23XT56 - Machine Learning Lab

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ABSTRACT:

Kuppa Thotti is a smart dustbin made to solve a common problem in student rooms - waste often ends up on the floor instead of inside the bin. The system helps students maintain a cleaner and more hygienic space by automatically detecting, identifying, and sorting waste. It combines computer vision, deep learning, and basic robotics to create a compact and fully automated waste management solution.

SYSTEM OVERVIEW:

The system is powered by a Raspberry Pi, which acts as the central processing unit. A Pi Camera is mounted on the dustbin to monitor its surroundings. The design uses simple, low-cost hardware components such as a servo motor, an LCD display, and a few peripheral modules, making it suitable for small spaces like hostel rooms.

MOTION DETECTION:

Motion detection is done using the libraries: picamera2 and opencv. The camera constantly watches the area above the bin, and when it detects significant motion, it captures an image after a short waiting period. To avoid detecting shadows or small changes in lighting as motion, the system uses a background subtraction method that can identify shadows by creating a mask of the moving objects. Next, a threshold is applied to remove pixels caused by minor lighting changes or shadows. Finally, morphological operations like opening and dilation are used to clean up the mask by removing small, isolated areas. These steps together ensure that only real movements of objects are detected, preventing false triggers and keeping the system idle when there is no actual trash above the lid.

WASTE CLASSIFICATION:

After the camera captures an image, it is sent to a deep learning model that runs on the Raspberry Pi. This model is trained to recognize common waste items such as paper balls, banana peels, plastic bottles, and pens. To train the model, the dataset was divided into three parts: training, validation, and testing. Data augmentation was applied during training which included flipping images horizontally, rotating them slightly, zooming in and out, and shifting them, along with which class weights were also calculated to make sure that all waste categories were learned equally, even if some categories had fewer images than the rest. These steps helped the model learn better and become more adaptive.

The base of the model is MobileNetV2, which is a lightweight network suitable for devices like the Raspberry Pi. At first, the layers of MobileNetV2 were frozen. This means that the pre-trained weights of these layers were not changed. Later, for fine-tuning, quite a few layers of MobileNetV2 were unfrozen. This allowed the model to adjust these layers to better recognize the specific types of waste in the dataset. On top of MobileNetV2, additional layers were added. These included a global average pooling layer, batch normalization, a dropout layer to prevent overfitting, and a final dense layer with softmax activation for classification.

The model was trained using early stopping and learning rate reduction. Early stopping stops training when the validation accuracy does not improve, and learning rate reduction lowers the learning speed if the model is not improving. The best version of the model was saved during training.

WASTE SEGREGATION:

After classification, a servo motor is activated to direct the waste into the correct compartment. The servo is controlled using the pigpio library, which allows precise movement by adjusting the pulse width sent to the motor. Items identified as biodegradable are moved to one compartment, while non-biodegradable items are guided to another. This automated segregation reduces human involvement and ensures that waste is separated correctly at the point of disposal.

FUTURE ENHANCEMENT:

The next stage of development focuses on enabling the system to detect and track waste in mid-air, including objects that are thrown or dropped. The system will compute the trajectory of the object, and predict its landing point. It will then navigate to that location, position itself accurately, and catch the waste, and then perform the existing processing sequence. This enhancement will elevate the dustbin from a passive container to an active, intelligent system capable of dynamically interacting with its environment to maintain hygiene and order.

CONCLUSION:

Kuppa Thotti shows how simple and affordable technology can solve real-life problems. By combining motion detection, image classification, and automatic sorting, the system reduces human effort and encourages proper waste management. It is a clear example of how computer vision and machine learning can be used in small devices to create a useful, eco-friendly innovation, tailored for student surroundings.