decision-making on how to improve the quality of air to help people plan their day properly and to take precautions when air quality levels are unsatisfactory.

The quality of air is affected by multi-dimensional factors including location, time, and uncertain variables. Recently, many researchers began to use the big data analytics approach due to advancements in big data applications and availability of environmental sensing networks and sensor data[2]. A study by Kang et.al.[3] The quality of air is affected by multi-dimensional factors including location, time, and uncertain variables. Recently, many researchers began to use the big data analytics approach due to advancements in big data applications and availability of environmental sensing networks and sensor data.

General Objective

The project aims to develop an IoT-Based Air Quality Monitoring System with Big Data Analytics to forecast air pollutants to aid city administrators in decision-making on how to properly improve the quality of air and to help people plan their everyday activities properly and to take precautions when air quality levels are unsatisfactory.

Specific Objectives

1. To develop and IoT device capable of measuring the concentration of aerosol, VOC, CO, CO_2, and temperature humidity for air quality monitoring.
2. To apply Big data analytics on the data collected using the developed IoT device to effectively detect and forecast air pollutants.
3. To aid city administrators in decision-making on how to improve the quality of air and to advice residents on how to plan their everyday activities and to take precautions when air pollution becomes unsatisfactory.

Methodology

The researcher will take the following steps in the development of the project.

1. Development of the IoT device

   An IoT device equipped with wireless sensor networks will be developed that is capable of detecting air pollutants such as aerosol concentration, VOC, CO, CO^2, etc.

2. Data Gathering

The researcher will gather data of air pollutants by installing the IoT Device in areas that were identifies to be greatly affected by air pollution. After installation, the device will send the data to a web server to record the readings.

3. Data Analytics and big data Processing

An algorithm will be employed by the system for proper monitoring and prediction of air quality in areas where the IOT device were installed for proper information dissemination and proper preventive actions in case air quality becomes a threat to the residents of the city.

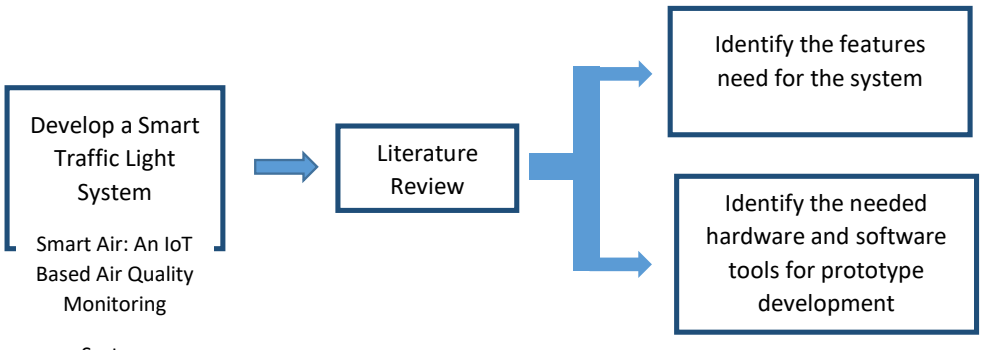
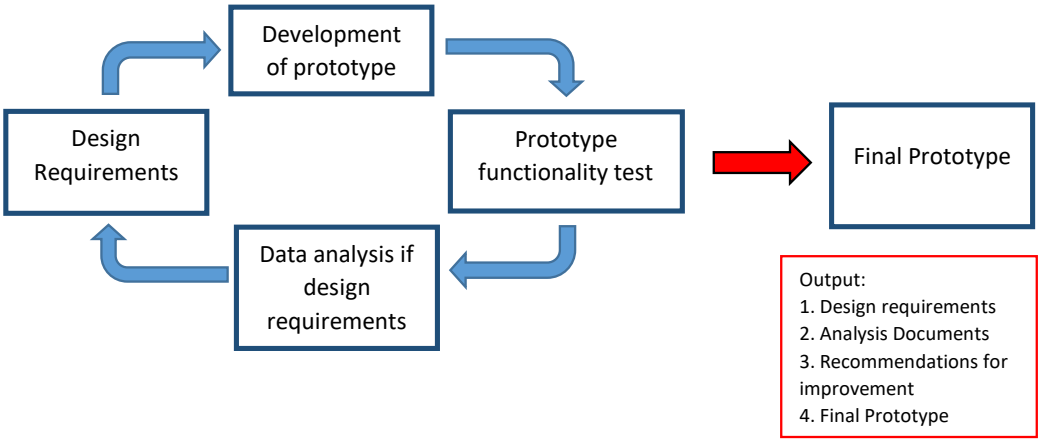
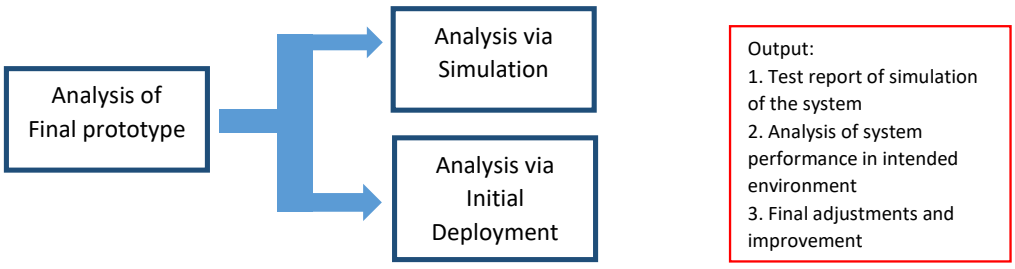
4. Evaluation and application of actual system

After installation and actual usage of the developed IoT device and applying it in the areas identified as being affected by air pollution the system will undergo analysis and evaluation.

Theoretical Framework

The development of the system starts with a more in-depth literature review to know the best practices and needed improvement of past works. This will give the researchers ideas on what features are to be included based on the objectives that is required to be satisfied by the system. Also, at this step, a preliminary design can be sketched so that hardware and software tools can also be identified. After this, the essential parts of the development are complete, it is now ready for execution.

The prototype will now be developed based on the set design requirements, this process is a continuous process of creation, testing and analysis until the desired outcome is met. The researchers would use the identified hardware and software tools to create the prototype, then it is needed to test its functionality if it behaves as it was intended to.

Process	Smart Air: Smart Air: IoT-Based Air Quality Monitoring
Design	
Execute	
Analysis	
Final Output	

Analysis of the test may say if there are things to improve or it is ready for deployment. The output of this process is the final prototype that has met all the design requirements. At this point the prototype has only undergone functionality tests in the lab, it requires to be tested on its intended environment. Simulation can be used in this step so that any minute adjustments can be done before deploying to the real world. In this step, software tool and data gathering techniques are to be used to full simulate the intended environment. When everything goes smoothly in the simulation, it can now be ready to be deployed in the physical world. The system still needs to be assessed if the target objectives have been met and adjustments or improvement can be applied until the whole system is ready for a full deployment. Lastly, maintenance is needed for the system, even if the system is fully automated, in time mishaps can occur. Training of the right people to maintain and troubleshooting the system is needed so that the system would continue to work.

Proposed measures to address possible implementation issues and gaps

In the underlying framework, barely any alteration and improvement are required to be seen, regardless of whether the framework carries on consummately in the recreation. This is not out of the ordinary in light of the fact that there are factors that the developers can't control. Subsequently, in the time of initial deployment, investigation of the framework is ought to be actualized. This will give the developers more opportunities to modify the capacities of the system to fit in the physical environment where it is intended to be installed. Likewise, regardless of whether the simulation is not perfect, the initial deployment can help anticipate the issues that might emerge. This would help design and define potential activities to forestall and take care of those issues.

Outputs

Publication

The researchers expected at least 2 conference paper submission and 1 journal publication for this project. The conference papers to be submitted would be about the development of the IoT-Based Air Quality Monitoring Sensors with Data Analytics. The final journal paper would be about the whole system implementation.

Patent/IP

The framework and the device that will be the output of this research will be protected with an appropriate IP protection. The developer have done the review of related literature survey to include the uniqueness in this venture. The novelty of the project is expected to be granted an IP protection of at least utility model

or should there exist some inventive steps after filing for a protection it might receive a full patent protection.

Product

This research is expected to produce an IoT-Based device capable of monitoring of air quality. The system can also classify and make necessary predictions that can be a great help to the city officials to make effective decisions in terms of improving the air quality and to advise residence on what to do when air quality becomes unsatisfactory.

People Service

Smart Air is a fully automated system but maintenance and troubleshooting are still needed during its full implementation. Training of personnel who will operate, maintain and troubleshoot the system will be assigned to the people who are working with the environmental sector of the target city beneficiary.

Place and Partnership

The project is targeted to be implemented in one of the "Belt of Cities" of Region IVA, which is the Dasmariñas City. The city is now gearing towards automating several processes within the city, implementing the system in the said locality will be of great assistance in making their objectives turn into a reality. We have started communicating with the city officials for assistance in the fulfillment of this undertakings.

Policy

In terms of policy, the project visualize the future where all residents of the targeted municipality will be breathing the air that are safe from harmful pollutants and will be properly informed ahead of time on what to do when air quality becomes unstable. The system will be designed to be dynamic and flexible so

as to fit with the needs its beneficiary. We hope that some policies can be drafted so that this would come to fruition.

Potential Outcomes

Here are some potential outcomes of this project

1. Monitoring of Air quality by performing a real-time readings of the amount of air pollutants.
2. Making predictions based on current status of the air quality to aid city officials in making decision on how to improve the air quality and to also inform its residence on the precautionary measures before the air quality becomes unsafe to humans.

Social Impact

The increase in numbers of death due to chronic disease linked to poor air quality has brought the researchers to come up with the idea of developing the Smart Air System. Making people aware of the dangers of air pollution thru this project will be of great help to the community where it will be implemented because proper monitoring and information can be derived from the system thus, making the people of authority make sound decisions on how to regulate factors that are affecting the air quality of the city (i.e. controlling/reducing cars and industrial emissions, etc.)

Economic Impact

Air pollution is one of the most serious environmental risks. Air pollution proven based on study to have an impact on labor productivity, health expenditures and agricultural crop yields thus, controlling and monitoring air quality using the system will also have an advantage in terms of improving the economy.

Target Beneficiaries

The following are the target beneficiaries:

1. The community – properly monitoring, reducing and regulating air pollution can be of great help to the community because it can assure the people in the community that they are breathing clean air thus, will lessen the risk of premature deaths and other serious air related health effects.

2. The city – the Smart Air will aid city officials in making sound decisions on how they can make sound decisions in terms of regulating the reasons of air pollutants in the city.

Sustainability Plan

After the full deployment of the project, the researchers would like to turn over the operation, maintenance and troubleshooting to the local government unit. The researchers will help to train the right people to be able to help in sustaining the project.

Limitations of the Project

The project is limited to the following:

1. The IoT device that will be developed will only be installed in strategic areas where air pollutants are identified to be concentrated (i.e. main roads, industrial areas, etc.). It will not cover the entire city.

2. The IoT device can only detect air pollutants such as aerosol, VOC, CO, CO2 and some particulates present in the air that might be harmful to one's health when inhaled in large amounts.

3. The project will only monitor and perform predictive analysis based on the data sent by the sensors to the web server. Decisions on how to properly control and stop air pollutions will still be in the hands of the city officials.

Risk and Assumptions

Some of the risks are:

1. Some of the hardware needed are not available in the Philippines and needed time to procure overseas.
2. There might be difficulty in installation and possible theft.
3. There would be some events in the government that would delay the full deployment of the project.

Some assumptions are:

1. The prototype development will be developed on time and all of the hardware needed are not faulty and working 100%.
2. The devices were installed properly.
3. The government prioritizes the project for installation and deployment.

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