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Smart City Garbage Monitoring System

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Abstract: ***In Sri Lanka, garbage dumping has long been a problem. The regional organizations have made various attempts to address this issue. But unfortunately, no appropriate action has been taken thus far. As a consequence, there are several environmental issues as well as human health issues, particularly among children. As a result, we have suggested some approaches to resolving these issues so that we can advance the nation. The prime objective of the suggested system is to provide a nation free from waste, and the suggested solutions support this objective as well. The suggested approach will benefit the municipality council in a variety of ways, reducing both labour and capital costs. The proposed system will calculate the amount of garbage that has been piled up effectively, giving truck drivers information that can be tracked via a mobile application. The system will warn pedestrians if they attempt to dump garbage out of the bin and also if they pile particular garbage in a different type of a bin other than designated bin. This will aid road cleaners in efficiently collecting garbage other than focusing more collecting trash from the roads. It will improve the garbage segregation process because the designated types of bins are also kept separately and can be utilized by the local bodies as they require, which helps to achieve our objective of this system***

I. INTRODUCTION

In most parts of the world including countries in the region of northern America and Asia we either burn or bury our regular trash. Both are harmful for the environment and us. Burning of the garbage will release harmful gases and dusts which will eventually pollute lakes, forests oceans and cities. These pollutants will contribute to the global warming and climate change. Now a days, most of the open burning in industrialize nations eliminates significant amounts of pollutants and contaminants guaranteeing better air. However, the majority of what they take out is dumped into land fields. Garbage burying causes air and water pollution and transportation of trash worsens this because of fossil fuel usage.

The assumption that waste is an unwanted substance with no inherent value has long dominated attitudes toward garbage disposal. Millions of tons of municipal solid waste are created every day all over the world. We are fully aware of the issues that arise from improper garbage disposal practices on a regular basis. Some people still burn waste materials, which is a serious concern. Using this form of garbage disposal can lead to several ailments, including respiratory diseases and others. All of these are a result of the general populace being misinformed and receiving inadequate guidance.

With the fast-growing population, the issue of overflowing garbage has grown worse. People do not have a proper waste disposal system in their area of vicinity.

As a result, people tend to throw away the waste to the place that is most close to them or any other area not knowing the consequences of improper disposal for that area. Right now, the damage done to the environment might be less but in future, it could severely affect even the lives of the people and affect them with various types of diseases. It is extremely disappointing to report that new solutions have frequently been presented to improve people's quality of life by addressing the growing waste management problem, but they have fallen short of

expectations because local government entities desired a good system but did not provide the priority it needed. People are constantly focused on just disposing of their trash; theydo not consider the recycling procedure. There won't be any improper waste dumping if it really matters to them. In many urban locations around the world, improper dumping has long been a concern. There are numerous steps involved in recycling rubbish, but because of ignorance and laziness, people tend to ignore the proper ways of recycling them. According to article [1], when segregating the different forms of thrown-away garbage, the workers suffer from various kinds of diseases as they aren’t provided with proper safety kits and equipment. This won't be a major issue to encounter and address if people dispose of their waste in the appropriate containers that are assigned by the municipal council. But both globally and locally, this has grown to be a significant issue. Additionally, even when there is a trash can, the general population frequently discards their waste outside the container and leaves immediately. Which has significantly exacerbated issues in our nation. Due to these practices, we have observed that some animals like stray dogs and cats, crows are used to carry the junk and drop it down on the main roadways, making the environment more polluted and unclean.

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II. PROBLEMS

The possible negative health impacts of various waste management practices, particularly those involving disposal and burning, have been extensively studied in recent years. There is relatively little information on recycling as well as very little on potential issues brought on by environmental exposures from composting [2]. Although a lot of study has concentrated on the general public's health particularly that of those who live close to a trash disposal site, occupational health issues of the staff engaged in waste management are also important to take into consideration.

There is a serious issue with people throwing rubbish away from trash cans and other locations, polluting the area and causing public places to become messy, untidy, and contaminated. where people throw their garbage in the wrong bin. People who don't use the designated bin to dispose of their trash make recycling and segregation processes more important. If waste is disposed of in the incorrect bin, there will be a significant labor expense. The smells and pollution brought on by abandoned household items and garbage unloading degrade the city and endanger the health of the populace. Additionally, mixing waste will bring on diseases and unnecessary air pollution, and when plastics are combined with wet waste, our land will become contaminated. Because of the reckless behavior of the general populace, which has a substantial effect on the nation's economy, foreigners are no longer attracted to the country. Additionally, the garbage that floats around the road makes it look unsightly and unpleasant to drive on, even if the entire road has just been freshly painted. People are unaware of the terrible pollution they cause for this nation. This is brought on by a lot of things, such as people's laziness, hurry, and lack of concern.

III. EXISTING WORKS

Before moving forward with the implementation of our proposed system, we went through certain existing projects that were developed in order to come up with a solution for the above said problems. So, for tracking the quantity of the garbage bin level, numerous systems were developed but some basic or important features were lacking in the said system. According to [3], the system would only track the quantity of waste in the bin but it doesn’t send the data to the local authorities and it doesn’t have a threshold level to notify that the bin is about to be full. In another research article [4], a said system was developed but it only tracks the amount of garbage in the bin and sends the data to the database. It doesn’t notify the local authorities or send a notification when the level reaches a certain limit.

For segregating the waste in the bn, [5]has proposed. The first compartment consists of an infrared IR sensor and metal detector. The second compartment consists of an IR sensor and moisture sensor to detect dry and wet waste. Further an automated approach to segregate recyclable material is proposed in [6]. The recycling bin is equipped with four types of sensors, namely inductive sensors to detect plastic, a capacities sensor to detect metal, a photoelectric sensor to detect paper, and a proximity sensor to detect motor position. When waste is inserted into the recycle bin, three types of sensors connected to Arduino Uno operate to detect the type of material. Once the detection is completed, the circular plate holding the waste will be rotated by the direct current motor to the respective material’s compartment. A pusher then pushes the recyclable material to the separation bin. The proposed system relies on several sensors that can add up to the maintenance and manufacturing cost of the recycling bin. As of now there haven’t been a proposed system yet that can detect the behavior of the person dumping the waste to the bin. When a person throws the waste, there should be an identification to check whether the waste was properly thrown into the bin or not. The research was to detect the unauthorized dumping of garbage through the camera in surveillance. Where they focus on datasets, they have stored earlier itself. Also, they have implemented this in real life through a real time monitoring algorithm system [7]. Also, there is another research which have been conducted where they monitor the human activity in order to know whether the people throw the garbage on the floor or somewhere else and capturing the particular person’s picture and tweeting the particular persons image in the twitter to complain him. This research was done through image processing algorithm and Histogram of Oriented Gradients (HOG). Using Histogram of Oriented Gradients, they have detected the human behaviors and using image processing algorithm which is OpenCV to track the trash or garbage [8].

Also another possibility to improve the waste disposal system, importance should also be given to timely collection of waste. Similar to the growth of businesses which depend on proper transportation, garbage waste also should be collected, transported and recycled in a proper way.

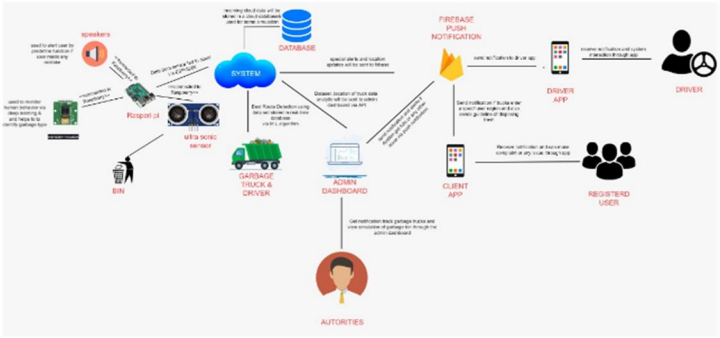
In order to achieve this, the participation of the public is also necessary. So a route tracking system has already been implemented but it lacks certain important features. According to [9], a route tracking was developed in order to help the waste collection process but it didn’t send an alert to nearby users when exactly the garbage truck comes unless they log in to a mobile application and check the location of the truck. As a result, users had difficulties in knowing when to dispose the waste to the nearby bin or keep it the door front.

Providing users with a route map, the truck is on its way. Users can also track the truck. However, some users do not have smart phones in their hands, while others do have smart phones but their network signal is very poor, so they cannot track and do not know whether they are coming or not. A similar system too was developed having only the said functionalities [10].

The proposed system will overcome most of the common problems that people have been facing due to improper waste management. The system has the ability to identify what type of garbage is about to be thrown into the bin. This way we can ensure that only designated waste types are encouraged to throw into the bin. The system also has a feature to capture the behavior of the user throwing the waste. If the user didn't throw the waste properly into the bin, an alert will be played to inform the user to throw the waste properly into the bin.

In order to help the local authorities to collect the waste in an efficient manner, the system sends an alert to the local authorities about the real-time garbage quantity that is present in the bin. This way they know which bins are about to be filled quickly and they can make sure to collect the waste on time. In order to help this process work well, the system will provide the best route to locate the bin that has reached its threshold level so that the overall process from collecting to removing the waste from the bin will be done efficiently. This way we can reduce the usage of resources of the local governing bodies such as labor, fuel, truck and truck drivers

IV. METHODOLOGY



A. Detecting the Waste Type in the Bin

The main objective of the proposed system is to find a solution to improper garbage dumping inside the bin. Where an image-based processing system should be developed to detect the garbage type and alerting the people through a sound if they are trying to dispose the garbage in improper way Which can help the authority to boost up the recycling process our system uses several libraries to detect waste type using image processing NumPy [11],Matplotlib [12],OpenCV [13].

To detect garbage type using image processing, sample waste images were collected from public Github repositories [14]and from Kaggle [15]for the dataset. There were about 2527 photographs, comprising 403 photographs of cardboard, 501 photographs of glass, 410 photographs of metal, 594 photographs of paper, 482 photographs of plastics, and 137 photographs of rubbish.

After collecting the waste images, we classified them using the Label Img tool [16] which is a graphical image annotation tool. It is written in Python and uses Qt for its graphical interface. Annotations are saved as XML files in PASCAL VOC format, the format used by ImageNet. Besides, it also supports YOLO and CreateML formats [17]. We labeled the appropriate portion of the image to the class it belongs to, such as cardboard, metal, garbage, plastic, paper and trash There are numerous algorithm available to detect object for an example convolutional neural network (CNN) [18], RCNN [19] and YOLO [20]. All these algorithm performs to or classify the pictures, cluster the images by similarity, and perform object detection with the help of pre trained data. We have choose YOLO because of the easiness in implementation and also as it is faster when compare with other algorithms such as R-CNN, Fast R-CNN, Faster R-CNN [21].

B. Monitoring Improper Dumping of Garbage

The primary objective of the suggested approach is to develop a way to properly dispose of the garbage inside the bin rather than putting it outside the bin for any other reason. Where a system based on image processing should be created to detect people's actions and warn them via sound if they throw garbage improperly saying correctly dump the trash.

The need for intelligent frameworks that can quickly identify unauthorized dumping and inform those responsible is critical. This will speed up the garbage collection process and make it easier for garbage collectors to collect trash. We require sample datasets

that can be utilized to train our model or system in order to accomplish this goal.

The data is compiled using the public GitHub Repository and additional sample images of the trash in our own nation. There were 5000 images of trash, including many different forms of trash like cardboard, metal, glass, photographs, and cardboard that had been thrown away. Every single kind of trash has been designated as garbage. If any form of rubbish is thrown to a floor where the camera has been mounted, the camera will alert the individual to correctly throw it inside the bin itself. Label Img was used to label every form of trash as garbage. The same set of libraries which is being used to detect garbage type has been used here as well. There were numerous approaches that could be used to complete this process. This proposed system can also be finished using HOG (Histogram of Oriented Gradients) Object detection, however that work is very hard HOG object detection allows us to record motion and classify it. After doing some research on choosing the most suitable algorithm that will help to categorize the datasets, YOLO was found out to be one of the suitable algorithm for this purpose because if it best fps(frames per seconds) in detecting object. With the help of any available algorithm, garbage can be found. but the chosen algorithm should operate well with inline chosen programming language We were able to spot the trash that had been thrown outside of the trash can using YOLO Version 4 However, the purpose of this approach is to teach people how to properly dispose of their trash inside the bin itself as opposed to tossing it outside the bin out of laziness or unawareness.

In order to achieve these objectives, a speaker must be fixed so that when trash is seen outside the bin where the camera is located, the speaker should sound an alarm to the public or pedestrians telling them to properly dispose of the trash inside the bin itself.

C. Detecting the garbage quantity

In order to keep track of the quantity of waste in the bin, a system is proposed where it helps to detect and alert the authorities when a bin reaches its threshold level. For example, if the remaining level in the bin reaches 20%, an alert should be sent to the authorities stating that the waste in the bin should be removed as earlier as possible or the bin might overflow with waste.

In order to overcome this, the proposed system has an Ultra Sonic Sensor embedded to the bin with the help of a NodeMCU **(**Node MicroController Unit). With the help of the sensor, the real-time garbage quantity can be detected. For the sensor to work, a code has been programmed in C++. For this, Arduino IDE will be used where the sensor is connected to the computer with the help of a USB cable. The program will then run in the background once the sensor is connected to the NodeMCU.

Now that the program has been written and implemented, we should also ensure to store the data of the real-time remaining quantity of the bin. For this, Firebase will be used as the database. It will keep updating the quantity and an added function should also be written to trigger an alert when the remaining quantity in firebase reaches 20%.

D. Finding the Best Route for the Truck

We proposed a solution like the waste bin is measured to see if it has reached a level that necessitates collection. If, as a result of this measurement, the bin is not completely full, the waste does not need to be collected, the system is put on hold until waste enters the system again. If the waste bin is full, the location information is transferred to the cloud in either measurement. The data from the waste bin is transmitted to the smart waste collection truck via the cloud. The route is then optimized using machine learning techniques. And the shortest path will be provided to truck, as well as an alert to users that the truck is on its way. The waste truck arrives at the waste bin via the optimized route and collects the waste in the bin.

Google Maps API: Will be used as a navigation tool. The reason for this is that the location information of and trucks is required for the route optimization process. The location bins are predetermined in the maps.

Electronic Visualization Tool: The use of a mobile phone as a visualization tool was deemed appropriate for the truck driver to follow the optimal route created by the model.

V. RESULTS AND DISCUSSION

The experiment is based on the Windows environment, using Google Collab, a cloud based IDE [22] for the training set and test set. Set the number of iterations to 2000, the batch size to 64.

Using 5,000 images as 6 types of garbage objects for training and 500 images for testing, it is found that when the number of iterations is between 0 and 200, the CIOU loss decreases significantly, and the accuracy improves significantly. From 800 to 1200, its training performance gradually stabilized, and the MAP value eventually reached 61% when the iteration came to 1800. The YOLOV4 training loss value is shown in Figure 2. The trained model is used to detect the garbage and its category. The detection result is shown in Figure 3. From the figure, it can be seen that the model not only detects the garbage object but also detects the garbage category.

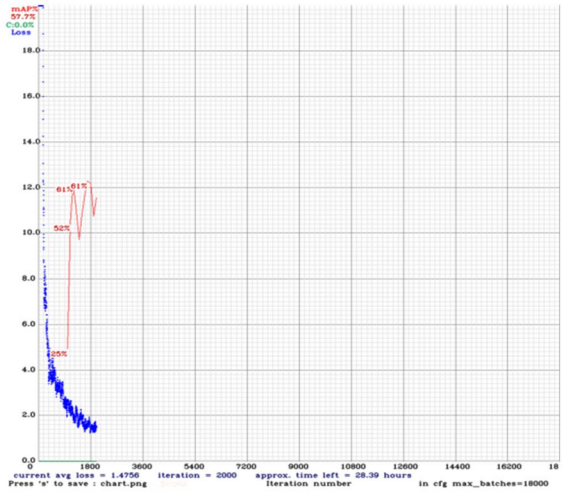


Figure 2

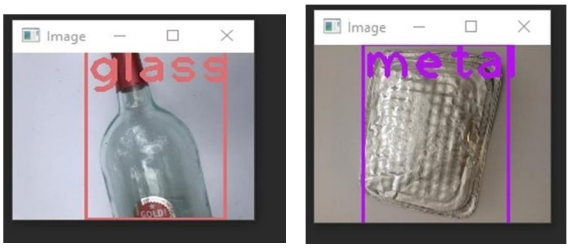


Figure 3

To train the model to capture the garbage type and improper dumping, there should be a significant amount of accuracy to achieve this. As shown in the results, the model was trained with about 5000 images and achieved about 61% accuracy. which has a moderate level of accuracy, but in order to achieve the objective of the functions, this accuracy is not ample. However, when the trained model is tested with actual objects, the model performs as expected and captures data at roughly 87% of the time. Some of the data that was recorded overlapped, for instance, some cardboards were mistaken for papers at night because of the darkness. The function should perform as it does in the daylight, thus that specific issue needs to be improved. Using Yolo5, the same number of photos may be trained, and the accuracy and data collection will be very effective in further improving the learned model.

With the use of the Ultra Sonic Sensor and the NodeMCU, the results of the experiment were collected. As mentioned in the methodology, the real-time remaining percentage of the bin helped us to accurately find out whether the bin is filled or not.

By placing the ultra-sonic sensor to the bin in a flat surface, waste items were constantly put into the bin to check the quantity that was remaining in the bin. For this sample, a 30cm long bin was used, according to the bin size the length that can be calculated was also programmed in C++ language using the Arduino IDE In order to power this sensor. Below, the screenshot of the captured data by the Ultra Sonic Sensor is shown.

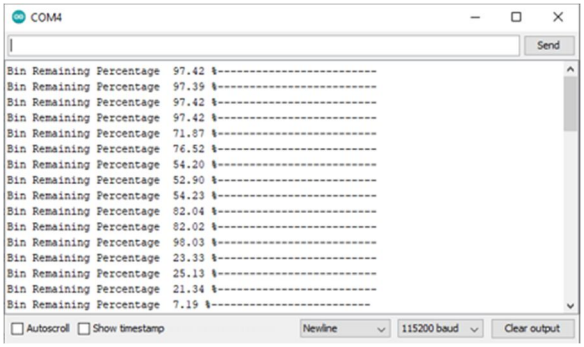


Figure 4

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As shown in the above figure 4, it can be stated that the data gathered are almost accurate and works well by calculating the remaining space of the bin. These collected data then have to be sent to a database where it can store in real-time and by the time the bin reaches 25% remaining, an alert will be sent through a mobile app to the local authorities to collect the waste. This way we can prevent public bins from overflowing with waste and making the surrounding unsuitable to walk past it.

We have tested the system with a mobile app that allows us to get the best route for the garbage to be collected. Through an algorithm, the shortest path will be shown to the drivers so that the cost on fuel expenses can be further reduced.

A Flutter app developed with Firebase as the database, has all the necessary features that helps to solve the problems that are related to distance and efficient truck and fuel management.

We have tested many routes in many areas and we have tested our mobile app in network area and some rural area where internet connection is slow .based on our results we able to determine our client app providing exact live location in well internet connected areas but when if the app functions in rural area, live location updates slowly but by sending sms based notifications we will able update users when truck nears to our customers by this solution we can neglect the issue of internet.

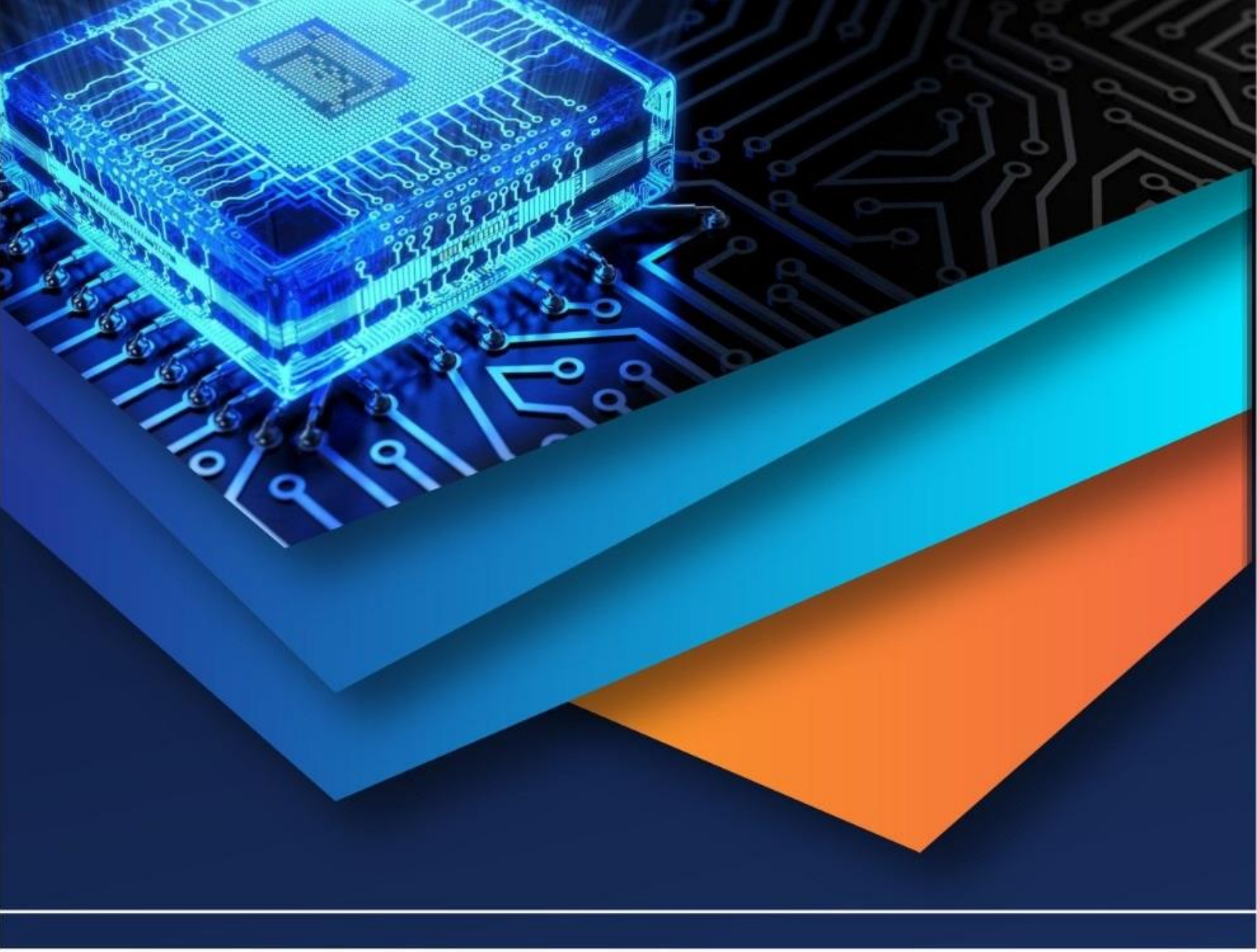
The route works well and efficiently when I try it with a certain amount of bins. Due to internal issues (network issues) and other factors, the route computation can occasionally take some time.

VI. CONCLUSION

So, by considering all the points that have been highlighted for the existing problem in the waste disposal system, the proposed and implemented system fixes most of the issues that are related to it. As a result, we can ensure that the system will be of huge benefit to the local authorities for them to collect and recycle waste in an efficient and effective manner.

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