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Short Paper*

Design and Development of Cross Capture Cam (3C): A Disaster and Traffic Management and Monitoring System using Image Detection of Urdaneta City

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Abstract

Purpose – The study aims to develop an innovative approach for monitoring traffic and disaster incidents in the Public and Safety Office of Urdaneta City. This involves implementing image-based processing algorithms through strategically positioned CCTV cameras on city streets. Specific research objectives include identifying user requirements for the monitoring system, determining the suitable image-processing framework, and assessing the acceptance of the developed system.

Method – The research primarily focuses on designing and developing an image processing-based traffic and disaster monitoring system. Adopting Extreme Programming (XP) as the software development methodology, the researchers prioritize rapid deliverable production and a collaborative environment between developers and clients. The study employs a descriptive research approach, utilizing quantitative analyses for data collection. Various instruments, such as interviews, survey questionnaires, observations, and literature reviews, were employed to gather user requirements and feedback. ISO 9126 was utilized for assessing user acceptability, offering a structured approach to evaluating software quality.

Results – The study aimed to streamline traffic management for the management team by developing a digital system. The focus was on the role of CCTV cameras in reducing crime and traffic violations. Findings highlighted the effectiveness of CCTV installations, particularly at red lights and intersections. Interviews with the Public Order and Safety Office in Urdaneta City emphasized the challenges in manual monitoring and the importance of adhering to safety rules. Collaboration with the PNP Urdaneta highlighted the need for timely responses to incidents. The study underscores the role of technology, collaboration, and efficient reporting in enhancing traffic management and public safety.

Conclusion – In this study, our focus was on creating an image recognition-based traffic and incident monitoring system utilizing video surveillance cameras for implementation in Urdaneta City. The following conclusions have been derived: The project requirements were meticulously analyzed by examining the existing business rules and policies of POSO Urdaneta City in incident monitoring implementation, influencing the design and development of the proposed system. While YOLOv3 proved efficient with its AI-based features for achieving research goals, its resource-intensive nature and limited small object detection capacity suggest considering alternative versions for enhanced performance in similar algorithm development. User acceptability testing results reveal a high acceptance level (GWM of 4.5), signifying satisfaction among system implementers. However, the researchers recommend additional technical testing on the CCTV devices for further refinement.

Recommendations – The research work has provided means of traffic monitoring through the use of technological innovations. Thus, to support the successful implementation of these technologies, the organization should maintain a sufficient working environment for these tools.

Research Implications – This undertaking provides insights as an administrative strategy to enhance traffic management and monitoring procedures using image-based detection. This study can be used to minimize errors and provide comprehensive and evidence-based documentation for traffic and disaster management that will be used in the future.

Social Implications – This research endeavor aimed to be part of the mechanism to provide a safer and more secure environment for the community enhancing their safety and security.

Keywords – cross capture cam, image detection, disaster management, traffic management

INTRODUCTION

According to the World Health Organization (WHO), traffic accidents kill approximately 1.35 million people a year and injure up to 50 million more. A large number of these accidents are preventable, caused by speeding drivers, or distracted drivers who are talking on their phones or texting on the road. As well as causing accidents and near misses, bad driving practices also increase traffic congestion, which is a major headache for motorists and local authorities who are required to reach the incident spots on time. Common driving behaviors that typically impact traffic flow include illegal vehicle stopping or parking, incorrect use of priority lanes, illegal U-turns, and unnecessarily sharp braking at traffic lights and junctions. (Hikvision 2020)

Moreover, Villanueva (2009) also signifies that the data show that in 2017, there have been recorded a total of 209,830 incidents of traffic violations in the National Capital Region alone. Common traffic flow-affecting behaviors include illegal stopping, improper use of priority lanes, unauthorized U-turns, and abrupt braking at lights and junctions. This study recognizes the difficulty of tracking vehicles and identifying violators, contributing to the escalating global road fatalities. Acknowledging the influence of factors such as road infrastructure development and legal systems on traffic accidents and violations, the research aims to address these challenges. The proposed solution involves the development of a real-time data collection system using static street video surveillance cameras. This system utilizes neural network architecture and an open-source tracker to analyze camera data, providing insights into traffic flow intensity, driving directions, and average vehicle speed. Rigorous testing indicates a high accuracy in vehicle counting and speed determination.

Urdaneta City is a developing city that needs technological support as to its traffic and incident management. Several issues were addressed by the officials of the city and technology is one of the key aspects to help them address those. To address these challenges and leverage video recognition technology, the research work introduces the concept of the Cross Capture Cam (3C) through the utilization of image detection systems, which can provide a comprehensive and viable solution to the problem of the community. The proposed image detection-based system leverages video and image recognition technology to enhance traffic monitoring and incident management in Urdaneta City, providing a safer and more secure community for the city.

Research Objectives

With all the foregoing, the study aims to design and develop an innovative means of monitoring and managing traffic and disaster incidents of the Public and Safety Office of the City of Urdaneta using image-based processing algorithms that will be implemented through CCTV around the streets of the city. Specifically, this research is sought to answer the following:

1. To identify the user requirements necessary in the design and development of the CCTV-based monitoring system;
2. To identify the image-processing framework to be used in the development of the system; and,
3. To measure the level of acceptability of the developed traffic and disaster monitoring and management system using image processing.

LITERATURE REVIEW

Foreign Literature

According to Chien et al. (2019), The Indiana Department of Transportation (INDOT) has over 300 digital cameras along highways in populated areas of Indiana. These cameras are used to monitor traffic conditions around the clock, all year round. Currently, the videos from these cameras are observed one at a time by human operators. It is very time-consuming for the operators to scan through all the video data coming from all the cameras in real-time. The main objective of this research was to develop an automatic and real-time system to facilitate the tracking process. The Transportation Active Safety Institute (TASI) of the Purdue School of Engineering and Technology at Indiana University-Purdue University Indianapolis (IUPUI) and the Traffic Management Center of INDOT have worked together to conduct a one-year research project to develop a system that will monitor the traffic conditions based on the INDOT CCTV video feeds. Specifically, the proposed system will perform traffic flow estimation, incident detection, and classification of vehicles involved in an incident. The goal was to develop a prototype system and prepare for future implementation. In this project, the research team developed the system architecture based on a detailed system requirement analysis. The prototype of major system components of the system has been implemented. Specifically, the team has accomplished the following: An AI-based deep learning algorithm provided in YOLO3 is selected for vehicle detection which generates the best results for daytime videos. Automatic traffic incident detection will be implemented after the traffic flow information is derived accurately.

According to Dhaya (2020), Monitoring of traffic and unprecedented violence has become very necessary in urban as well as rural areas, so the paper attempts to develop CCTV surveillance for unprecedented violence and traffic monitoring. The proffered

method performs the synchronization of the videos and does proper alliance employing the algorithms of motion detection and contour filtering. The steps in motion detection identify the movement of the objects such as vehicles and unprecedented activities whereas filtering is used to identify the object itself using its color. The synchronization and the alignment process afford to provide the details of each object in the scenario. The proposed algorithm is developed in Java which assists its model using its library that is open source. The validation of the proposed model was carried out using the data set acquired from real time and results were acquired.

According to Michael Bramberger (2022), A prototyping development of a smart camera for traffic surveillance. We present its scalable architecture consisting of a CMOS sensor, digital signal processors (DSP), and a network processor. We further discuss the mapping of high-level video processing algorithms to embedded DSP-based platforms and identify typical pitfalls for the porting of software from desktops to embedded platforms. Our mapping strategies are demonstrated on an algorithm for the automatic detection of stationary vehicles. This algorithm is migrated from a Matlab-based prototyping implementation to an embedded DSP implementation in our smart camera.

Local Literature

According to Caballo and Aliac (2022), Traffic management is one of the challenging issues that need to be addressed by any urban area, one of which is Tagbilaran City, located in the Province of Bohol, Philippines. Thus, the need to employ measures such as traffic surveillance systems is imperative. In such a system, vehicle detection is a basic functionality and, in this paper, a YOLO-based model is developed to detect a tricycle, which is a unique kind of public transportation. Training of the model is done on images of tricycles, extracted from actual traffic videos of selected intersections and the performance of the model is measured using the average precision. In this case, a 37.91% average precision is generated for tricycles. Increasing the number of annotated images of tricycles in the training dataset will produce a more precise detection model and including more of the other types of common vehicles will generate data that will support any traffic reduction measure.

According to Del Rosario et al. (2020), A comprehensive and interdisciplinary review of notable literature conducted were topics closely related to object detection and surveillance, mainly vehicle tracking. This survey of the literature is focused on multi-view vision systems in various platforms like static and dynamic cameras.

Foreign Studies

The paper of Channi et al. (2021) titled "AI-Powered YOLO based traffic management system through application advancement", discussed that the expansion in Urbanization of areas around the globe is witnessing a surge of increase in the number of vehicles which

has led to genuine gridlock issues. One major drawback that influences the traffic flow is the administration of the traffic at street convergences or road intersections. Subsequently, a good traffic management framework is expected to expand the proficiency of the traffic stream. It is more noteworthy to work on effective traffic frameworks that help in intelligent and efficient traffic management. In this work, an integrated prototype framework is designed to address the difficulties in vehicle traffic systems. A deep learning-based image processing technique is used for the detection of vehicle images and processing of other details towards its establishment at the intersection. The data available in the cloud is fetched and processed through the controller "ESP8266" and employed on a deep learning-enabled YOLO (You Only Look Once) algorithm for further analysis in the monitoring hub. The valuable data produced by the monitoring hub is accumulated in the server and further interfaced to the information system which conveys the necessary traffic information to the end-user through a mobile application.

Local Studies

Real-time which does not record the number of frames of images to analyze. For cross-line roadways, multi-camera surveillance is implemented to utilize a mathematical approach for switching emergency events. During evening rush hours, surveillance processing for monitoring vehicle movements is essential. This study of Haar-like features, for object and digital image recognition, leads to Haar wavelet processing which is used in real-time face detectors. The Viola-Jones algorithm is known for image and motion detection which is until now undergoing improvement for innovation. This algorithm is also used for pedestrian detection. A similar related study is for determining walking pedestrians, with a high accuracy detection algorithm of 90% from the test conducted. CCTVs of today are more advanced than before. Pedestrian crossings are one of the places where CCTVs are installed. In some pedestrian crossings, push-button devices are used instead of CCTV cameras. The existing push button or Ped call button, which DeVoe and Wall called in their paper, in pedestrian crossings are used by pedestrians where the traffic light control system's time changes once the pedestrian pushes the button Manlises (2020 et al.).

To appropriately address the effects of this technology, it is important to first understand where these tools are being deployed and how they are being used. Unfortunately, such information is scarce. To provide greater clarity, this paper presents an AI Global Surveillance (AIGS) Index— representing one of the first research efforts of its kind. The index compiles empirical data on AI surveillance use for 176 countries around the world. It does not distinguish between legitimate and unlawful uses of AI surveillance. Rather, the purpose of the research is to show how new surveillance capabilities are transforming the ability of governments to monitor and track individuals or systems Steven Feldstein (2019 et al).

The development of a video surveillance-based system for improving road safety. Based on the framework, a set of algorithms is developed that is capable of detecting various traffic pre-events from traffic videos, such as speed violations, one-way traffic, overtaking, illegal parking, and wrong drop-off locations of passengers. After detecting the pre-events, an alarm will be automatically generated in the control room which helps to take precautionary measures to avoid any potential mishap on the road, thereby improving road safety. In previous studies, a single system can handle either one or two pre-events. Whereas, in our present study, five anomalies can be detected in a single system using five different algorithms. Our study further contributes to the detection of "wrong drop-off location of passengers". The effectiveness of the developed algorithms is demonstrated over 132 traffic videos acquired from an integrated plant in India. Some additional comparative studies for overtaking and illegal parking are done using two benchmark datasets, namely 'CamSeq01' and 'ISLab-PVD'. Through an extensive study, it can be concluded that our developed algorithms are superior to some state-of-the-art algorithms in the detection of pre-events on roads Anima Pramani a, Sobhan Sarkar b, J. Maiti (2021 et al).

METHODOLOGY

The main objective of the research is to design and develop an image processing-based traffic and disaster monitoring system for the City of Urdaneta. In this perspective, we used XP or Extreme Programming as the software development methodology for the developer's awareness of the need for rapid production of the deliverable as well as the significance of the collaborative environment between the developers and the clients.

The research work also implemented a descriptive type of research where quantitative analyses were employed. During data collection, the researchers used several instruments to collect user's stories and their feedback. Interviews, distribution of survey questionnaires, and observations alongside reviews of related literature were used to collect user requirements. Meanwhile, for the user's acceptability, ISO 9126 was utilized. Using ISO 9126 in the acceptance test questionnaire provides a structured and comprehensive approach to evaluating software quality. It also helps the researchers to identify areas where their software product may need improvement, allowing them to take corrective action to improve the overall quality of their product. Figure 1 shows the distribution of respondents of the study where POSO Admin has (n=1; 2%), POSO Special Task Force (n=2; 3%), POSO Office Staffs (n=3; 5%), POSO Traffic Enforcers (n=10; 15%), and Citizens of Urdaneta (n=50; 76%).

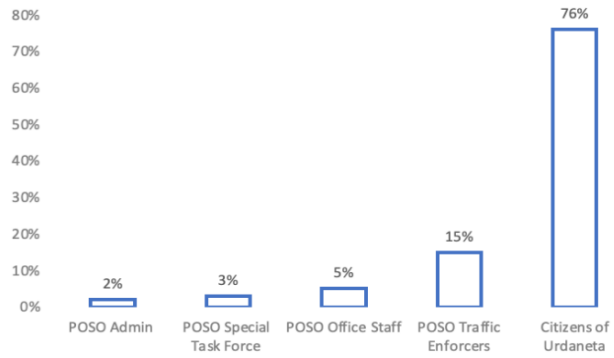

Figure 1. Distribution of Respondents

RESULTS AND DISCUSSIONS

The following are the salient findings of the research study:

RO #1: Based on the data collected from POSO officials, the office uses the classical CCTV monitoring system in managing traffic situations and incident monitoring that occurs within the bounds of the city. Currently, there are CCTV operators are the one watching over the city roads and send radio reports to traffic enforcers to clear the area where an event to occur until police patrols and officers can reach the area to block and conduct an investigation as well as set up checkpoints to stop and check private and public vehicles that will come and go. On the other hand, Disaster Risk Reduction and preparedness have a big role in the City of Urdaneta that can measure their readiness to respond to any disasters or accidents that happen in some parts of the city where there is unexpected casualtv.

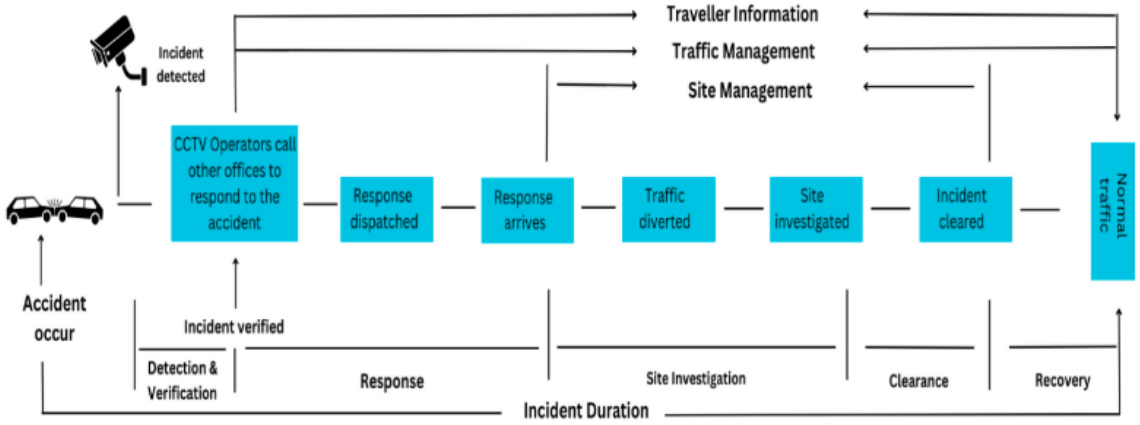

Figure 2. Existing Traffic Monitoring and Incident Response of POSO Urdaneta

Figure 2 shows existing procedures that were strictly mandated by POSO Urdaneta regarding traffic and incident response mechanisms. The researchers interviewed the investigating officer of the PNP Urdaneta and based on the interview, a police officer should respond to addressing a traffic incident and it should be submitted within 5 minutes, as per the directive, to secure evidence and prevent it from being tampered and more so if

they will be investigating. Then POSO CCTV Operators will call other offices that are required to respond in an incident such as a minor incident where POSO enforcers will manage the situation to align the problems and hard cases where PNP will manage all types of dangerous acts of incidents.

RO#2: Image processing is used in this project to develop a monitoring system for POSO Urdaneta. The proposed system specifically employed YOLO object detection. Initially, the researchers used OpenCV in Python for the planning stages. In this same phase, the researchers used the HAAR Cascade to test the performance of a real-time camera that is running through software and at the same time developing initial object detection. After conducting several tests, due to its inaccuracy, the HAAR Cascade has been changed to the YOLO Object Detection Model which is more accurate and turned out to have better detection management based on available empirical literature. YOLO is an abbreviation for the term 'You Only Look Once' which is an algorithm that detects and recognizes various objects in a picture (in real-time). Object detection in YOLO is done as a regression problem and provides the class probabilities of the detected images. Using the YOLO Model, the system detection has been modified several times for much more accurate detection which resulted in up to 60% to 70% accuracy. Figure 3 shows the object detection framework that was built for the project.

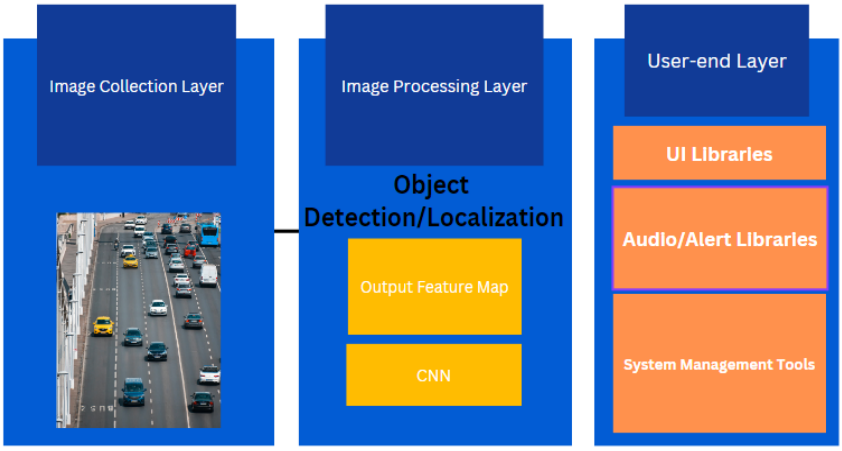

Figure 3. YOLO's Object Detection Framework

Figure 3 denotes the transition from testing a single-camera detection model to evaluating a multi-camera detection system (2 to 4 cameras). Due to the resource-intensive nature of the YOLO AI Model, the number of cameras used had to be limited for optimal hardware performance. Threading was employed to sequentially detect collisions in a multi-camera setup. The development, facilitated by the Tkinter Library for the User Interface, was seamlessly transferred and translated to function cohesively. Audio alerts and "Alert" text display upon collision detection were achieved using the Pygames Library. Administrative features automatically refreshed the video list for user review and post-review, and videos were uploaded to the tkVideoPlayer module for display, ensuring an efficient and streamlined process.

Figure 4. Object Detection UI

There should be an explanation for Figure 4 here. This content shows the detection of collisions in the road. Every color has a different meaning. First is the green, when the color that comes out is green, it means that the flow of vehicles is continuous. The second one is the yellow, when the yellow light comes out, it serves as a warning because the vehicles are approaching each other and there is a possibility of a collision. Last but not the least is the red, the color red serves as a signal that a collision has occurred.

Figure 5. Collision Detection that Triggers Alarm

This is one of the highlight features that the system has. because this serves as a notification to the operators who monitor the CCTV. This is a great help to the Organization because even if the operators are not looking at the monitor 24/7, they will know if a collision has occurred.

RO#3: The user acceptability of the developed software was assessed using ISO 9126, an international standard for software evaluation, employing a 5-point Likert scale. Results reveal high acceptability across key domains: Functionality (4.7), Reliability (4.38), Usability (4.76), and Performance (4.37), while Efficiency (4.3) and Portability (4.36) are deemed

acceptable. The overall Average Weighted Mean (AWM) of 4.5 indicates a highly acceptable result. These findings affirm user acceptance of the proposed system within the ISO 9126 domains of software quality. Figure 6 illustrates the comprehensive outcome of user acceptability for the developed system.

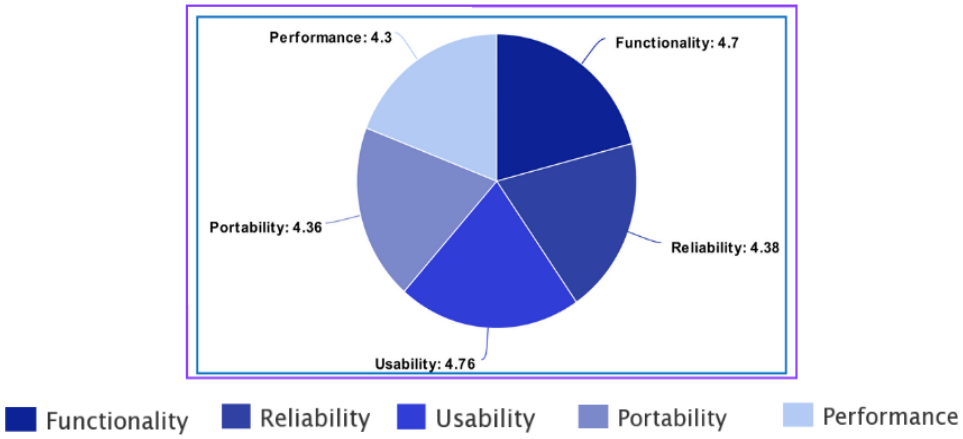

Figure 6. Overall User's Acceptability Results

CONCLUSIONS AND RECOMMENDATIONS

In this work, we focused on developing an image recognition-based traffic and incident monitoring system using a video surveillance camera to be implemented in Urdaneta City. As to the requirements of the project, the researchers have analyzed the existing business rules and policies of the POSO-UC in the implementation of monitoring incidents. These were considered in the design and development of the proposed system.

On the image detection system that was used, YOLOv3 has provided a better and faster way of achieving the goals of the research work through its AI-based features that are significant in the design and development of the proposed architecture model of the system. However, YOLOv3 is a resource-intensive model based on existing literature and has limited detection capacity for smaller objects. Thus, for developers planning to use the same algorithm, consider other versions for comparison purposes.

The results of the user's acceptability testing show that the system is highly accepted by the users with a GWM of 4.5. This indicates that the developed system has satisfied the implementers of the system. However, the researchers would like to recommend further technical testing on the CCTV devices.

IMPLICATIONS

Roving is multifaceted and holds significance for various stakeholders. First and foremost, it addresses the need for a notification platform that enables first responders to efficiently communicate readiness status and access turn-by-turn navigation details. The

integration of a CCTV surveillance system allows for the tracking of vehicles violating road rules, contributing to enhanced road safety. The study's implications are as follows:

Residents of Urdaneta:

The study directly benefits residents by bolstering safety and security through the surveillance system, encouraging compliance with traffic laws. The proactive approach of Urdaneta City's residents aligns with the promotion of road safety, fostering a safer environment for all.

POSO Urdaneta:

The study aids the Public Order and Safety Office (POSO) in Urdaneta by streamlining the tracking of traffic incidents captured by CCTV cameras. This automation reduces the need for manual monitoring, ensuring that POSO's enforcement efforts remain well-coordinated and effective in maintaining a secure environment.

ACKNOWLEDGEMENT

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FUNDING

The study did not receive funding from any institution. Instead, it relied on the expertise and resources available within the research team's own academic or professional affiliations. This self-funded approach underscores the researchers' commitment to the integrity and objectivity of their work, as well as their passion for the subject matter being investigated. while external funding in this study highlights the researchers' dedication to pursuing scientific inquiry for the sake of acknowledging advancement rather than financial gain.

DECLARATIONS

Conflict of Interest

The authors declare that they have no conflict of interest directly or indirectly that could influence this research work. The researchers also declare that there is no internal or

external funding for this research. All the expenses were incurred during the research and its publication is shouldered by the authors.

Informed Consent

In this work, the use of informed consent is deemed inapplicable due to the reason that the data collection has been identified to have a minimal risk where data that are protected may not necessitate informed consent, as the potential harm or the invasion of privacy is negligible or has a minimal impact.

Ethics Approval

The research work has obtained the required approval from the office of the research director of the university who approves all research-related endeavors of the students and its faculty.

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Author's Biography

Hannah Dorothy B. Niño, a dedicated graduating student from the College of Information and Technology Education at Urdaneta City University, stands at the intersection of academic excellence and technological innovation. With a passion for information technology, she actively participated in the international conference on information technology education, showcasing not only individual prowess but also contributing to a winning team. Leading her team to victory, Niño secured the prestigious title of Best Poster Presentation during the contest held on November 17, 2023. This achievement not only reflects her commitment to academic pursuits but also underscores her ability to collaborate and excel in a competitive academic environment. She is poised for a promising future, continuing to lead with distinction in the ever-evolving landscape of her chosen field.

A highly skilled programmer, Ian Eleazar B. Marinas is a graduating student from the College of Information and Technology Education at Urdaneta City University. Known for his exceptional programming prowess, he has been an invaluable asset to our team, contributing significantly to the success of various projects. Marinas combines technical expertise with a meticulous approach to coding, ensuring the implementation of efficient

and innovative solutions. He has demonstrated a commitment to continuous learning and staying abreast of the latest technologies in the dynamic field of information and technology education. As he nears graduation, Ian Eleazar B. Marinas stands as a promising professional poised to make substantial contributions to the world of programming and technology.

Dr. Arnel B. Ocay, a distinguished Doctor of Information Technology Professor at Urdaneta City University, serves as both the esteemed adviser and co-author for this group. With a wealth of knowledge and expertise in the field, Dr. Ocay has been instrumental in guiding and shaping the research endeavors of the group. His extensive academic background has not only enriched the project but has also inspired the formulation of innovative ideas. As a co-author, Dr. Ocay has played a pivotal role in contributing to the scholarly content and ensuring the project's alignment with the highest academic standards. His commitment to academic excellence and mentorship has significantly influenced the success of the collaborative efforts within the group.