Material Identification using Electronic Sensors

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Abstract

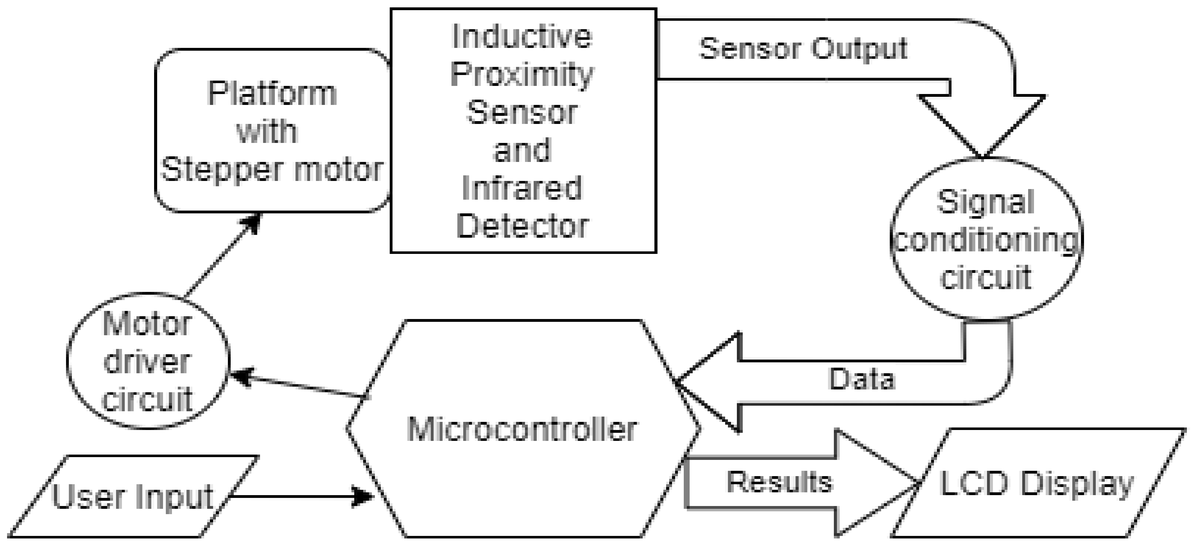
In a previous project I developed a circuit that I used to sort objects into two categories, metallic and non-metallic. This was accomplished using an infrared phototransistor circuit to detect the presence of an object, and an inductive proximity sensor to identify which objects are metallic.
A process like this could be useful in an industrial automation system such as material handling or sorting of recyclable materials.
I found that the proximity sensor could detect ferrous metals from a greater distance than nonferrous metals, and that the phototransistor had different results depending on how translucent the material is.
Using this information, I developed a system that can correctly identify a variety of metals and plastics.
The metals are identified based on the sensing distance of the proximity sensor, and the plastics are identified by using a microcontroller to determine the amount of light received by the phototransistor.

Objectives

To develop a system that can distinguish between the following:

- Aluminum
- Copper
- Brass
- Iron
- PVC
- Nylon
- Acrylic (clear)
- Acrylic (frosted)

Methods



Metal Identification

- Inductive sensors have a rated sensing distance for detection of ferrous metals such as iron or steel
- Non-ferrous metals can also be detected, but the sensing distance is adjusted by a correction factor

Material	Correction Factor	Expected Sensing Distance
Iron	1.00	8.00 mm
Aluminum	0.30 - 0.45	3.6 mm - 4.8 mm
Brass	0.35 - 0.50	2.8 mm - 4.0 mm
Copper	0.25 - 0.45	2.0 mm - 4.8 mm

Material	Test 1	Test 2	Test 3	Test 4	Test 5
Iron	8.59 mm	8.55 mm	8.60 mm	8.59 mm	8.51 mm
Aluminum	3.77 mm	3.75 mm	3.69 mm	3.71 mm	3.68 mm
Brass	4.46 mm	4.43 mm	4.42 mm	4.39 mm	4.36 mm
Copper	3.27 mm	3.25 mm	3.37 mm	3.30 mm	3.29 mm

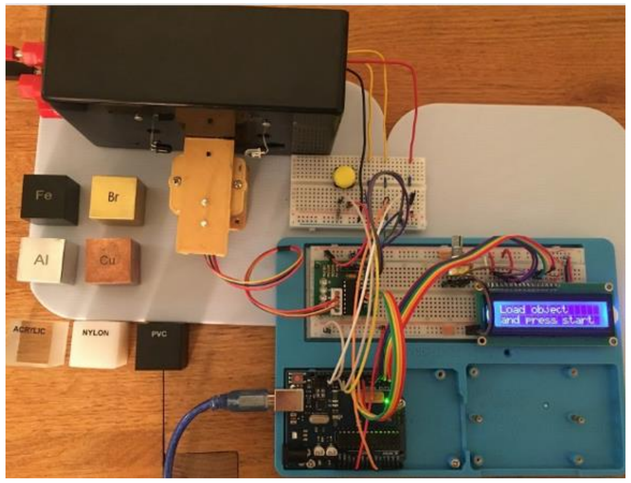
Measured sensing distances

Plastic Identification

- When light hits an object, it can be absorbed, reflected, or transmitted
- A phototransistor can be used to determine how much of the light was transmitted through the object
- A microcontroller was used to interpret the information received by the phototransistor

	Sensor Output (Volts)	Data (Volts)
Clear	1.76	0.75
Nothing	2.46	1.05
Frosted	5.89	2.52
Nylon	9.76	4.17
PVC	9.78	4.18

Results



The above circuit accomplishes the objectives of this project. It is able to differentiate between each of the different materials and can also detect when no object is present.

Conclusion

Through working on this project, I learned about using a microcontroller to interface with various input and output devices.
The system I created does perform the material identification but has notable shortcomings

- The metal identification requires physical movement of the object
- The plastic identification is very slow

I would like to do further work to improve on this system. I plan to research these possible improvements:

- Design a circuit that allows for adjustment of the sensing distance
- Use lasers for the plastic identification