DETECTION OF VIOLATORS OF GARBAGE DISPOSAL SCHEDULE WITH MONITORING SYSTEM

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ABSTRACT

The Detection of Violators of Garbage Disposal Schedule with Monitoring System tackles important waste management issues such as compliance challenges with garbage disposal schedules, illegal dumping, and monitoring problems in Barangay Santiago, Malvar, Batangas. The work relies on rigorous data collection from related studies and literature, which is enriched by the knowledge gained from interviews with local government representatives. Through the use of camera technology, the system proposed here provides a new way to improve monitoring and enforcement. The efficiency of the project clearly exceeds existing solutions, demonstrated through the thorough evaluation of the metric system. This new system will help other areas to have positive results for more efficient waste disposal, safe, clean and healthy environment. More studies can be conducted to determine its scalability, cost-effectiveness, and the potential of adaptations for different geographical areas to make it more effective and sustainable.
Keywords: YOLO, Person and Garbage Detection, Model Testing, Detection Capability, Result from the System

1. 0 INTRODUCTION

Waste disposal can be carried out in a variety of ways including sludge disposal and direct discharge to land or water. Such wastes must be managed so that any negative effects are minimized to protect the environment and human health.

Waste management is a necessity in communities throughout the world to keep cleanliness and protect environmental health. However, one of the major conflicts arises when residents do not follow the scheduled garbage collection system. This recurring problem causes unattractive waste piling, foul smells, and health hazards which diminishes the quality of life for all. According to Abubakar et al. (2022), uncollected and untreated waste has socioeconomic and environmental costs extending beyond city boundaries. Environmental sustainability impacts of this practice include methane (CH4) emissions, foul odor, air pollution, land and water contamination, and the breeding of rodents, insects, and flies that transmit diseases to humans. Decomposition of biodegradable waste under anaerobic conditions contributes to about 18% and 2.9% of global methane and GHG emissions, respectively, with the global warming effect of about 25 times higher than carbon dioxide (CO2) emissions. Aside from that, our country, the Philippines, has a continuously rising amount of waste and is expected to further increase in the succeeding years (Coracero et al., 2021).

To address this problem, an effective solution is the violation detection system that detects and solves people who throw garbage unplanned. This system makes use of modern technology including cameras to monitor the garbage disposal activities, and an algorithm that adds functions such as face recognition and object detection. With the installation of a violator detection system, communities can get to know those who do not follow the scheduled garbage disposal routine. Such a system may alert the local authorities, who can then take concern actions, such as issuing warnings, fines or educating people on the need to adhere to the waste management timetable. Finally, the adoption of a violator detection system may contribute to preserving the cleaner and more sustainable environment, promote a sense of responsibility and accountability among community members.

Thus, the goal of the study is to develop a Detection of Violators of Garbage Disposal Schedule with Monitoring System that can detect both garbage and person, resolves one issue faced by Barangay Santiago, Malvar Batangas.

This paper presents the key outcomes and findings of the abovementioned research on monitoring cleanliness of the community in Santiago, Malvar, Batangas.

2. 0 REVIEW OF RELATED WORK

Garbage disposal violators are persons who commit the act of improperly disposing waste, causing pollution and related health hazards. The following study intends to mitigate the problem by reviewing algorithms that can help build a better system. Utilizing modern algorithms, the objective is to make

a more competent and proactive waste management solution that identifies and punishes offenders as well as promotes responsible waste handling for a cleaner and sustainable environment.

According to Kenan, Bunyamin, & Baris (2022), the YOLO Algorithm can predict faster than other algorithms. YOLO applies a CNN (Convolutional Neural Network) to the picture, divides the picture into grids, calculates bounding boxes and the appropriate confidence score for each grid, and calculates the bounding boxes with the estimated confidence score. The YOLO algorithm can process images at around 40-90 FPS (Frames per second). Therefore, it is very fast compared to other methods. This shows that a video can be processed by the YOLO Algorithm with a delay of a few milliseconds. Compared to another object detection method, Yolo is said to be 1000 times faster than R-CNN and 100 times faster than Faster R-CNN.

3.0 METHODOLOGY

This chapter presents the detailed methodology used by the researchers to come up with the development of Detection of Violators of Garbage Disposal Schedule with Monitoring System. It includes the design process (IPO), methods of data collection, Block Diagram and Flow Chart. All the Figures and tables are seen in 10.0 Appendix.

3.1 Method of Data Collection

To carry out the Detection of Violators of Garbage Disposal Schedule with Monitoring System, the researchers used different related studies and literature obtained from a number of sources including articles and internet-based existing studies. The researchers were able to identify the necessary characteristics and improvements that are required for the detection and monitoring system aimed at solving the problem with violations to the garbage disposal timeframe. This success was a result of their wide collection and interpretation of different data and information sources. The researchers also took into consideration recommendations and suggestions of thesis advisers as well as the location where the project will be realized.

3.2 Conceptual Framework

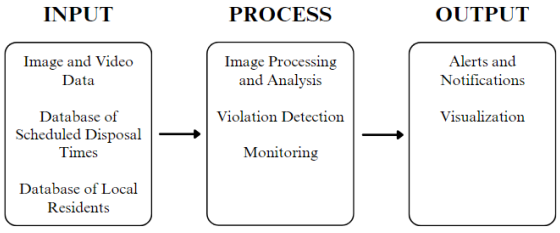

Figure 1. Input-Process-Output Model

In Figure 1, the Input-Process-Output model of the Detection of Violators of Garbage Disposal Schedule with Monitoring System illustrates the flow of information and actions within the system. By processing input data, detecting violations, and providing monitoring and notifications, the system ensures effective waste management, adherence to disposal schedules, and a cleaner environment.
To further understand, the input represents all the resources, data, and variables that will be used for the system. From Figure 3.1, three variables were listed on the input which are the image and video data to capture or continuously monitor the waste disposal activities around the area, database of the scheduled disposal time to know when will a waste disposal activity be considered as violation, and database of the local residents to identify the violators. For the process, this represents the steps and procedures to process the gathered variables from the input. As can be seen from the figure, there will be an image processing and analysis to identify and extract relevant features from the images to determine violators and violations wherein the data and the database of scheduled disposal times will be used to identify or have a decision-making for the violation instances, and monitoring. Third, and lastly, is the output which represents the result or outcome from the two previous processes. Here, alerts and notifications will be shown as there will be a pop-up notification from the monitoring system to alert the authorities of violations and visualization to observe the live video feed.

3.3 Block Diagram of the System

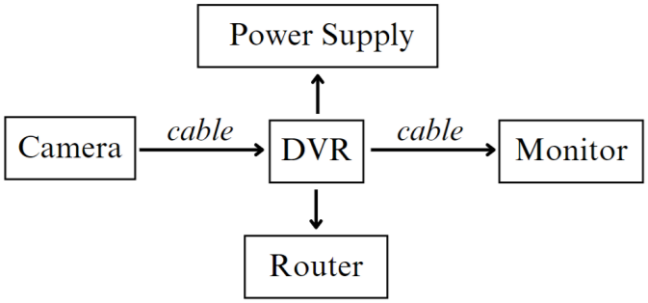

Figure 2. Block Diagram of the System

The block diagram of the Detection of Violators of Garbage Disposal Schedule with Monitoring System is a visual representation of its key components and their interconnections. This system aims to efficiently detect and monitor violations of garbage disposal schedules using modern technology. The major components include a power supply, DVR, camera, and monitor.

3.4 Flowchart of the System

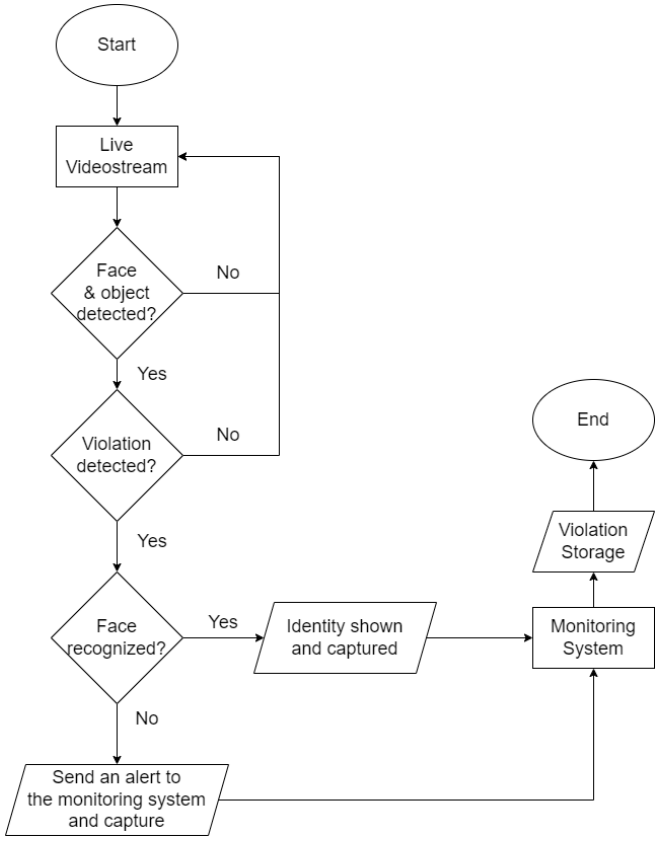

Figure 3. Flowchart of the System

Figure 3 illustrates the step-by-step procedure on how the system will operate once it is implemented. The first step is to power up the camera and it will automatically do live video streaming to monitor the place and detect whether there is a violation or none. When there is no violation, the camera remains on a live video stream to continue monitoring the place, however, if there is a detected violator ("yes"), the violator's identity is registered in the system as it shows the violators name under its face showing the identity. If the violator is not registered, the system will show "Unrecognized" under its face. Afterwards, it will send an alert to the monitoring system to notify the barangay officials, however, if a face is recognized ("yes"), it will display its identity as a message and send an alert to the monitoring system to notify the barangay officials. Furthermore, all the detected violators will be captured, and the violators images will be stored in a folder.

3.5 Algorithm

The system starts with the power supply providing the necessary electrical energy to all components. The camera captures images of the waste disposal area at regular intervals or in response to specific triggers. For the coding system, YOLO works by dividing the input image from the CCTV camera into a grid and simultaneously predicting bounding boxes and class probabilities for objects within each grid cell. The object detection approach enables YOLO to rapidly process video feeds, capturing and analyzing multiple frames in one pass. For the waste disposal monitoring system, YOLO is used to recognize specific objects or behaviors indicative of schedule violations, such as unauthorized disposal or non-compliance with designated disposal times. By leveraging YOLO's speed and accuracy, the monitoring system can promptly identify and alert authorities about violations, enhancing the overall effectiveness of waste disposal surveillance.
The monitor continuously displays the live video feed from the camera, enabling monitoring of the waste disposal site. It serves as a critical component for observing and monitoring the area. Through the monitoring system, surveillance operators or authorized personnel can also configure system settings.

4.0 RESULTS AND DISCUSSION

This chapter presents the summary of the analyses and discussions of the results of the project. This chapter discuss the Actual Device Testing (Initial Results, Garbage Detection, Person and Garbage Detection, and Result from the System) Dataset Classifications, Detection Capability and Classification Testing

4.1 Detection Capability

Distance	Garbage Detection	Person Detection	Face Recognition
1 meter	-	-	-
2 meters	-	-	-
3 meters	Detected	Detected	Detected
4 meters	Detected	Detected	Detected
5 meters	Detected	Detected	Undetected
6 meters	Detected	Detected	Undetected
7 meters	Detected	Undetected	Undetected

Table 1. Detection Capability

Table 1 presents a comprehensive overview of the performance of a surveillance system equipped with distance, object detection, and face recognition capabilities. Notably, at 1 and 2 meters, garbage detection, person detection and face recognition are rendered ineffective due to the specific

angle and height of the camera. As the distance increases to 3 and 4 meters, all functions become successfully detectable. The shift occurs at 5, 6 and 7 meters, where the system excels in detecting garbage and person but encounters limitations in face recognition. This discrepancy arises from the constraints in the camera's field of view and resolution at longer distances, making facial features challenging to discern accurately. The results highlight the nuanced interplay between camera specifications and the effective range of surveillance functionalities, emphasizing the need for careful consideration of both factors in the design and implementation of such systems.

4.2 Dataset Classifications

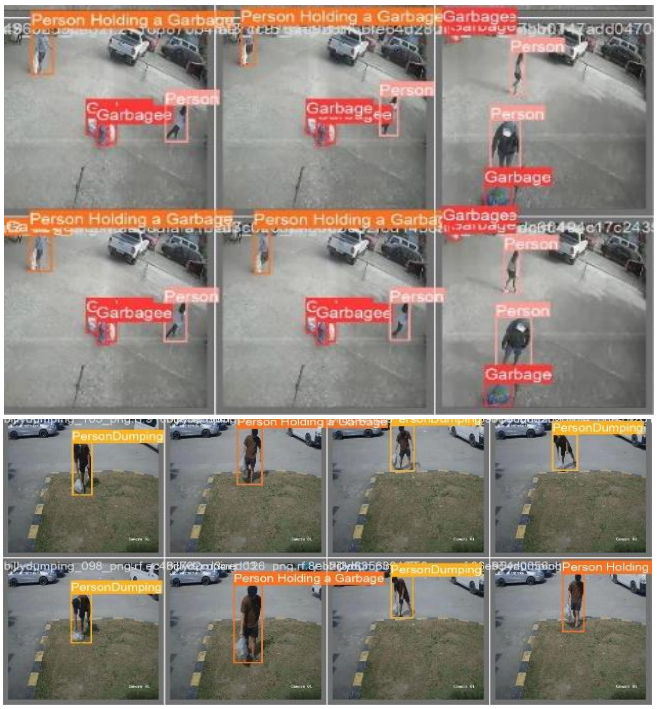

Figure 4. Dataset Classifications

The dataset for classification comprises diverse images categorized into four distinct classes: garbage, person, person holding a garbage, and person dumping. Each class encapsulates unique visual scenarios, allowing for the development and training of machine learning models to distinguish and classify these specific image categories.

4.3 Garbage Detection

Figure 5. Garbage Detection

In Figure 5, a screenshot is extracted from the live stream captured by the CCTV camera. Evident in the image is a grid or box on a garbage. This visual cue serves as a clear indicator that the algorithm is actively at work, demonstrating its precise detection and classification capabilities for garbage detection. The integration of the grid with the corresponding label provides a user-friendly and visually intuitive representation, underscoring the algorithm's effectiveness in garbage identification within the surveillance feed.

4.4 Classification Testing

Figure 6. Classification Testing

Figure 6, above shows the results of the model that was trained with the YOLOv5s module. The classifications effectively demonstrate the model's functionality as it highlights its ability to identify and label objects within the images.

4.5 Person and Garbage Detection

Figure 7. Person and Garbage Detection

Beyond the successful detection of garbage, Figure 7 showcases the algorithm's capacity to identify and track individuals within the scene. In this dynamic capture, the algorithm not only highlights the presence of waste but also recognizes and labels the people present on the video stream. This dual ID underscores the algorithm's versatility, demonstrating its potential applications in both waste management and crowd monitoring.

4.6 Person and Garbage Detection

Figure 8. Initial Results

In Figure 8, the initial results of the integrated algorithm in the CCTV and web camera are presented, demonstrating the output or performance of the algorithm when applied to surveillance footage or live video feeds from the system. This step is crucial to evaluate the algorithm's effectiveness in real-world scenarios and to identify any areas for improvement or refinement.

4.8 Person and Garbage Detection

Figure 9. Result from the System

In Figure 9, the diagram illustrates the detection and display components of the monitoring system. Each button serves a specific function: the "Start" button initiates system operation, the "Stop" button halts system functioning, the "Change Schedule" button allows for time settings adjustment and specification of detection days, and the "Register" button facilitates citizen information registration within the barangay. These buttons are purposefully designed to ensure efficient system operation and user-friendly interaction. Moreover, the first image shown above indicates that face recognition and object detection are both working, furthermore, the reason why it doesn't look like the person is dumping is that the system experienced delays that's why on the next test the face recognition will only prompt when there's a violation detected to minimize delays and to have a smoother and faster real-time detection. However, on the other hand the result below the first image in Figure 5.14, is the next test where the face recognition will only prompt when there's a detection where it also shows that when the system recognizes the person dumping which is labeled as "person dumping" it will recognize it as an "unrecognized violator" if the person being detected for violation is not registered in the system and when the person being detected for violation is registered in the system it will output like this "name of the violator is a violator".

5.0 CONCLUSION

The researchers were able to successfully design and implement their goal to create a monitoring system capable of detecting both instances of improper garbage disposal and the individuals who were responsible for such violations. This innovative system combines a deep learning algorithm called YOLO with a CCTV camera to identify violators using facial recognition. The successful integration of cutting-edge technology and surveillance tools has enabled the system to not only monitor and identify illegal activities, but also to categorize and identify violators, improving the overall efficiency of garbage disposal enforcement.

Furthermore, the researchers placed a strong emphasis on the quality of the surveillance tools used. The use of a camera with an enough resolution was a deliberate choice to scan the face of violators. This aspect significantly contributes to the system's ability to provide precise identifications, reducing false positives and improving overall monitoring process reliability. The incorporation of advanced imaging technology adds a level of sophistication to the system, laying the groundwork for effective and precise identification of individuals involved in illegal garbage disposal.

The researchers also conducted a comprehensive performance evaluation of the system. This evaluation was made possible by implementing a coding system and utilizing a GPU. This comprehensive assessment highlights the system's efficacy and viability as a practical solution for monitoring and enforcing garbage disposal regulations.

6.0 RECOMMENDATIONS

It is critical to develop recommendations that not only strengthen the current system's capabilities, but to also pave the way for its long-term effectiveness and ethical application. These recommendations cover a wide range of technological, ethical, and community-oriented issues, with the overarching goal of developing a monitoring system that works in tandem with waste management enforcement dynamics. Based on the findings, the following recommendations were made:

Utilization of High-Performance Hardware (GPU)
Using high or higher specifications for hardware components, particularly the GPU, is critical for optimizing the system's processing speed and overall performance. A powerful GPU improves the efficiency of the YOLO deep learning algorithm, resulting in faster and more accurate identification of violators.

Implementation of Backup Power Supply
Install a dependable backup power supply system to reduce the effects of power outages on the monitoring system. Consider using uninterruptible power supply (UPS) units or alternative power sources like solar or battery backups. This ensures the surveillance system's continuous operation, even during unforeseen power outages, and maintains the system's vigilance in detecting and identifying violators without interruption.

Use of CCTV Camera with Higher Resolution
Employing a higher resolution for CCTV systems significantly enhances the capacity for facial recognition and object detection, especially over longer distances. The increased clarity and detail provided by higher resolution cameras enable more accurate identification of faces and objects within the surveillance area, even at considerable distances.

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9.0 ABOUT THE AUTHORS

All the authors of this study are all graduating student of college of engineering. Moreover, Mr. Billy G. Cabungcal and Mr. Neo D. Hidalgo are taking a program of BS Computer Engineering while Ms. Allen Valerie U. Lorzano is taking BS Electronics Engineering. In addition, Mr. Billy G. Cabungcal is having an internship at Unisol Electrical Installation Services, Lipa City, Batangas, while Mr. Neo D. Hidalgo is taking his internship at Arkray Industry, Inc. FPIP Santo Tomas, Batangas and Ms. Allen Valerie U. Lorzano is taking her internship at Xinyx Design Consultancy and Services Inc. Alabang, Manila.

10.0 APPENDIX

This section includes figures and tables that are too bulky to be placed next to the discussion. It helps to maintain the smooth flow of discussion while maintaining the technical merit of the study through appropriate data and figures.

Appendix A – Camera Specifications

DESCRIPTION	SPECIFICATION
Image Sensor	5MP CMOS
Frame Rate	5MP at 20 fps
Video Resolution	2560×1944
Lens Type	2.8 mm fixed lens
Camera	HIKVSION Analog Camera
Image Settings	Brightness, Sharpness, Mirror, Smart IR

Appendix B – DVR Specifications

DESCRIPTION	SPECIFICATION
Product	HIKVISION 4CH 5MP TURB HD DVR
Encoding Ability	5MP at 12 fps
Channel	4 channels with 1 TB HDD
Resolution	Up to 2560 x 1944 Resolution
Compression	H.265

Appendix C – Cost of Hardware

DEVICE	COST
HIKVISION 4CH 5MP TURBO HD DVR	4, 088 PHP
HIKVISION 5MP at 20 fps IP67 Camera Outdoor Waterproof Analog Camera	1, 348 PHP
Power Cable	196 PHP
Total: 5, 632 PHP	

Appendix D – Miscellaneous Fees

DEVICE	COST
CCTV Installation	5, 600 PHP
Power Supply	800 PHP
Cable	114 PHP
BLC Connector (2)	90 PHP
DC Connector (2)	90 PHP
Power Plug (2)	70 PHP
Total: 6, 764 PHP	