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Waste sorting using machine vision

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Abstract

Waste management is a growing problem everywhere around the world. Waste such as plastics, electronic wastes and many other recyclable items usually end up in landfills polluting soil and groundwater. Recycling is the best way to manage the waste menace but it is also a tedious process. Handling large amount of waste generated, requires assistance of advanced technology. Wastes may also contain harmful chemicals or toxic metals such as lead, mercury etc and therefore employing humans in waste sorting can affect the health of workers. The solution to this problem is to use advanced machines for doing jobs which are risky for humans. Machine vision technology can be used to recognize most of the objects in the waste stream which moves on a conveyor and it can be sorted based on the detection. These waste sorting machines can operate round the clock. Thus the speed and capacity of waste processing is improved. A miniature working model of a waste sorting machine is fabricated.

Keywords: Machine vision, waste sorting, waste recycling

1. Introduction

Waste management is a growing problem everywhere around the world. With growing population and immense amount of waste generated every day, many countries resort to dumping these wastes in landfills. This cause's soil and groundwater pollution. While in some regions people locally burn components contain potentially harmful materials such as mercury, lead, cadmium, beryllium, etc.

Reuse and recycling of materials is the most effective solution to the growing waste problem. But recycling is also a tedious process. Harmful chemicals or other toxic substances which may be present in the waste affect health of people who work in recycling plants.

Solution to all these problems is to employ robots for handling tasks which are difficult, hazardous or risky for humans. Machine vision and sensors can be used to identify objects and then it can be sorted by robots.

Automation of waste processing plants have numerous benefits. Waste can be processed faster and in larger amounts. It reduces impact of harmful chemicals or materials on health of workers since there is minimal human intervention. Resources and energy is saved by recycling and reusing.

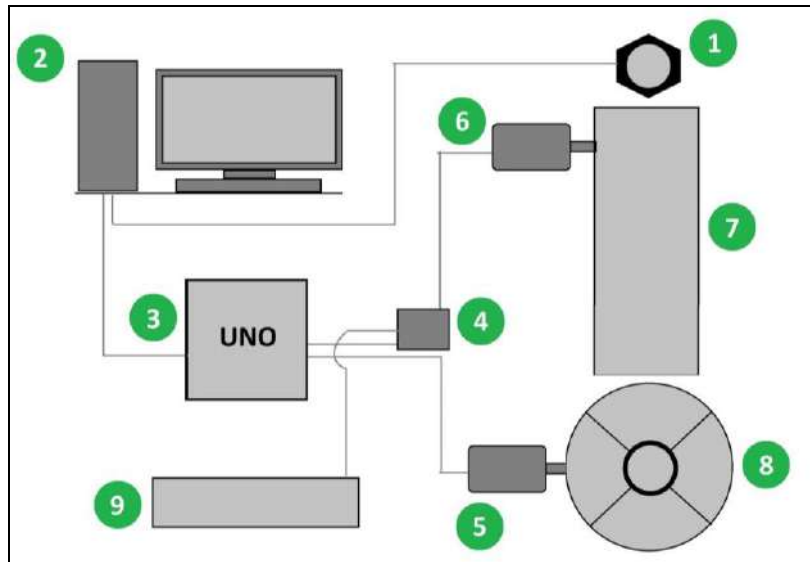
2. Design

2.1 Process flow

Android device continuously provide video data to the computer over internet. Video is captured by Android device camera. An application 'IP Webcam' is used to stream the video to an IP address generated by the application. Video data is received on the computer by connecting to the IP address. The Java program connects to the IP address and receives the video data. Individual frames are processed by the program at specific intervals and scanned for presence of any object. The object recognition program is written in Java using opencv library.

Waste is loaded on to the conveyor one item at a time. When an object is recognized, program sends control signal to the arduino microcontroller via serial port. The program running on the arduino detects the signal. It firstly aligns the correct tray below the conveyor and then starts the conveyor. Thus the object falls into collection tray.

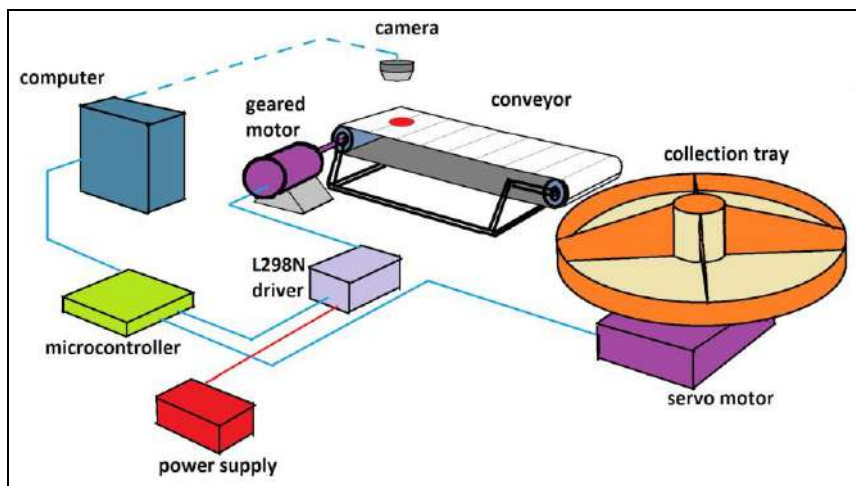
2.2 Basic layout



Img 1: Basic layout of components

2.2 Components

- | | |
|----------------------------|--------------------------|
| 1. Camera | 5. Servo motor |
| 2. Computer | 6. Geared motor |
| 3. Arduino microcontroller | 7. Conveyor |
| 4. L298N driver | 8. Waste collection tray |
| | 9. Power supply |



Img 2: 3D layout of components

3. Materials and Methods

3.1 Materials and components details

- Android device with camera
- Computer -
- Microsoft Windows 8.1 64-bit OS Intel core i3-2100 CPU (3.10 GHz)
- Arduino UNO
- L298N driver
- Servo motor
- Geared motor - 150 RPM
- Battery - 9V rechargeable
- Roller for conveyor

Raw materials

- Cardboard - 3 mm thickness
- Plywood - 0.5 inch thickness for platform
- Aluminum L angle

- (Side x side : 25mm x 25mm)
- Nut and bolt
- Mild steel rod - 4 mm diameter

3.2 Methods

Component fabrication and assembly

Video data acquisition and object detection module

Android device is held on a holder made of cardboard with the camera above the conveyor

Conveyor module

Frame for conveyor was made by joining aluminium L angle pieces using nut and bolt. Holes are provided in the frame to hold rollers for the conveyor belt. Conveyor belt is made of thick paper. Geared motor drives the roller and the conveyor belt and it is powered by battery connected via the L298N driver.

Collection tray module

Tray was made by shaping cardboard. The tray is circular and it is rotated at specified angles by the servo motor to align it as required, below the conveyor. Servo motor is directly powered by the arduino microcontroller.

4. Results and Discussion Limitations

- Dirt, dust, stains, discolouration etc can change the external appearance of objects and can interfere with recognition.
- If waste items are deformed, crushed, broken etc recognition will be difficult.
- Some items will be an assembly of multiple objects and so cannot be classified into one category.
- Some items may have multiple parts inside a casing or cover and so the individual parts are not visible to the camera.
- If an item is not in the object recognition software database it cannot be detected.
- Even if everything goes fine there are chances of errors in object recognition
- In practical situation if this type of a waste sorting plant is to function efficiently then wastes should be collected from source in its original form without crushing.

The waste items should be loaded on the conveyor in scattered manner for camera to detect individual objects. This requires the intervention of a human worker. Certain items which have no specific form or shape (Such as torn clothes, plastics etc) may not be recognized by the software. This again requires human intervention.

5. Conclusion

Use of machine vision to sort waste is an effective way to improve performance of waste processing plants especially in case of non-deformable waste. If waste items are deformed, crushed, broken or discoloured, recognition will be difficult. In such cases, use of advanced object recognition algorithms will be required. Also computers with more powerful processors, dedicated GPU and more RAM can improve the overall performance of the object recognition system. With the current state of technology, human assistance is still required in combination with artificial intelligence for the smooth operation of automated waste processing plants.

6. Recommendations

Higher resolution camera with higher focusing capability for handling objects in wide range of sizes can improve the performance of the object recognition system.

In the current design, the computer is connected to arduino microcontroller via USB. If this wired connection is replaced by wireless communication over the Internet then the computer is no longer physically connected to the rest of the hardware. This can be achieved by using server computers and a wifi module attached to the arduino microcontroller. This means the computer can be anywhere in the world and still control the operation of the waste sorting plant.

In the current design, only one item is loaded on the conveyor at a time. This is not practical in a waste processing plant. There will be multiple items scattered over the conveyor under the camera and in such a situation the object detection program should identify all the objects as

well as their corresponding positions on the conveyor and then robotic hands can be used to pick and place the items in the appropriate collection tray.

Humans use a combination of senses to identify objects. In this machine, additional sensors which detect properties such as magnetism, electrical conductivity etc can aid in improving the results of classification

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