MEDICAL WASTE SEGREGATION AND MANAGEMENT

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Introduction:

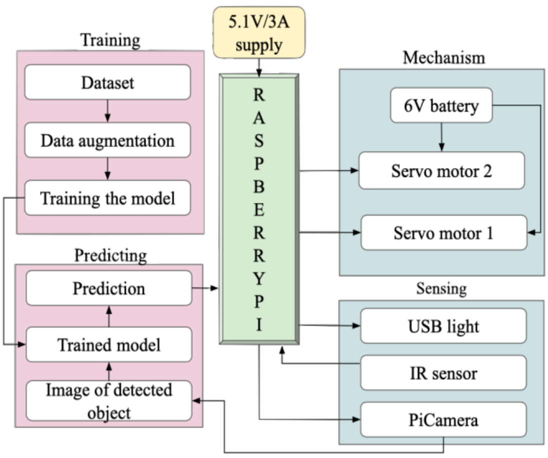
This project pioneers an automated waste sorting system, leveraging CNNs, Raspberry Pi, and servo motors to enhance medical waste management. Previous efforts in waste automation underscore the need for accurate, scalable solutions, especially in healthcare. The CNN-based approach enables real-time identification and sorting of medical waste, reducing contamination risks and improving recycling. Raspberry Pi's versatility ensures accessibility and portability, crucial for widespread adoption. The integration of servo motors allows precise sorting based on CNN's classification. Earlier work involved dataset creation and model training using the AlexNet architecture, ensuring robustness and accuracy. Overall, the project represents a significant leap in sustainable waste management, addressing critical environmental and public health challenges.

Objectives:

The objective is to develop an automated waste sorting system using CNNs, Raspberry Pi, and servo motors. This system aims to accurately identify and segregate medical waste in real-time, reducing contamination hazards and enhancing recycling efforts. Key goals include achieving high accuracy in waste classification, ensuring scalability and portability with Raspberry Pi, and enabling precise sorting with servo motors. The project seeks to streamline waste management processes in healthcare facilities, promoting sustainability and public health. By leveraging advanced technology and machine learning algorithms, the objective is to revolutionize waste sorting practices and contribute to a cleaner, healthier environment.

Methodology:

The block diagram of the suggested system is depicted in the following picture, which is divided into two separate sections: software and hardware. The training, prediction, and their steps are all included in the software portion. The USB light, Pi camera, infrared sensor, and separation mechanism's servo motors are all found in the hardware section. This system's software consists of classifying the items that are detected and developing a model. Building a sizable dataset and utilizing the AlexNet architecture to train it is the process of training a model. The model is used for prediction after it has been trained. To predict the type of object, the trained model receives the image of the identified object. The Raspberry Pi4 serves as the main operating module for the hardware component. It provides signals to the servo motors and Pi camera after receiving signals from the IR sensor. A Raspberry Pi 2 module B, a Tower pro MG995 servomotor, an infrared sensor, a USB light, and connecting wires are among the parts of the system. Aluminum composite panels are used only for the hardware setup because of their lightweight nature. Additionally, ball castor wheels were added beneath the plate that the input bin is placed on to improve the rotating motion and prevent overloading the servo motor. By employing the AlexNet architecture to train a model, the segregation is accomplished. To train the model, a dataset comprising a syringe, cotton, gloves, and mask was constructed. These things were photographed in a variety of colors and shapes. To provide a strong dataset for the model's training, each of these objects was tossed several times to acquire different positions.



Results and Conclusions:

The analysis of key performance metrics, including accuracy, loss, ROC curve, and confusion matrix, underscores the effectiveness of our CNN-based approach in segregating medical waste. With training accuracy reaching 98% and testing accuracy plateauing at 96% after 30 epochs, our model demonstrates robust learning without overfitting. The steady decrease in training loss to 0.2 and stabilization of testing loss at 0.25 indicate effective reduction in prediction errors. The ROC curve exhibits smooth upward trajectories with AUC values of 0.89 for gloves, 0.85 for syringes, 0.96 for needles, and 0.89 for cotton balls, highlighting the model's discrimination capability between waste categories. While minor misclassifications were observed, the confusion matrix demonstrates overall good performance.

In conclusion, our CNN-based system, integrated with servo motors and Raspberry Pi, presents a novel approach to medical waste segregation, reducing contamination hazards. Transfer learning on the AlexNet model enhances the system's ability to recognize and segregate items effectively. Raspberry Pi's computational prowess enables real-time image processing, while servo motors facilitate seamless waste disposal. By eliminating manual labor dependency, our system ensures human safety and contributes to sustainable waste management practices, setting a benchmark for technology-healthcare collaboration.

i) What is the innovation in the project?

- CNN-based image recognition for precise waste identification.
- Raspberry Pi for real-time data processing and analysis.
- Servo motors for automated sorting based on CNN's outputs.
- Diverse dataset for enhanced model accuracy and adaptability.
- Transfer learning on AlexNet to optimize model training.

j) Scope for future work (about 20 lines).

Looking forward, future developments for the automated waste sorting system will focus on expanding its capabilities to include a broader range of medical waste categories and improving accuracy through advanced image recognition techniques. Integration of IoT technology will enable remote monitoring and control, while the potential incorporation of robotic arms may enhance precision in waste handling. Additionally, optimization through data analytics and mobile application development for real-time updates and user interaction will be pursued. Sustainability measures and regulatory compliance will remain key considerations, alongside collaboration with industry partners to drive ongoing innovation in medical waste management practices.