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DEEP LEARNING APPROACH FOR WASTE CLASSIFICATION

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Abstract
Every country's growing population causes an excessive amount of waste to be produced, which builds up everywhere. Our environment is contaminated by this waste, which also causes a host of health problems. The remainder of the generated waste is disposed of in landfills, with only one-fifth being treated. Waste treatment facilities become much simpler when waste is segregated. Waste is typically separated manually by the employees who collect it. The project identifies various waste types, including paper, plastic, and metal cans, using a neural network algorithm. Waste treatment facilities benefit greatly from the automation process, which also saves a great deal of time and effort. The two specialized code-editing programs PyCharm and Google Colab were used to create this project.

Keywords: Segregation, Pycharm, neural network algorithm, Keras.

I. INTRODUCTION

One of the biggest problems facing the world's population growth today is the amount of waste produced, which makes environments less hygienic and increases the spread of infectious diseases. The problem is made worse by the conventional municipal waste management systems, which are unable to keep up with the speed at which waste is generated. This leads to overflowing garbage bins. Our project aims to transform waste management practices by utilizing machine learning (ML) algorithms, as we recognize the pressing need for inventive solutions. We seek to address these urgent environmental and public health issues by utilizing technologies like Tensor Flow and Keras within PyCharm, ultimately aiming to create a cleaner and greener environment for everyone. Integration of YOLO with Python allows for efficient image processing, real-time object detection, and seamless communication with the traffic control system.

To guarantee environmental protection by putting into practice efficient waste management techniques. Preventing pollution and ecological degradation brought on by unchecked waste accumulation is essential to this mission. Using machine learning (ML) algorithms, we aim to reduce the negative environmental effects of improper waste management practices by streamlining waste collection procedures. Furthermore, in keeping with our dedication to preserving public health, our project aims to offer a reasonably priced waste collection service that is available to everyone, thereby enhancing community well-being and quality of life.

Combining with the potent machine learning libraries Tensor Flow and Keras to separate waste materials into three groups: paper, metal cans, and plastic. Utilizing the power of these state-of-the-art technologies, our system is able to distinguish and separate waste with previously unheard-of accuracy and efficiency. Using PyCharm, we have created a stable and user-friendly platform that makes ML algorithm implementation easy. This allows for smooth experimentation and collaboration. With these resources at our disposal, we can finally bring our vision of a more sustainable future to life, one in which efficient waste management techniques guarantee pollution avoidance, environmental preservation, and the advancement of public health and welfare.

II. LITERATURE SURVEY

In [1] a smart solid waste management system uses sensors in bins to collect real-time data on waste levels and composition. This data is transmitted to cloud servers, enabling efficient waste management strategies, prioritizing waste-generating regions, streamlining collection routes, and implementing targeted interventions. The study proposes real-time garbage level monitoring using ultrasonic sensor technology and microcontroller-based systems in dustbins[2] This system is linked to a central monitoring system, allowing remote viewing of garbage levels. The WiFi module's functionality ensures smooth communication and timely waste accumulation updates. In [3] the proposed mobile application tracks waste levels in bins and provides real-time fill status information without physical inspection. It streamlines waste management procedures by prioritizing removal based on waste levels and odor detection. This approach maximizes resource allocation and improves efficiency, thereby raising cleanliness and hygiene standards in the surrounding area.

The study proposes [4] a method for analyzing garbage using volume estimation, 3D reconstruction, and image segmentation techniques. It uses deep neural networks for image segmentation, SIFT features for 3D reconstruction, and Poisson surface reconstruction for volume estimation, aiming to improve waste management and environmental preservation.

The study[5] presents a prototype IoT-based system that monitors garbage bin fill levels, enabling efficient collection routes. This data is sent to a central server for processing, improving operational effectiveness and reducing unnecessary trips. This innovative waste management strategy could significantly enhance urban sanitation practices.

The Integer Linear Programming (ILP) algorithm [6] is used for waste collection path planning, optimizing parameters like truck numbers, routes, and acoustic effects. It integrates with the Net2Plan-GIS planning tool, allowing for easy integration of GIS data, resulting in streamlined urban waste collection procedures, reduced environmental impact, and increased operational efficiency.

In [7] the Automated Garbage Disposal System (AGDC) uses a robotic arm controlled by a microcontroller to efficiently pick up and dispose of waste. It uses real-time video analysis and a Raspberry Pi to detect and calculate garbage distance, achieving a 90% detection accuracy rate.

A [8] novel robotic design uses Convolutional Neural Networks (CNN) with SegNet architecture to efficiently identify and categorize trash in grassy areas. With an average ground segmentation time of 10.3 milliseconds and garbage recognition time of 8.1 milliseconds, it improves waste management effectiveness.

The [9] proposed IoT infrastructure effectively separates waste into recyclable and organic categories in indoor and outdoor environments. Its response time is impressive and can manage 3902 garbage bins simultaneously. This scalable architecture offers efficient waste segregation, encourages sustainable behaviors, and promotes cleaner, greener communities.

In [10,11,12] a three-tiered architecture bin that includes a smart bin, gateway, control station that tracks the bin's real-time parameters, and an accelerometer that tracks the lid's opening. Data is transmitted from the bin to the gateway via ZigBee, and from the gateway to the control station via GPRS. The bin status is tracked by six distinct sensors.

III. PROPOSED SYSTEM

The world's population growth is causing a significant issue with waste production, which leads to less

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hygienic environments and increased spread of infectious diseases. Conventional municipal waste management systems struggle to keep up with waste generation, resulting in overflowing garbage bins. A project aims to transform waste management practices using machine learning algorithms, such as TensorFlow and Keras, within PyCharm. The goal is to create a cleaner and greener environment, preventing pollution and ecological degradation caused by unchecked waste accumulation. The project also aims to offer a reasonably priced waste collection service, enhancing community well-being and quality of life. The system uses TensorFlow and Keras libraries to accurately and efficiently separate waste materials into paper, metal cans, and plastic. PyCharm provides a user-friendly platform for ML algorithm implementation, allowing for smooth experimentation and collaboration.

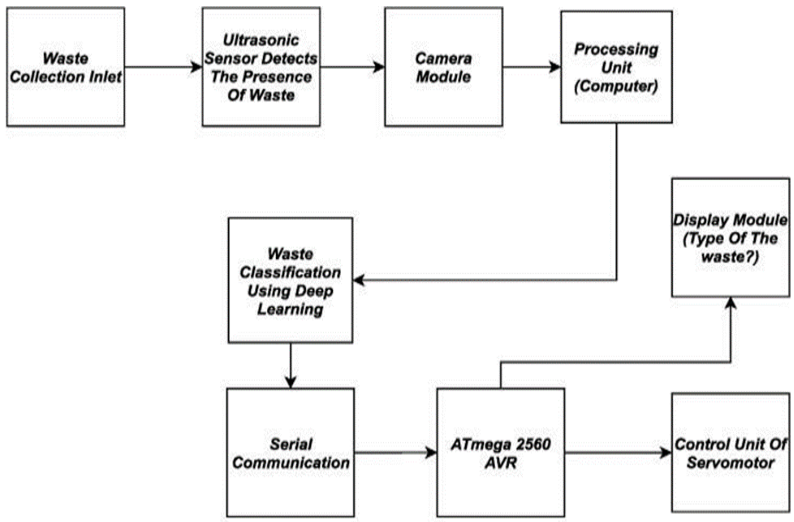

Fig 1: Block diagram

IV. METHODOLOGY

NEURAL NETWORK

A computational model called a neural network is modelled after the composition and operation of biological neural networks seen in the human brain. Layers of linked nodes, referred known as neurons, make up this structure. After receiving input signals and processing them using an activation function,each neuron sends its output to the layer of neurons below it. It is possible for neural networks to learn from data by using a procedure known as training. In order to reduce the discrepancy between its expected outputs and the actual objectives, the network modifies the weights connected to each neuronal link throughout training. Usually, gradient descent and other optimisation methods are used to accomplish this operation.

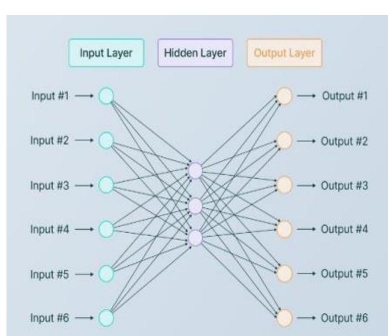

Fig 3.2 Neural Network Architecture

In a number of industries, including computer vision, robotics, natural language processing, healthcare, and finance, neural networks have demonstrated impressive results. They are still a vibrant field for research and development, propelling advances in machine learning and artificial intelligence.

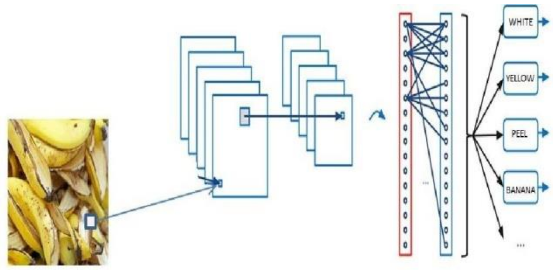

Fig 3.2.Neural network utilized for prediction and waste classification

Fig 3.2 shows the structure of the CNN model to detect and classify the garbage images. Similar to image classification, CNNs are commonly used for this task. We can train the CNN on a dataset of labelled images, each with bounding boxes and class labels identifying the objects in the image. During training, the network learns to identify and classify objects in the image and locate them using bounding boxes. All the input images are resized to 224×224 pixels. Since all the images are in color, there will be 3 channels for RGB. The input image will be given to 3 convolutional layers and pooling layers for better feature extraction. Then ReLU is activated to get linear output.

The image size is reduced to 28×28 by the max pool layer. 19 Next is flatten layer. This converts the previous output to the 1D array and gives it to the dense layer. In dense layer only, actual learning process takes place. It does the mathematical operations same as artificial neural network. The weight will be multiplied with the input vector and it will be added with the bias. The number of output neurons of the first dense layer is 64. After that ReLU gets activated. Dropout is added to avoid overfitting of the output. Here dropout value is 0.2 which means 20% of the random data will be dropped out. The next dense layer has 32 output neurons and again dropout is added. The final dense layer has 6 output neurons since the number of classes to be identified is 6. The Softmax layer will be added just before the output layer which also has the same number of neurons as the output layer. The Softmax function is used to apply probability distribution for all classes during testing. The class which has the maximum probability will be the output.

V. IMPLEMENATATION OF THE PROPOSED SYSTEM

PROPOSED ALGORITHM

Garbage classification and detection with Deep Convolution Neural Networks for Smart waste management.

1. First load the directory containing all the types of trash images.
2. Divide the data set into training, validation and testing dataset.
3. Generate training, validation and test image set using Image Data Generator.
4. Image pre-processing is done. Image resizing is also done only since the dataset is taken in a controlled environment.
5. Generate labels for each of the image in those folders using the directory name in which the images are stored.

6. Print some details like labels, image batch size.
7. Store the labels in a file to be viewed later.
8. Create the 15-layer neural network architecture for the project. It is done so thatit can conveniently run at the system. A larger network though may create a betteraccuracy,it may not possible for the system to comprehend such a network model.
9. Train the model using the training images with epoch=50.
10. Validate the model using validation images.
11. Now the model run the testing images, to print the accuracy and loss.
12. It also print probability of each image for each of the label, training accuracy, validation accuracy.

DOWNLOADING THE DATASET

The dataset contains images that comprises of

1. Paper
2. Plastic
3. Can

The dataset is downloaded from Github. The images are already resized to 512 * 384 . These images are split into training and testing images.

TRAINING THE MODEL

The model is made to train in such a way that it is able to classify the waste as :

1. Bio-Degradable waste
2. Non Bio-Degradable waste

Also, it identifies and classifies the detected waste and categorize it into one of the following three categories.

VI. SYSTEM SPECIFICATIONS

i.PYCHARM :

PyCharm is one of the most widely used tools for Python programmers working on machine learning projects. An excellent array of integrated scientific tools is provided by PyCharm Professional, including integrations with Jupyter Notebook, Conda, and a REPL Python terminal. It features a scientific mode that suppo,rts interactive scientific computing and data visualisation, as well as the ability to create scientific projects.

ii.LIBRARY FILES

a. Keras -

The free opensource python library for developing and evaluating deep learning models. It allows to define and train neural network models in just a few lines of code. It acts as an interface for the Tensorflow library.

b. Tensorflow

The end- to- end opensource platform for machine learning. It is the main opensource library used to develop and train ML models.

c. OpenCV

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The crossplatform library to develop computer real time computer vision applications. It mainly focuses on image processing, video capturing and analysis including features of face detection and object detection.

iii.TINKERCAD

Tinkercad is a web-based computer-aided design (CAD) software developed by Autodesk. It is primarily targeted towards beginners, educators, and hobbyists who want to learn 3D modeling and design without the complexity of traditional CAD software. Tinkercad offers a user-friendly interface and intuitive tools, making it accessible to users of all ages and skill levels.

VII. HARDWARE REQUIREMENTS

Arduino UNO

Ultrasonic sensor

LCD Display

Servo Motors

ARDUINO UNO

Arduino UNO is a low-cost, flexible, and easy-to-useprogrammable open-source microcontroller board that can be integrated into a variety of electronic projects. This board can be interfaced with other Arduino boards, Arduino shields, Raspberry Pi boards and can control relays, LEDs, servos, and motors as an output. Arduino UNO features AVR microcontroller Atmega328, 6 analogue input pins, and 14 digital I/O pins out of which 6 are used as PWM output, shown in fig 4.1.

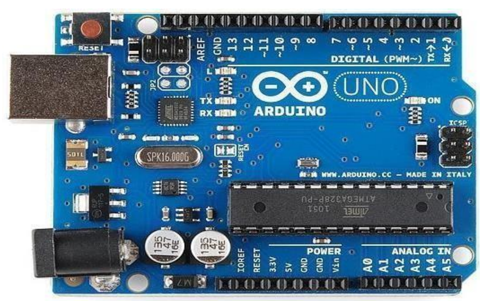

Figure 4.1 – Arduino UNO board

ULTRASONIC SENSOR

An ultrasonic sensor is a device that uses ultrasonic waves to measure distances to nearby objects. It works on the principle of sending out high-frequency sound waves and measuring the time it takes for the waves to bounce back after hitting an object. Ultrasonic sensors can be used as an alternative to camera modules in certain applications where visual data is not required or where environmental conditions are not suitable for camera-based systems.

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Figure 4.2 – Ultrasonic sensor

LCD DISPLAY

A Liquid Crystal Display (LCD) is an electronically-modulated optical device shaped into a thin, flat panel made up of any number of colour or monochrome pixels filled with liquid crystals and arrayed in front of a light source (backlight) or reflector. It is often utilized in battery-powered electronic devices because it uses very small amounts of electric power. LCD has material, which continues the properties of both liquids and crystals. Rather than having a melting point, they have atemperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered from similar to a crystal.

Figure 4.3 – LCD Display

SERVO MOTORS

In waste segregation systems, servo motors can control sorting mechanisms within the bin to separate different types of waste. For example, the bin could have compartments for recyclables and non-recyclables, and the servo motors could move dividers or gates to direct incoming waste to the appropriate compartment based on its type. Servo motors can be integrated into the waste bin to detect when it reaches its maximum capacity. Once the bin is full, the servo motor can trigger an alert system, such as a light or sound indicator, signaling that the bin needs to be emptied. This helps prevent overflow and ensures timely waste disposal. By integrating servo motors into automated waste bins, these bins can become more efficient, hygienic, and environmentally friendly, while also improving the overall waste management process.

Figure 4.4 – Servo Motor

ISSN 2394 - 9554

VII. CIRCUITDIAGRAM

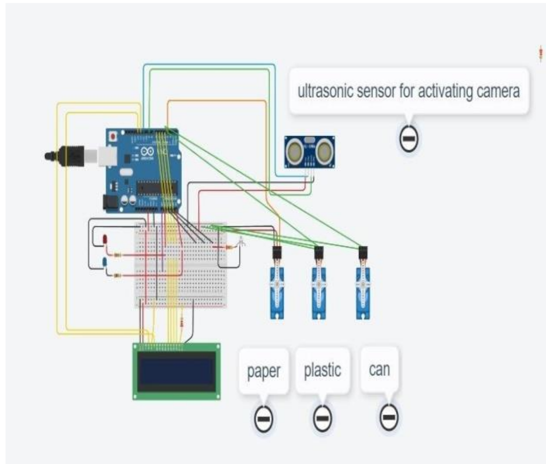

Figure 4.5 – Circuit Diagram figure.

The above circuit diagram is designed using Tinkercad. It is an open source simulation tool. The above figure integrated Arduino Uno , Breadboard, Potentiometers, a LCD display and an ultrasonic sensor. The sensor is used to measure the level of garbage bin . The garbage bin is replaced here with potentiometers. There are three potentiometers corresponding to Plastic , Paper and Can. Whenever the level of garbage reaches the threshold value , the potentiometer changes its position indicating that the bin level is getting high and the respective message is printed on the LCD display.

VIII. SIMULATION RESULTS USING PYCHARM

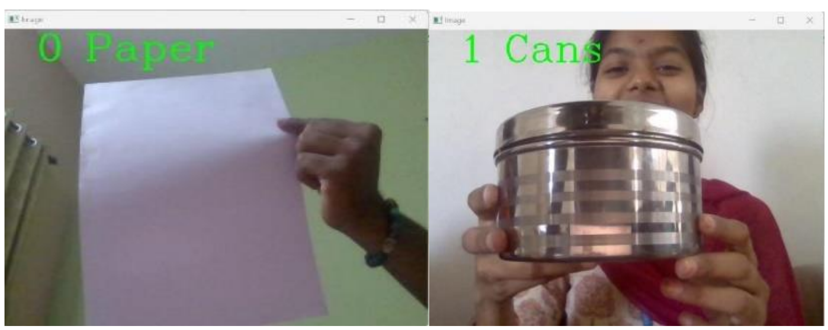

Figure 5.1 – Paper and Can classification

The above figure depicts the Pycharm simulation result which classified the provided waste into Paper and a Can respectively.

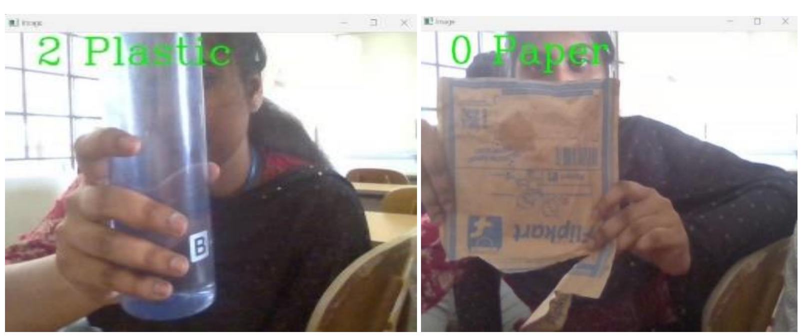

Figure 5.2 – Plastic and Paper classification

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The above figure depicts the Pycharm simulation result which classified the provided waste into Paper and a Can respectively.

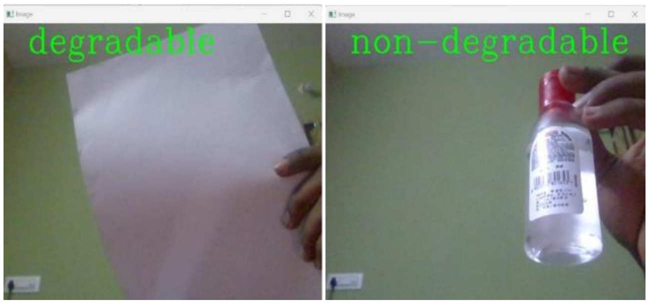

Figure 5.3 – Classification based on degradation

The above classified output is almost correct with maximum accuracy. To get much more accuracy, the epochs and learning rate have to be increased. The output shows the classified class. The above images show some of the outputs of the tested images. Here the tested images are splitted from the dataset. The above outputs for the images captured in mobile phones.

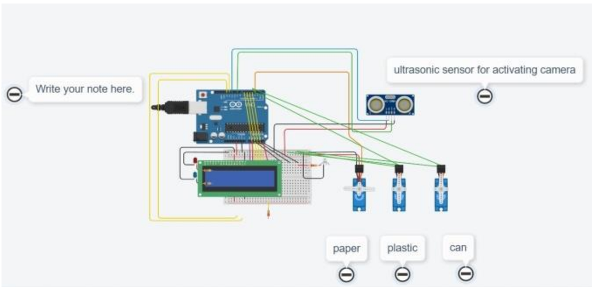

Figure 5.4 – Simulation output using Tinkercad

In the above figure, we infer that whenever any waste (plastic or paper or can) is brought near the bin, the detection and capturing is done with the help of the ultrasonic sensor which acts as the camera module here. It captures and classifies the image. Once it is classified, the corresponding bin gets opened. The activity of the bin is replaced with the help of the servo motor which does automatic opening and closing of the lid. In this case, a paper waste is brought near the bin. Hence the motor corresponding to the paper rotates and the position is being changed.

IX. CONCLUSION AND FUTURE SCOPE

Monitoring the garbage and waste segregation today requires human support and moreover it is difficult to cover the entire urban area. The proposed system of garbage classification using Neural Networks and plays a vital role in the development of smart cities. Many images of garbage including plastic, paper and can are collected for training. The training and testing were done. By giving different garbage images the model was tested and the output attained the maximum accuracy. This system has the lower cost and the better performance than the traditional method. Thus, this technology is used to provide improvement on garbage disposal methods in urban areas, smart cities and smart home. In future work, this model will be scaled to increase the performance by increasing the number of images in the dataset with different backgrounds. Moreover, a comparison with other classification algorithms will be performed in order to validate the current scheme or improve it. Future work will involve adding this model to real-time cameras and drones and detecting the places with more wastes in streets and sending the information to the responsible person or to the collector. The collector can be essentially being programmed to receive

ISSN 2394 - 9554

inputs from the drone about the type of garbage detected upon which the collector will clean up the litter, segregate the waste into recyclable and non-recyclable materials.

As future work, cameras and microcontroller can be integrated to build a robot that can move around a public space and identify waste object on the ground, then pick, collect and segregate the wastes automatically without any worker.

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