Embedded System for Waste Management using Fuzzy Logic

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Abstract:

The non-degradable wastes such as plastic are a big threat for the environment. Hence an embedded system for Automation in splitting up, disposal and recycling of wastes is the best solution. The entire process is done with Artificial intelligence. The A.I. is provided with the help of Fuzzy logic. In this paper, all the common wastes such as Ferrous & its compounds, Paper, Plastic, Polythene, E-wastes, Bio-degradable wastes, etc. are considered. The input wave is given for detecting the type of wastes. By using the IF …THEN… ELSE condition it is processed. The image processing has been implemented to check the material. This paper provides the entire design of the embedded system, the entire logic for the automation with the required IF…THEN….ELSE... codes. The automation used in this paper eliminates a significant amount of entire manual work.

Keywords: Waste Management, Fuzzy Logic, Embedded System, Artificial Intelligence

1. Introduction

The main aim of the paper is to bring automation in the process of splitting up and disposal of wastes. Such an embedded system should have a sensing element to sense the material. Many properties such as magnetic property, chemical property, reflection property are used. For detecting certain wastes, instruments like Spectrophotometer are used. Image processing technique is also used. After sensing the element, it is been processed with the help of fuzzy logic. There are many reasons for selecting the fuzzy logic. They are discussed below.

1. All the wastes that are to be disposed safely without affecting the environment are grouped separately (e.g.: plastic).
2. The wastes that are to be sent for recycling are grouped separately and sent for it (e.g. paper).
3. Some of the wastes which are bio degradable are separated and sent for the manufacturing of manure.
4. This method not only provides a cleaner environment but also brings in revenue to the organization taking it up.

2. Overview of Fuzzy Logic and Fuzzy Control

A system whose principal function is not computational but is controlled by a computational system embedded within it is referred to as a computational embedded system, which is usually shortened to embedded system.

An objective of fuzzy logic has been to make computers think like people. Fuzzy logic can deal with the vagueness intrinsic to human thinking and natural language and recognizes that its nature is different from randomness. Using fuzzy logic algorithms could enable machines to understand and respond to vague human concepts such as hot, cold, large, small, etc. It also could provide a relatively simple approach to reach definite conclusions from imprecise information. Fuzzy logic is derived from fuzzy set theory dealing with reasoning that is approximate rather than precisely deduced from classical predicate logic. It can be thought of as the application side of fuzzy set theory dealing with well thought out real world expert values for a complex problem.

Thus Fuzzy Control is essentially a control system based on an algorithm composed of IF … THEN … rules. A fuzzy logic operation may be used in the construction of the rule. More than one rule may fire at the same time. Fuzzy logic is the logic which takes a Continuum value from 0 to 1. The major objective of the scheme is to enable the computer to make human like decision.

Fuzzy logic usually uses IF/THEN rules, or constructs that are equivalent, such as fuzzy associative matrices. Rules are usually expressed in the form “IF variable IS set THEN action”. The AND, OR, and NOT operators of Boolean logic exist in fuzzy logic, usually defined as the minimum, maximum, and complement; when they are defined this way, they are called the Zadeh operators, because they were first defined as such in Zadeh's original papers. So for the fuzzy variables x and y:

NOT x = (1 - truth(x)); X AND y = minimum (truth(x), truth(y)); X OR y = maximum (truth(x), truth(y))

There are also other operators, more linguistic in nature, called hedges that can be applied. These are generally adverbs such as "very", or "somewhat", which modify the meaning of a set using a mathematical formula. In application, the programming language Prolog is well geared to implementing fuzzy logic with its facilities to setup a database of "rules" which are queried to deduct logic. This sort of programming is known as logic programming.

Thus, in comparison with conventional control systems, Fuzzy control uses information about the system rather than a mathematical model, and for this reason, fuzzy logic has been used in the proposed automation in the process of splitting up and disposal of wastes.

3. Design and Discussion

The various wastes considered are Ferrous & its compounds, Plastic, Polythene, Paper, E-wastes and Bio-degradable or vegetable wastes. In the above mentioned wastes, some are to be recycled, some are to be disposed and some are to be sent for preparation of manure. Wastes like plastic, E-Waste, polythene are sent for proper disposal. Wastes like ferrous compound, paper, are to be sent for the recycling. Bio degradable waste is to be used for making manure.

All the wastes containing ferrous and its compounds are classified as magnetic wastes. If it is a magnetic waste, it is separated with the help of its magnetic property and sent for recycling. If it is not a magnetic substance, then the wastes will be classified with its structure. The wastes such as paper, plastic and polythene can be detected by using image processing technique. If it cannot be classified with its structure then it is checked if it is an e-waste. In the e-waste, the silicon and its compounds are detected with the help of Chemical tests or Spectrophotometer. The other toxic substances of e-wastes such as lead, etc. are

detected by means of chemical tests. If it is not an e-waste, it is checked whether it is biodegradable vegetable waste and is disposed accordingly.

When light is incident on a material, the light is reflected. The intensity of the light reflected depends upon the reflecting property of the material. We have a light source at one end at an angle with the material. The reflected light falls at an angle. The camera lens is placed at that angle where the reflected ray of light travels. The intensity of light is measured. It is then compared with the incident light. From the data obtained it is classified whether it is paper or plastic or polythene. For this classification we use Fuzzy logic. A continuum values between 0 and 1 is given. Then the details from the camera is checked and seen to which category it falls.

If it is sensed as plastic, it can be used to check the quality of the plastic also. If the plastic is of a high quality it can be re-used. Else it is sent for safe disposal. The disposal of polythene is very important because it is a big threat for the environment.

Instead of using a CCD camera, we can opt for light sensors. Photodiodes and phototransistors are two of the most popular and low-cost light sensors. These devices are readily available. Both devices produce current outputs as a function of light intensity. The operating range of such devices varies depending on the manufacturer. Many of these sensors are equipped with built-in lenses tuned to particular wavelengths, so they're most effective for detecting or measuring light with those wavelengths. To get the best performance, the voltage across the sensor must be held constant during measurement.

Microcontrollers of PIC16F series have two voltage comparators and an internal voltage reference. One of the voltage comparators and the voltage reference are used to interface to the sensor circuitry. The second voltage comparator, left unused. The RA3 pin has multiple functions. It can be configured as a digital I/O, or an analog connection to the inverting input of the voltage comparator. Both RA3 and RA0 pins are used to control the sensor. Initially, the system is in an idle state, where RA0 is a high output to disable the sensor, and RA3 is a low output to discharge C1 through R3. This idle state helps minimize power consumption.

To start a measurement, RA0 is set to a low output to activate the sensor circuitry. RA2 is now set to an input and connected to the voltage comparator's inverting input. The non-inverting input of the comparator is connected to the internal voltage reference. The capacitor voltage then starts to ramp up. The microcontroller now begins its timer while monitoring the state of the comparator's output. When the capacitor voltage and the voltage reference are equal, the comparator output goes from a high to a low state.

As soon as the microcontroller detects this transition, it stops its timer. At this point, the measurement is completed, and the micro sets the RA3 and RA0 port lines back to the idle state. The time measured during the ramp is inversely proportional to IS. The microcontroller can process this information to meet whatever the application's goal is, such as activating the horn in a smoke detector, running the motor in a robot, or simply sending the reading to the host computer.

The above considered wastes are detected with the input waves. According to the triangular input waves using IF THEN ELSE condition the output wave is designed. Hence automation is produced in splitting up the waste and disposal.

System calibration and linearization are required. The size of C1 and the maximum measurement time depend on the light sensor, amount of light used in the application, and the internal voltage-reference setting.

The sets of input waves considered are:

1. The input wave is given to check if it is a magnetic or a non magnetic substance. If it is a magnetic substance, it is a ferrous compound and represented by A. If it is a non-magnetic substance it is represented by B and it is non ferrous.
2. Next step, the output from the image processing camera is used and the waste is classified accordingly. If it is paper, then it is represented by S1. Otherwise if it is polythene, then it is represented by S3. Or if it is a plastic, it is represented by S4. If the waste is neither paper nor polythene or plastic, then it is represented by S2.
3. Next the triangular input wave is given to check if it is an e-waste. If it contains Silicon and its compounds, it is represented by E1. Else if it consists of other toxic compounds, such as Lead, etc it is represented by E2. It is not an E-waste, and then it is represented by E3.

Thus, the conditions are given as :

IF A AND S2 AND E3 THEN FERROUS

IF B AND S1 AND E3 THEN PAPER

IF B AND S3 AND E3 THEN POLYTHENE

IF B AND S4 AND E3 THEN PLASTIC

IF B AND S2 AND E1 THEN SILICON

IF B AND S2 AND E2 THEN OTHER E-WASTES

IF B AND S2 AND E3 THEN BIO DEGRADABLE WASTES

Initially the triangular input wave is given; these input waves represent the various detection methods for the tests. The test results are stored and using IF … THEN…. ELSE condition the splitting up of wastes and disposal is done.

The advantages of the proposed system are as follows:

- The main advantage of this method is that the entire splitting and disposal of wastes are done automatically without any need of man power.
- Polythene is non bio degradable. Hence it pollutes the soil, if unchecked.
- For making one long size notebook, 10 to 15 trees are consumed. But by this method, recycling is done thereby saving the trees.
- The toxic contents of the e-wastes when gets mixed up with the soil affects the micro-organisms present in the soil thereby reducing the fertility of the soil. But by this method those problems are getting solved.

- We can make manure from the bio-degradable or the vegetable wastes present. Hence we can obtain the natural manure.
- Prominently, it protects the environment.
- It also brings in a lot of useful product from which can make money. Many products which were to be wasted are recycled.

Thus, in essence, by this method we don't waste even the wastes.

4. Conclusion

In this embedded system, the entire splitting and disposal of wastes are done automatically without any need of man power. So far fuzzy logic was used only for Hi-fi Home appliances like Washing machine, Microwave oven, Dishwasher, Bio medical instrumentation and other related applications. But for the first time we are applying fuzzy logic for saving the environment by splitting up and disposing of wastes and also recycling process. Above all, by this method we save the environment which is the need at the moment.

Figures

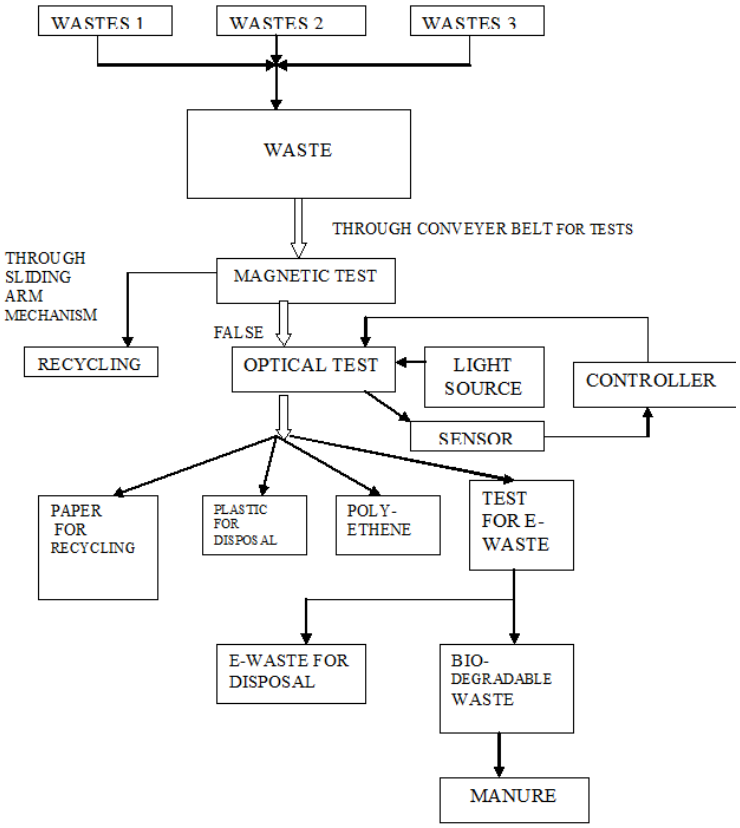

Figure 1 Control Flow in the Embedded System Design

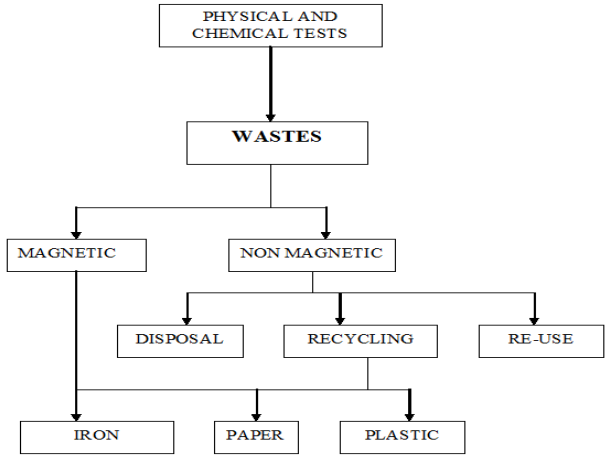

Figure 2 Classification of Wastes

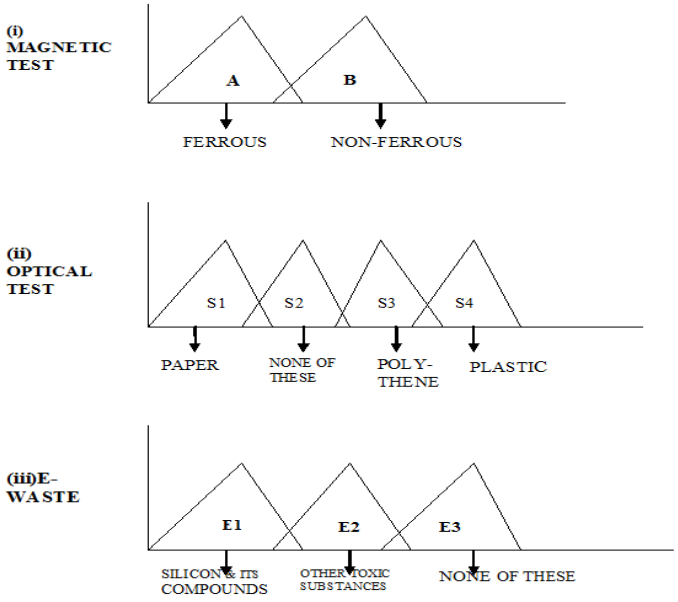

Figure 3 Input Waves

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