Automatic Segregation of Waste Materials

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***Abstract*—Around the globe, solid waste generation is increasing day by day and the improper management of this waste is hazardous to human health and the ecological system. The world faces a problem of disposal, segregation and recycling of solid waste. The increasing population, urbanisation and industrialisation resulted in an increase in the generation of solid waste. Wastes are not always waste if they are segregated, transported and disposed of. The economic value of waste is best comprehended when it is segregated. Waste segregation will lead to the reduction of risks to public lives and a sustainable environment. Currently, there is no such system employed of the segregation of glass, plastic and metallic wastes at the industrial level. To segregate the waste material, the team propounds an automatic segregating bot consisting of sensors, conveyor belts, shaft motors, servo motors, motor drivers and microcontrollers. The inductive and capacitive sensors identify the type of material and the different materials are dumped into separate bins respectively, through the conveyor belt, the whole process is controlled by the microcontroller.**

***Index Terms*—Automation, segregation, solid waste, waste management.**

I. Introduction

The primary motive of this project is to aid the proper management of waste material in the scrap industry. The waste generation around the world was estimated to generate 2.24 billion tonnes of solid waste, amounting to 0.79 kilograms per person per day and it is expected to increase by 73 percent from 2020 levels to 3.88 billion tonnes in 2050. So it is necessary to manage the waste through recycling of solid waste. For this the segregation of waste is needed to be done, this paper proposes an automation of waste material Segregation in the scrap industry. This gives the solution of segregation of three types of waste: glass, plastic and metal. It is designed to sort the trash into metallic waste, plastic waste and glass waste ready to be processed separately for the next process. Automatic waste segregation will lessen the human interaction with waste materials and it reduces the threat through proper management of solid waste.

II. Literature Survey

Waste segregation can be defined as the process of identifying, classifying, dividing and sorting garbage and waste products in an effort to reduce, reuse and recycle materials. In order to segregate waste appropriately, it is important to correctly identify the type of waste that is generated. For the purposes of waste segregation at source, waste is identified and classified into the following categories depending on its biological, physical and chemical properties: Dry Waste, Wet Waste, Sanitary Waste, Hazardous Household Waste, etc. When waste is unsegregated, it may get contaminated with different types of waste being stored together. Waste Segregation is always stepped one for all types of waste management solutions that may be implemented either on an individual level or community level.

III. System Architecture

A. Existing System

The separation of waste has been assisted by many robots, including Dr. A. Prashant Gupta and Brintha Therese, who proposed using Raspberry Pi to create a Robotic Arm with Real-Time Image Processing, which can either be automated or can be operated manually. Jash Shah and Sagar Kamat presented an artificial intelligence-based system for identifying, removing, and sorting items on a moving conveyor. The majority of the top-performing object detection networks today use CNN (convolutional neural networks). Recycling and organic materials must be categorised using advanced approaches since they are challenging to categorize. A worldwide strategy is required for industrial applications in addition to the gathering of datasets. The study proposes an optimal waste categorization method that is more accurate and efficient.

B. Proposed System

Waste plays a significant role in our society. Separating it into its own categories helps in effective recycling. For the process of separation, automatic segregation of waste bots is employed. It comprises sensors, a microcontroller, four motors and a motor driver to control them.

When the waste is dumped into the funnel, a single object is allowed fall on the conveyor belt. Firstly the object passes through the inductive proximity sensor. If the sensor detects a frequency which matches a metallic one the conveyor belt rotates in the opposite direction and falls in the respective bin else the belt moves forward and stops at the Capacitive proximity sensor. This sensor detects whether it's plastic or glass. If it is plastic, with the help of rack and pinion the

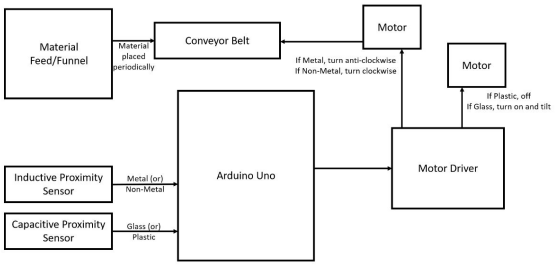

Fig. 1. Workflow

object will be pushed in the opposite direction which then falls into the bin else the belt will be moved forward till the object is made to fall into the glass bin.

IV. Architecture

A. Hardware

1) Arduino Uno: The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button

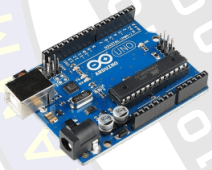

Fig. 2. Arduino Uno ATMEGA328P

The Atmega328 has 32 KB of flash memory for storing code (of which 0,5 KB is used for the bootloader). It has also 2 KB of SRAM and 1 KB of EEPROM.

2) Motor driver L298N: This L298N Motor Driver Module is a high-power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver

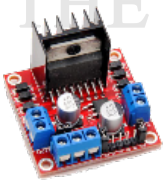

Fig. 3. Motor Driver L298N

IC, a 78M05 5V regulator, resistors, a capacitor, Power LED, 5V jumper. L298N Module can control up to 4 or 2 DC motors with directional and speed control.

3) Inductive proximity sensor: An inductive proximity sensor is a sensing device that detects metal targets using electromagnetic energy and without contact.

The sensing range of an inductive proximity sensor changes based on the type of metal being detected. They detect objects

Fig. 4. Inductive proximity sensor

and typically give a 0–10 VDC output based on the distance between the target and the sensor. Inductive proximity sensors enable the detection, without contact, of metal objects at distances of up to 60 mm.

4) Capacitive proximity sensor: Capacitive Proximity Sensors can detect non-metal objects, such as liquids, plastics, and glass. They detect their targets through changes in capacitance

Fig. 5. Capacitive proximity sensor

between the sensor and target material. They usually have a larger sensing distance than their inductive counterparts, and it typically falls between 5 and 40 millimetres

5) Center shaft motor: These motors are simple DC Motors featuring gears for the shaft for obtaining the optimal performance characteristics. Nut and threads on shaft to easily connect and internal threaded shaft for easily connecting it to the wheel.

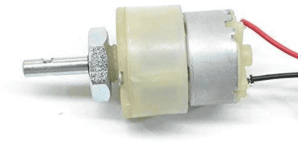

Fig. 6. Center shaft motor

They are known as Center Shaft DC Geared Motors because their shaft extends through the centre of their gearbox

assembly. These standard-size DC Motors are very easy to use.

6) Side shaft motor: A side shaft motor has a high performance. Many can be made to run in the opposite direction

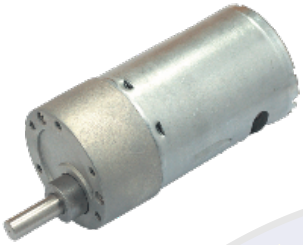

Fig. 7. Side Shaft Motor

by switching leads where they attach to the motor.DC geared motor with metal gearbox used for high torque application and other automation purposes.

7) Servo motor: A servo motor is a self-contained electrical device that moves parts of a machine with high efficiency and great precision. In simpler terms, a servo motor is a BLDC motor with a sensor for positional feedback. This allows the output shaft to be moved to a particular angle, position, and velocity that a regular motor cannot do.

Fig. 8. Servo Motor SG90

A servo motor is controlled by controlling its position using Pulse Width Modulation Technique. The width of the pulse applied to the motor is varied and sent for a fixed amount of time. Servo Motor generally requires a DC supply of 4.8 V to 6 V.

8) Jumper wires: Jumper wires are tiny metal connectors used to close or open a circuit part. They have two or more connection points, which regulate an electrical circuit board. Their function is to configure the settings for computer

Fig. 9. Jumper Wires

peripherals, like the motherboard. Jumper wires come in three versions: Male-to-male jumper, Male-to-female jumper, and Female-to-female jumper.

9) Vector board: A vector board is a solderable board used to prototype electrical circuits. All boards have provisions for I/O connectors. Components on this board can be soldered

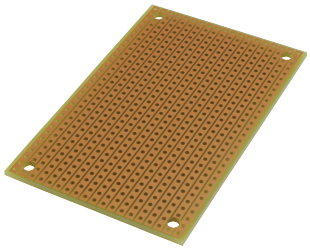

Fig. 10. Vector board

together to provide electrical connections to make up multiple circuits.

10) Rack and Pinion: Racks and pinions are power-transmission components primarily used for converting rotary to linear motion and vice versa.

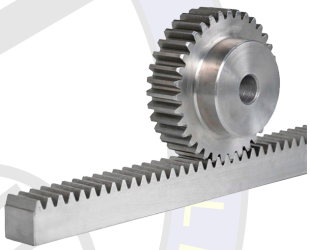

Fig. 11. Rack and Pinion

Rack and pinion combinations are often used as part of a simple linear actuator, where the rotation of a shaft powered by hand or by a motor is converted to linear motion.

B. Software

1) Arduino IDE: Arduino Integrated Development Environment is an open-source application software created by Arduino.

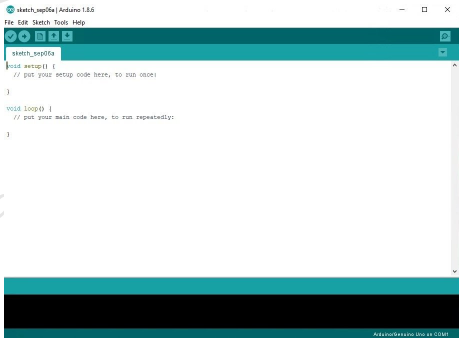

Fig. 12. Arduino IDE

The microcontrollers can be programmed using the C and C++ programming languages, using a standard API which is also known as the Arduino Programming Language. The

boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced with various expansion boards.

2) Fusion 360: Fusion 360 has built-in capabilities to do 3D modelling, sheet metal, simulation and documentation. It can manage manufacturing processes such as machining,

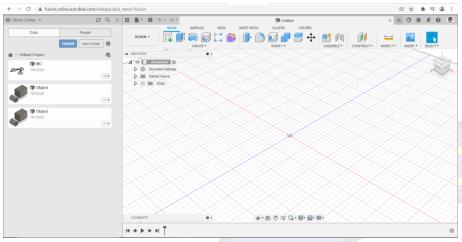

Fig. 13. Fusion 360

milling, turning and additive manufacturing. It also has electronic design automation (EDA) features, such as schema design, PCB design and component management. You can use it also for rendering, animation, generative design and a number of advanced simulation tasks (FEA).

3) Fritzing: This software allows a designer, artist, researcher, or hobbyist to document their Arduino-based prototype and create a PCB layout for manufacturing using the Processing programming language and the Arduino microcontroller.

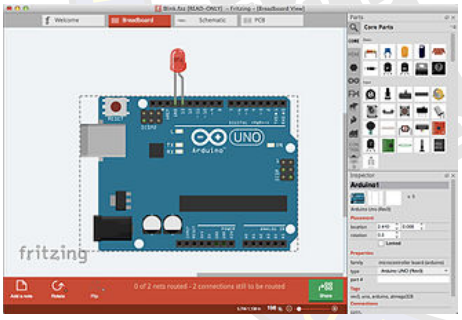

Fig. 14. Fritzing

This website allows users to exchange drafts and experiences, reduce manufacturing costs, and share experiences.

V. Working Mechanism

The working mechanism of the product is mostly controlled by the microcontroller ARDUINO UNO.

It begins after the user manually dumps the waste materials(metal, glass plastics) in the funnel. The Servo Motor SG90 which is directly controlled by Arduino Uno opens and closes the funnel making the materials slide onto the Conveyor Belt one after the other.

In segregating process Inductive Proximity Sensor, Capacitive Proximity Sensor, Motor Driver L298N are linked to the Arduino Uno as shown in Fig. 1.

The material on the Conveyor Belt is first examined by the Inductive Proximity Sensor and the result is sent to the Arduino Uno which commands the motor driver L298N accordingly, if the result is positive the belt is run in an anticlockwise direction by the side shaft motor which is instructed by the L298N and the material is dumped in the bin placed at the back of the belt. If the result is negative the material is moved forward to be examined by the Capacitive Proximity Sensor and again the result is sent to microcontroller Arduino, Motor Driver L298N gets commanded for each result respectively. If the material is plastic, then the motor driver runs the central shaft motor first with rack and pinion arrangement and the plastic is pushed into the bin in front. If it is a glass material then Conveyor Belt runs forward and dumps it into the bin at the end. All the connections 0f components of the product are shown in Fig. 15.

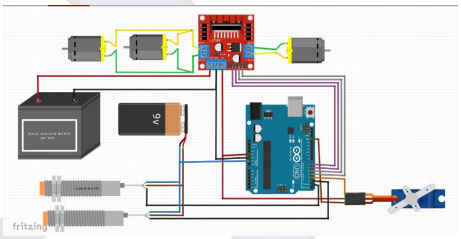

Fig. 15. Circuit diagram

VI. Algorithm

A. Algorithm for Product Functioning

- The waste materials are dumped into the funnel.
- Servo Motor SG90 opens and closes the funnel.
- Inductive proximity sensor examines the material slid onto the conveyor belt and the result is sent to the Arduino Uno ATMEGA328P.
- Arduino Uno gives commands to Motor driver L298N according to respective results.
- Result is positive then by the command from Arduino motor driver L298N instructs Side Shaft Motor to turn anti-clockwise making the Conveyor Belt to dump metal into Bin 1.
- If negative, the Conveyor Belt carries material to the range of the Capacitive Proximity Sensor to be examined and the result is sent to the microcontroller.
- If the material is plastic, commanded by the microcontroller motor driver instructs Central Shaft Motor such that the plastic is pushed into Bin 2 by rack and pinion setup.
- If the material is glass, the motor driver instructs the Side Shaft Motor making a belt to carry the glass material to be dumped into Bin 3.
- The bins are emptied once in a while after they are filled.

VII. CAD Design

The CAD design for the prototype

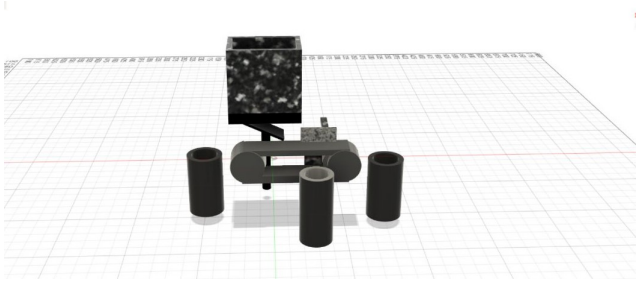

Fig. 16. CAD Design of Prototype

VIII. Future Enhancements

The model built by our team is an elementary prototype. It can be replicated on a large scale by introducing more authentic designs for universal healthcare benefits.

Based on its functionality, the robot can be altered to monitor and thwart a wider variety of health issues. Future alternatives could potentially be used at all times, additionally to treat other complaints.

IX. Conclusion

To conclude, the human effort of segregation will be reduced with the help of our robot. Thereby increasing hygiene in society and keeping the environment clean. The advantage is making a smart city through its work. Waste management is one of the most important challenges that a city faces

The discarded waste can then be processed to recover materials productively and metamorphose them into energy as usable fuels. This can be further developed with the help of machine learning and artificial intelligence to make a humanoid waste segregation robot.

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