AUTONOMOUS WASTE SEGREGATION ROBOTICS

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ABSTRACT

In this paper, taking inspiration from the existing autonomous solutions in the waste management sector we have created a vision system to segregate 5 types of plastic wastes - HDPE, LDPE, PET, PVC, and Polystyrene for different recycling purposes. We have used Pybullet, a Real-Time Physics Simulator to implement a KUKA LBR iiwa robotic arm for picking and sorting plastic wastes in simulation. Simulation and real-world results show that the vision system can classify different plastic wastes. Segregation of different plastic wastes is important since each plastic type has its unique use after recycling. This project has been done under the Robotics Research Group(RoboReg) at the Indian Institute of Technology(BHU) Varanasi.

1 Introduction

Although still a major portion of the population relies on manual labour at work in dump yards and landfills for manual sorting of waste into recyclable waste or not it cannot be denied that it poses a great risk to the worker's health. For this reason and for much smoother and efficient handling and sorting of waste materials many countries have come up with autonomous solutions with Artificial Intelligence and Robotics to sort and segregate recyclable waste items.

Different plastic objects generally tend to be made of particular plastic types. We have implemented a Deep Learning Model since they are relatively cheaper to deploy along with neural networks and models being good function approximators and estimators. We have aimed to group and segregate different plastic objects based on the plastic types they are likely to be made through the vision system. This serves as a primary level filter to sort different plastic wastes. We had further aimed to implement haptic technology along with the vision system to accurately segregate plastic waste with the use of a robotic arm since each plastic type has unique mechanical properties. The entire motivation behind this model is to provide a cost-efficient solution in the waste management industry along with providing advanced human-like perception with the use of both vision and haptic technology to the autonomous solution. However due to constraints caused by the COVID-19 pandemic the haptic technology section could not be accomplished since real-time environment testing was not possible off-campus. Hence we have wrapped up with the vision system working and implementing the primary plastic waste segregation with KUKA LBR iiwa robotic arm in simulation.

2 Task Description and Methodology

We have created 4 groups for plastic classification using the vision model and chosen 4 plastic objects belonging to each of the respective groups. The respective groups and plastic objects are:

- HDPE and PVC : Pipe
- LDPE and HDPE: Plastic Toys
- LDPE , HDPE and PET : Plastic Bottles
- POLYSTYRENE : Thermocol Sheets

where PVC plastic pipes find applications in drainage systems, irrigation, and sewers. HDPE pipes are generally used for the distribution of chemicals, natural gas, and water transportation system. Flexible toys are made of LDPE. PET is the plastic that is widely used for bottled water packaging.LDPE plastic bottles are used as lab bottles as they provide good chemical resistance. HDPE bottles are generally white and provide mild stiff impact resistance along with a moisture barrier. The vision model predicts results both on real-world objects and simulation objects. We aim to successfully classify pictures of these plastic objects both in real-world and simulation environment into their corresponding plastic-type categories.

2.1 Training the Vision Model

The training and creation of the vision system has been done on Google's Collaboratory, with the training data uploaded on Google Drive. The training dataset consists of 425 images consisting of both real-world images and simulation images of plastic objects. 75 percent of the training dataset images have been used as the training set and the rest 25 percent have been used as the cross-validation set. Transfer Learning VGG-16 model with Deep Convolution Neural Network has been used to have faster and more accurate results. Batch size of 32 and the number of epochs 15 were chosen which yielded the least training and validation loss at the end of training the vision model.

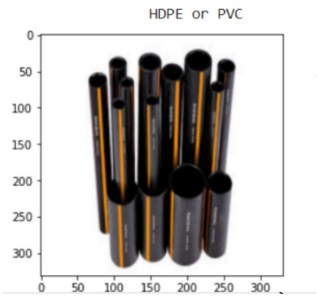


Figure 1: Pipe

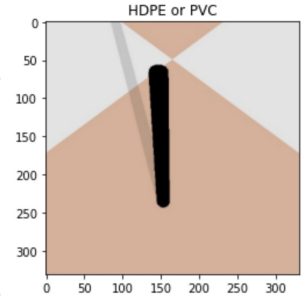


Figure 2: Pipe Simulation

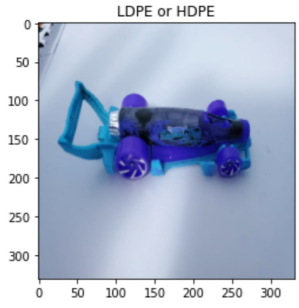


Figure 3: Toy Car

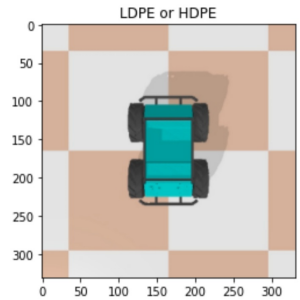


Figure 4: Toy Car Simulation

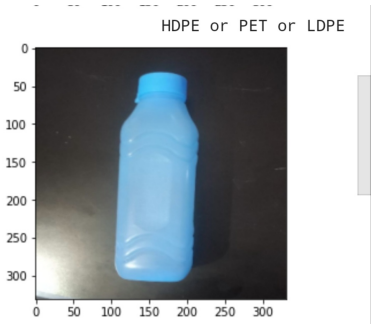


Figure 5: Bottle

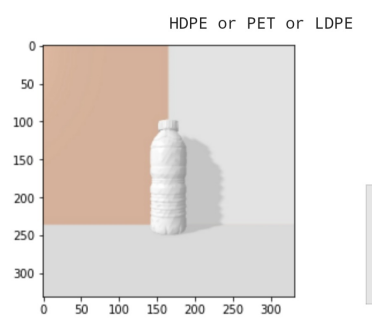


Figure 6: Bottle Simulation

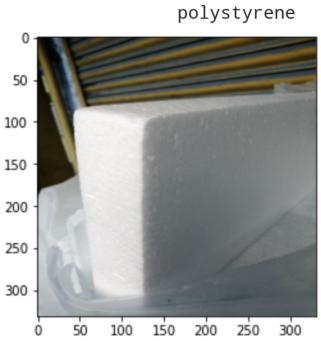


Figure 7: Thermocol Sheet

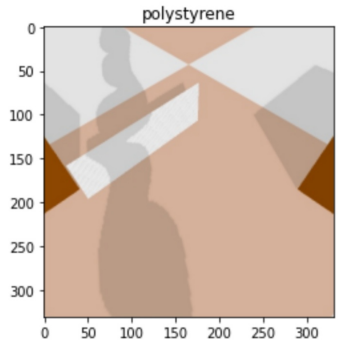
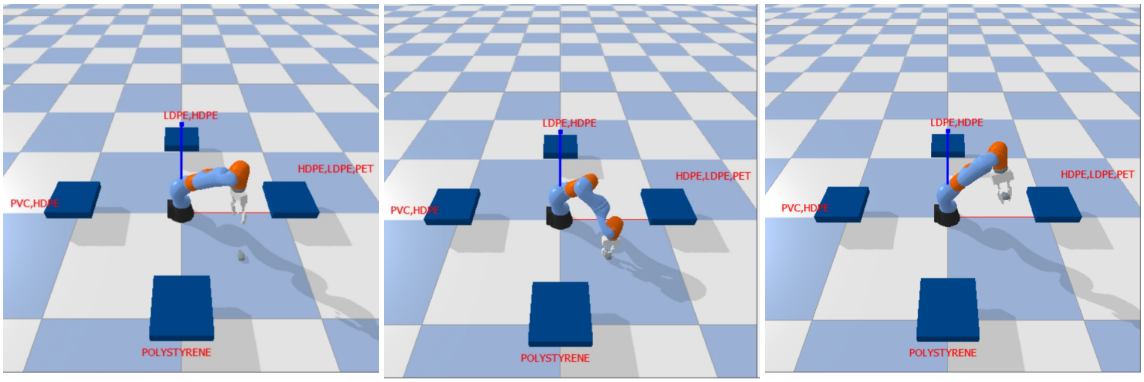


Figure 8: Thermocol Sheet Simulation

2.2 KUKA LBR iiwa robotic arm Movement



The robotic arm used is a modified Kuka arm (KUKA LBR iiwa robotic arm) where a different gripper has been chosen. The environment consists of four platforms labeled polystyrene, LDPE or HDPE, HDPE or PVC, HDPE or PET or LDPE placed equally spaced at four corners and with the robotic arm placed at the center. The waste material(object) which is to be classified, is simulated at a certain area. The position of the object is estimated by object detection (for example, we can use YOLOv3). Thereafter, pose estimation is done, and then, the object is grabbed using a gripper by applying a definite force. Once the object is grabbed, the arm then places it to its definite place according to the predictions yielded by the vision model.

3 Future Research Scope

The vision model serves as a primary filter to sort a large number of plastic wastes into groups of plastic types it can be made of. However, with the introduction of haptic technology along with the vision system with the use of pressure sensors/tactile sensors, it can impart the model 2 characteristics from human perception power and thus can provide more accurate results and increase the power and robustness of the autonomous solution.

References

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