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A Comparative Study of Real-Time Semantic Segmentation for Autonomous Driving

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Abstract: *Semantic Segmentation (SS) is the task to assign a semantic label to each pixel of the observed images, which is of crucial significance for autonomous vehicles, navigation assistance systems for the visually impaired, and augmented reality devices. However, there is still a long way for SS to be put into practice as there are two essential challenges that need to be addressed: efficiency and evaluation criterions for practical application. For specific application scenarios, different criterions need to be adopted. Recall rate is an important criterion for many tasks like autonomous vehicles. For autonomous vehicles, we need to focus on the detection of the traffic objects like cars, buses, and pedestrians, which should be detected with high recall rates. In other words, it is preferable to detect it wrongly than miss it, because the other traffic objects will be dangerous if the algorithm miss them and segment them as safe roadways. In this paper, our main goal is to explore possible methods to attain high recall rate. Firstly, we propose a real-time SS network named Swift Factorized Network (SFN). The proposed network is adapted from SwiftNet, whose structure is a typical U-shape structure with lateral connections. Inspired by ERFNet and Global Convolution Networks (GCNet), we propose two different blocks to enlarge valid receptive field. They do not take up too much calculation resources, but significantly enhance the performance compared with the baseline network. Secondly, we explore three ways to achieve higher recall rate, i.e loss function, classifier and decision rules. We perform a comprehensive set of experiments on state-of-the-art datasets including CamVid and Cityscapes. We demonstrate that our SS convolutional neural networks reach excellent performance. Furthermore, we make a detailed analysis and comparison of the three proposed methods on the promotion of recall rate.*

Keywords: Semantic Segmentation

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Smart Bins contribute to a cleaner, safer, and more sanitary environment, as well as improved operating efficiency, while lowering management costs, resources, and roadside radiation. Campuses, theme parks, airports, railway stations, and shopping malls are all good candidates for the Smart Bin. Smart bins are a trash management device that is clever. They include wireless ultrasonic fill-level sensors built within that detect how full the bin is and send the data to a cloud-based monitoring and analytics platform via the Internet of Things. A dustbin is a garbage receptacle constructed of metal, plastic, or any other hard-to-store waste material that is used for temporarily keeping trash. They store energy in a variety of renewable and non-renewable materials and contribute to environmental protection clean. When the trashcan receives the signal, it automatically opens and closes its hatch. A level measuring ultrasonic sensor is also included in the dustbin, which continuously measures the amount of waste in the bin and automatically identifies when it is about to fill up. Smart waste management is characterized by the application of technology to improve waste management efficiency. This not only allows trash collectors to design more effective routes for emptying the bins, but it also reduces the likelihood of any bin remaining full for more than a week. As the world around us transforms and becomes more linked and digitalized, public transportation is expected to provide in every way. How far are we from developing a complete Smart Rail system, from cutting-edge technology to comfort, safety, reliability, and sustainability? We remark that cleanliness of the surrounding space in the train is also vital. We don't know how much scrap is collected in the dustbins because so many people go by train, and we don't utilize enough manpower for each train, so we apply this system and establish a green and clean city. The smart railway dustbin locator is primarily focused on human health issues, as various variant viruses, such as Covid-19, are having an impact on human bodies and reducing human life spans. As a result, human power will be reduced by using this system, which will automatically notify you on your screen where dustbins need to be replaced and where ordnance is detected

Shikha Parashar and colleagues [1] Waste management, from collection to dumping and interruption, has become one of the most difficult and time-consuming tasks for municipal organizations all over the world. A new concept of Smart Dustbin has been considered for Smart buildings, hospitals, schools, and train stations to make this arduous choreeasier. The Smart Garbage Collector concept is an evolution of the standard garbage collector that incorporates sensors and some type of logic to make it smart. This smart collector is a ground-breaking concept that uses a line-following garbage vehicle and a pole-mounted rubbish component to follow a pre-planned railway pattern. The stationary bin uses ultrasonic sensors to detect garbage levels and uses an RF module to communicate the bin's current level to the garbage car. As a result, this is a fully automated system that contributes to the Clean India, Green India theme.

According to M.Ashwin et al. [2] trash management is a big issue all over the world. The clever is a cutting-edge automated gadget that collects old absorbent care products separately. In smart cities, the Automatic Intelligence Smart Bin assists in resolving trash management issues. In smart cities, the smart bin will play a vital role. The smart lifestyle starts with a clean environment in the city, which starts with a smart bin. The HC-SR04 Ultrasonic Sensor is used to recognize humans, and the TowerPro SG90 Servo Motor is used to automatically open and close the smart bin lid. The smart bin's overall functioning was controlled by an Arduino Uno microcontroller. The smart bin uses an IoT sensor to differentiate dry and wet waste collection. When the smart bin is 80 percent full, the microcontroller automatically sends a warning message to the garbage collector.

M. Dhaifallah and colleagues [3] on a micro grid model of a hospital, hybrid optimization of diverse energy resources was undertaken to evaluate the capability of a standalone energy system and simultaneous waste mitigation. The study'smain goals were to gather renewable energy resource data for a hybrid hospital, use the average amount of hospital waste from the literature and NASA surface meteorology, as well as the solar energy database from HOMER Pro software, to build a hybrid model for a conceptual hospital in Saudi Arabia's new green city, NEOM. Biogas cofire and diesel generators, as well as a PV solar array and batteries, made up the hybrid model. The load requirements of a freestanding hospital were analyzed using simulations. Tesla batteries were used to design the energy storage system.

One of the most significant applications of the Internet of Things (IoT) in this digital era, according to Jacob John et al. [4], is the development of smart cities. Smart objects (devices) are connected to each other via the internet as a backbone in IoT-based smart cities. Using multi hop connectivity, the smart objects' detected data is sent to the sink for further processing. Smart cities use studied data to improve their infrastructure, public utilities, and services by utilizing IoT technology for the betterment of the general population's well-being. Waste collection is a major issue for governments that want to establish a clean environment in IoT-based smart cities. As the population of metropolitan areas grows, so does the amount of waste produced.

D. Krishnakumar and colleagues [5] On India, solid waste management has been a big issue in railway waggons for decades. It is common knowledge that if solid waste is not adequately managed, it will have a significant negative impact on the environment. The goal of this project is to collect solid garbage that passengers throw out the window and recycle or reuse it. Between two parallel window frames, two conveyor belts are placed one above the other. Four collection tanks are also installed, one pair at each end of one conveyor belt. A level sensor (ultrasonic sensor) and a GSM module are installed in the tanks. The garbage is directed onto the conveyor via two exit pipes connected from the interior. Each coop is equipped with a switch that, when pressed, activates the conveyor belt, preventing it from running indefinitely without any work to be done. The entire system, which consists of two sets of conveyor belts, is housed in a casing between the window's parallel frames.

According to Dr.T.M.N.Vamsi et al. [6,] appropriate waste management through the use of technology is a serious worry of the hour. Monitoring and disposal of waste are currently done by people, which is inconvenient; however, by augmenting the traditional system with the flavour of IoT, monitoring of garbage bins will be simple. This benefits those who work in the traditional garbage collection system, and it is the most practical solution. The SGMDSS is a cutting-edge information management control system that aids metros, cities, and villages in maintaining hygiene and cleanliness through improved waste disposal. This technology employs a cutting-edge approach that automates garbage monitoring and disposal. SGMDSS monitors garbage bins at various locations and notifies cleaning employees of the level of waste gathered in the bins via an android mobile application for disposal, as well as providing the shortest path to the garbage bin site that is almost full. This data is also transferred to a webpage, and the full database is saved and retrieved via the cloud. In addition, the worker receives an alarm message.

According to Ashi Goel et al. [7], the centrality of a town is determined by the quality of its air, the cleanliness of its roads and highways, and its overall atmosphere. One of the most pressing concerns as we work toward our wonderful vision 2020 aim of becoming a developed and affluent nation is hygiene. Our mission is 'Swachh Bharat Abhiyan,' hence we invented a 'Smart Toilet' and a 'Smart Dustbin.' Those who live in the city must be forced to suffer from a variety of ailments if cleanliness is not maintained. Suddenly, a plethora of new diseases appeared. There are numerous rubbish bins available, as well as many public toilets being built by the government, but most people have no knowledge where they are or where they are located when they walk out in new places. The method's architecture collects this information and transmits it via a wireless network. This paper may be useful in encouraging the majority to support the Clean India effort. It will be able to demonstrate the emerging role in the Clean India scheme in the future. Sensors are used to detect the level of rubbish in the dustbins and public bathrooms, and the information is transferred to the official mobile station via GPS module.

Mudike Koushal Yadav and colleagues [8] Modern garbage management practices, from collection to dumping and disruption, have become a difficult and time-consuming task for municipal organizations all over the world. A novel concept of Smart Garbage Collection System has been considered for Smart buildings, hospitals, schools, and railway Stations to make this tedious work easier. The Smart Garbage Collector concept is a modernization of the traditional garbage collector that incorporates sensors and electronics to make it smart. This smart garbage collector is a ground-breaking concept that uses a line-following garbage vehicle and a pole-mounted rubbish component to follow a predetermined train path. The fixed bin uses ultrasonic sensors to indicate waste level and uses an RF Module to update the volume level of the bin to the garbage car. As a result, this gadget is a completely automated system that contributes significantly to the Clean India, Green India initiative.

According to Murali Krishna Thirumalakonda et al. [9], waste collection in public spaces and communities is a big problem today. Unsanitary conditions cause a variety of diseases and harm to the environment. This may be avoided by placing a smart dustbin in the vicinity. This smart garbage management system is an advance over a regular bin, and it uses ultrasonic sensor systems to check the garbage level above the dustbin. An ultrasonic sensor is a device that measures the distance between an object and the user. The bin may be opened and closed automatically using a sensor. When the bin is full, the buzzer will sound. Then, when the trashcan is full, it will transmit an alert message through GSM module, which is attached to the circuit. As a result, the system is useful in waste management when it is monitored and informed on a regular basis. This results in a cleaner city for a higher quality of life. The smartphone app is developed as a graphical representation of daily updates to ensure a greener environment and support for Swachh Bharat for cleanliness. It is improved by the use of two bins, one for wet garbage and the other for dry waste. Wet trash decomposes quickly to produce biogas, which can be used in the home.

According to Rishabh Kumar Singhvi et al. [10], a smart system that monitors the trashcan and provides real- time status is required for the development of smart cities. Municipal corporations in India do not yet have access to real-time information about trash cans. In order to address this issue, we are building an Internet of Things (IoT)-based system that can send a notification to a company about the overflow and toxicity level of the dustbins. A website is also being created to keep track of the data related to the trash cans. The dustbin status is updated on the website and a message is sent to the mobile phone through GSM module. Citizens can also file complaints about trash cans or waste management on this website. Arduino is utilized as a microcontroller in the recommended system to interface between the GSM/GPRS module and the sensors. Dustbin level and toxicity are measured using an ultrasonic sensor and a gas sensor, respectively.

III. PROBLEM STATEMENT

Railway workers, like humans, are on the front lines of the fight against contagious diseases. They are regularly in contact with diseased people and also with health in the surrounding railway boogie.

IV. PROPOSED SYSTEM

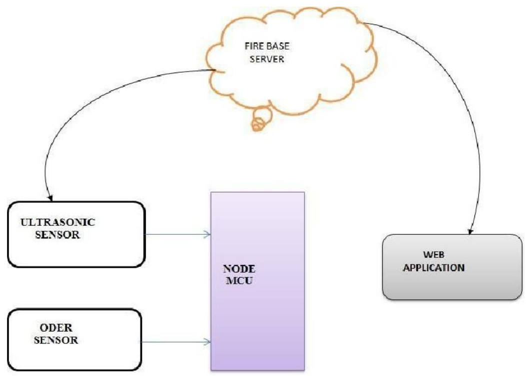


Figure 4.1: Architecture of proposed system

4.1 Working of Proposed System

A. Ultrasonic Sensor

Ultrasonic sensors work by emitting a sound wave that is above the human hearing range. The sensor's transducer functions as a microphone, receiving and transmitting ultrasonic sound. To deliver a pulse and receive the echo, our ultrasonic sensors, like many others, use a single transducer. The sensor measures the time between sending and receiving an ultrasonic pulse to determine the distance to a target.

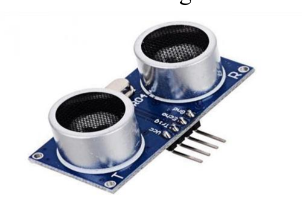


Figure 4.2: Transmit and receive signal

1. Ultrasonic sensors send sound waves at a target and measure the time it takes for the reflected waves to return to the receiver to determine its distance.
2. This sensor is an electronic device that uses ultrasonic sound waves to detect the distance to a target and then converts the reflected sound into an electrical signal.

B. Oder Sensor

Fig 4.3 Oder Sensor

When molecules of any chemical element are placed on the surface of a sensor, the e-nose operates. When a sensor is exposed to scents, the change in resistance is detected. The outcome is a pattern that is unique to that element. Our technology is built around an Oder sensor that detects where Oder is present in the trash can. To keep the railway bogie’s environment clean. Aside from that, there is a stench there, and there isn't a lot of scrap. As a result, we'll need another sensor to detect odor.

C. NODE MCU

The ESP-12E module on the NodeMCU ESP8266 development board contains an ESP8266 chip with a Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor runs on a configurable clock frequency of 80MHz to 160MHz and supports RTOS. To store data and programmer, the NodeMCU contains 128 KB of RAM and 4MB of Flash memory. It is perfect for IoT projects due to its high processing power, built-in Wi-Fi / Bluetooth, and Deep Sleep Operating capabilities. A Micro USB jack and VIN pin can be used to power NodeMCU (External Supply Pin). It has interfaces for UART, SPI, and I2C. The NODE MCU is the system's heart in our design. This is used to control all operations by connecting two sensors, one Ultrasonic sensor and the other an Oder sensor

Figure 4.4: Node MCU

4.2 Server / Web Application

In this system, data can be predicted by ultrasonic sensor and order sensor, which is nothing more than an ultrasonic sensor that detects the level of scrap in the dustbin and whether or not there is a smell present. This data is sent to the server, where we register/ login with our login id and password and then open one sheet with content ID, level, order, and comment, which is nothing more than whether or not the dustbin needs to be replaced. And the above technology provides excellent information regarding dustbin levels, resulting in a reduction in human manpower and a significant reduction in other infections infecting humans.

Login ID	Level	Oder	Comment
12546	5inch	Present	Need to replace
25345	8inch	No	Need to replace

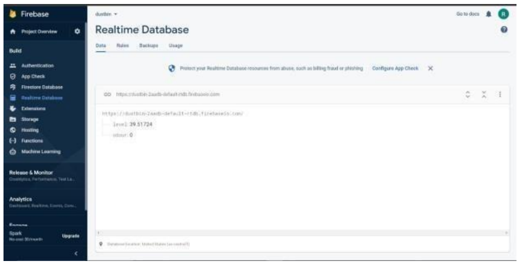
Login /Register Output:

The heading of the Acknowledgment section and the References section must not be numbered. Causal Productions wishes to acknowledge Michael Shell and other contributors for developing and maintaining the IEEE LaTeX style files which have been used in the preparation of this template.

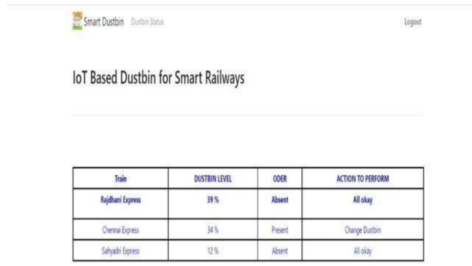
V. RESULT AND DISCUSSION

The below result page shows the construction of a login and registration page, which has we give a signup and login page with a username and password to present the real-time database of design project results.

Result page 1. Login and Registration



Result Page 2. Fetching Hardware components to take real time database.



Train	DUSTBIN LEVEL	ODER	ACTION TO PERFORM
Rajdhani Express	39 %	Absent	All okay
Chennai Express	34 %	Present	Change Dustbin
Sahyadri Express	12 %	Absent	All okay

Result page -3 Experimental result of smart Railway dustbin.

Above result page which will show Real time database from server to this page project is designed based on hardware module which is mechanically connected with dustbin and Node MCU ESP8266 is Wi-Fi compatible is heart of system which takes real time analog value to send server and design and developed web application to show all the notifications of the dustbin related where is level, Oder is present or not, and what will be action to take.

Above result page shows real-time experimental results of smart railway dustbin, which clearly displays train position such as rajdhani express to display dustbin level 39 percent and order is absent, action performance is all right. At the Chennai express location, the second row displays 34% of the dustbin level and an order is present, therefore action will be taken to change the trash.

VI. CONCLUSION AND FUTURE WORK

Smart Bins contribute to a cleaner, safer, and more sanitary environment, as well as improved operating efficiency, while lowering management costs, resources, and roadside emissions. The Smart Bin is suitable for high- traffic areas. The smart bin transmits information about fill levels and guarantees that the bin is only collected when it is completely full. As a result, the streets will be cleaner and safer. Because of the pattern of the presence of keen innovation, the advancement of clever frameworks, notably in the improvement of clever dustbins, would in general increase. The experimental results show that the smaller-than-normal and super-brilliant dustbins framework works and performs as expected. The results of the evaluation of the application for savvy dustbins revealed that the presence of shrewd dustbins spread throughout the room unequivocally consented to provide benefits and drew in extremely exorbitant interest in familiarity with discarding waste perfectly positioned, notwithstanding, it is important to further develop the brilliant dustbin framework to further develop its presentation just as it is important to further develop the brilliant dustbin framework to further develop its presentation just as it is important to further develop the brilliant dustbin

FUTURE WORK

Using photoelectric, methane, and smell sensors, separate garbage (wet and dry) based on moisture content. To sort garbage into hazardous and non-hazardous categories. To dispose of the garbage created in an efficient manner.

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