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Mechatronics-based Waste Collection and Disposal System

Dr. OnyedinmaOsita, Eze Daniel Uzoma
Masters Degree in Computer Science
Nnamdi Azikiwe University, Awka, Awka

Abstract:- Waste collection system driven by Artificial Intelligence and Robotics is sine qua non to having a smart city. Unlike the traditional waste collection systems which have been largely ineffective due to lack of technological advancement and increasing growing population, the proposed system provides more efficiency and timeliness in waste collection and disposal, giving room for less lacuna for waste bin overflows. The Bin is based on the concept of mechatronics, which empowers it with sensors, and robotic control systems that is capable of detecting the status of the waste bin, and automatically moves it to the disposal center whenever it is filled up. The mechatronic waste bin consist of rover wheels which allows the bin to move around uneven roads and terrains, each wheel has a DC motor, Digital servo, RC Transmitter, a sensor camera, a PCB, and an Arduino mega board. The sensor monitors the bin and gives an alarm signal to the controller. If the bin is filled up, it covers itself automatically, and moves to a nearby dump with the aid of the Dc motors.

I. INTRODUCTION

Mr. TetsuroMoria, a senior engineer of a Japanese company, Yaskawa, first coined the word "Mechatronics" in 1969.

Mechatronics is the synergistic combination of Mechanical engineering ("mecha" for mechanisms), Electronic engineering ("tronics" for electronics) and software engineering.

It is a multi-disciplinary approach to product and manufacturing system design. It involves application of electrical, mechanical, control and computer engineering to develop products, processes and systems with greater flexibility, ease in redesign and ability of reprogramming.

Mechatronics can also be termed as replacement of mechanics with electronics or enhance mechanics with electronics. With the help of microelectronics and sensor technology, mechatronics systems are providing high levels of precision and reliability.

Today's domestic washing machines are "intelligent" and four-wheel passenger automobiles are equipped with safety installations such as airbags, parking (proximity) sensors, antitheft electronic keys etc.[1][2]

A. *Objectives of Mechatronics system*

- Integration of mechanical systems with electronic and computer systems
- To improve efficiency of the system
- To reduce cost of production
- To achieve high accuracy and precision
- For easy control of the system
- Customer satisfaction and comfort

B. *Relevance of the Proposed System*

Recently, we experience waste bins in abandonment due to lack of effective waste collections, man power, lack of timely monitoring and disposal, and further spreading of diseases, pandemics and other airborne diseases due to decay. The proposed system is a mechatronic based waste bin, designed to monitor its fill level, and trigger movement to deliver itself to a nearby waste dump site with or without human intervention.[3]

This ensures cleanliness in the environment, safety of residents in the particular environment, mechanization, automation and computerization of waste bins, which is sine qua non to having a smart city.

In addition, having a waste bin deliver quality services with artificial intelligence and other concepts that make up mechatronics is worthy of development and implementation.

II. RELATED WORKS

The combination of mechanical and electrical engineering with computer programming, mechatronics is increasingly everywhere. The following are some famous inventions as a result of application of mechatronics:[4][5][6]

A. *Sophia the Robot*

Developed by Hanson Robotics, Sophia is one of the most famous robots in the world for her interactions with people based on an artificial intelligence. She's become an ambassador for AI, with her creators exploring and pushing the boundaries of that new technology every day. But did you know that Sophia also uses mechatronics to operate? She moves, talks, and needs power to run in addition to that famous computer brain. According to her, "I… have IK solvers and path planning for controlling my hands, gaze, and locomotion strategy. My walking body performs dynamic stabilization for adaptive walking over various terrain."

Sophia's social skills would be less impressive if she didn't understand that she should look at you by tilting her head, or that she should move her mouth according to the timing of her speech. She chooses to send power to various parts of her body to move when her programming tells her to, or in other words, she functions via mechatronics.

B. *NASA's Curiosity Rover*

"In some sense, the Mars Science Laboratory rover's parts are similar to what any living creature would need to keep it "alive" and able to explore," says NASA. They describe Curiosity as having a computer brain, a battery and power for energy, and wheels for mobility. It can also move its arm and hand to collect samples and analyze its environment and communicate with NASA back on Earth with further instruments on board. [7]

C. *Anti-lock Brakes*

This is one we bet you didn't think of, but mechatronics engineers are responsible for a lot of the functions of your car. Anti-lock braking systems, or ABS, work via sensors that detect the speed of your wheels in addition to an algorithm that tells the car when your wheels are turning faster even though you are trying to brake. When your wheels lock up the ABS activates and tries to keep your wheels from skidding while you slow down. It lets you continue to be able to steer the car while it helps you stop.

"The ABS controller knows that such a rapid deceleration is impossible, so it reduces the pressure to that brake until it sees acceleration, then it increases the pressure until it sees the deceleration again. It can do this very quickly, before the tire can actually significantly change speed. The result is that the tire slows down at the same rate as the car, with the brakes keeping the tires very near the point at which they will start to lock up."

D. *i-Limb*

Biomechatronics is a newer field, but a fascinating one. Mechatronics engineers are making machines to support, or in the case of a loss to replace, the natural functions of the human body. One of the most sophisticated examples of this today is i-Limb, a prosthetic hand with bionic components to aid amputees. i-Limb uses sensors placed on the wearer's skin that allow them to control the movement of the hand and fingers through muscle signals. Each finger has its own motor so that wearers can move every part of the hand in a way that mimics the body's natural motor control. [8][9][10]

III. COMPONENTS

The materials required for the design and implementation of the mechatronics-based waste collection and disposal system are as follows:

- DC motor
- Digital servo
- RC Transmitter
- d.Sensor camera,
- PCB
- Arduino mega board.

A. *DC Motor*

A **DC motor** is any of a class of rotary electrical motors that converts direct current (DC) electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields.

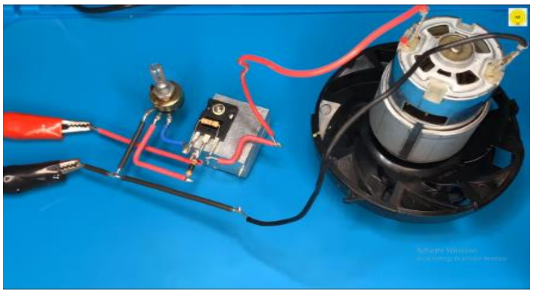

Fig. 1: Dc Motor

B. *The Digital RC Servo*

A digital servo receives a signal from the receiver onboard the RC vehicle and translates this in to a pulse sent to the servo motor. The rate at which pulses of power are sent to the servo motor are much higher. You can expect that a digital servo would send a pulse to the servo motor at a rate of 500hz. This is equivalent to every 0.002 seconds.

Fig. 2: Digital RC Servo

C. RC Transmitter

The transmitter is essentially the controller that you hold when using the vehicle. It is also referred to as a radio controller or a remote controller. You then make your commands via buttons, dials, and other features and the data is sent to the receiver. The receiver itself is connected to the vehicle, and uses this information to power the vehicle and turn the wheels (or equivalent) for turning and maneuvering.

RC transmitters are, therefore, one of the most important features of any RC cart setup. They connect to the receiver via a 2.4GHz radio transmission. Once the link is made, it cannot be disrupted by external radio frequencies. [11][12][13][14]

Fig. 3: RC Transmitter

D. CIRCUIT BOARD DESIGN

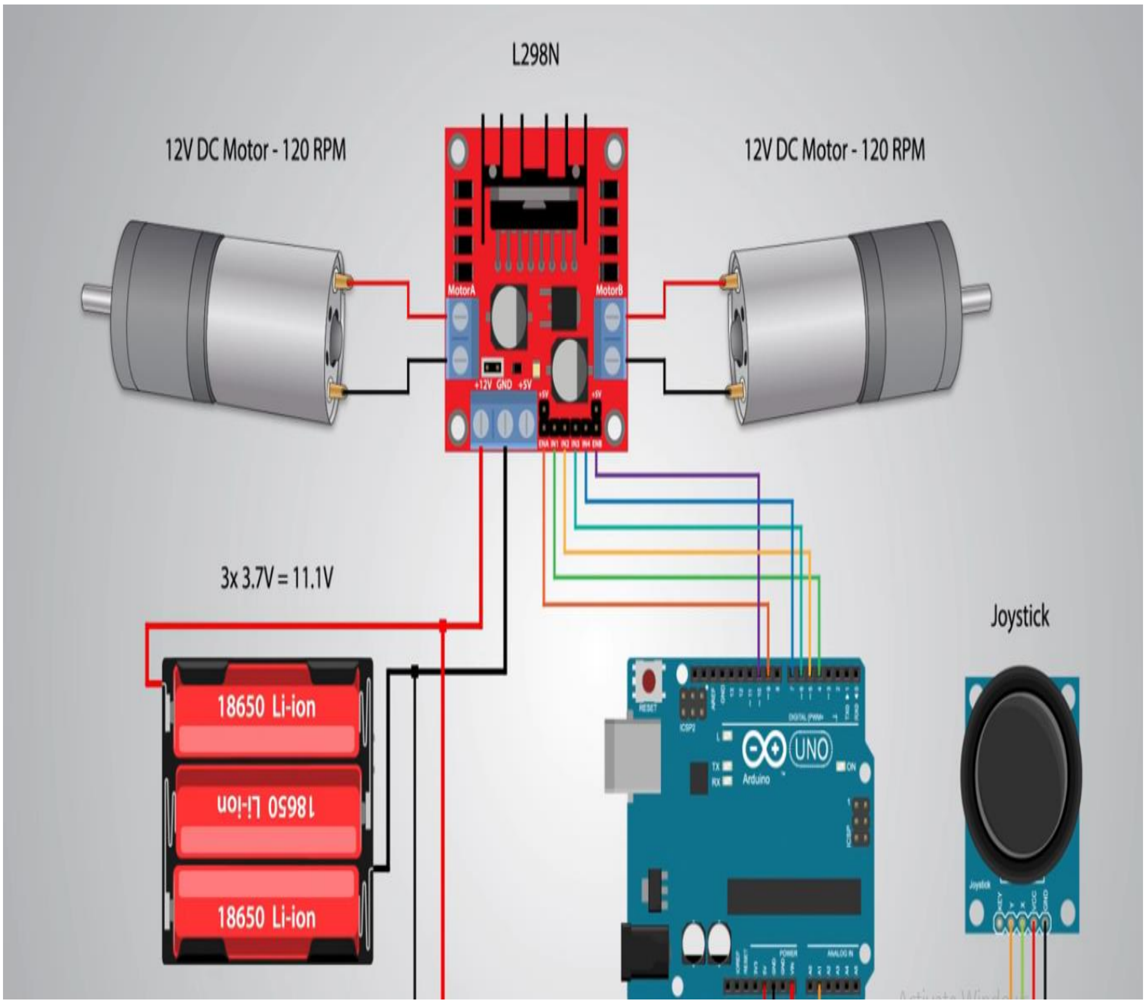

Fig. 4: Circuit Board Design

* **Architecture of modern automation systems with sensors, actuators, and controllers**

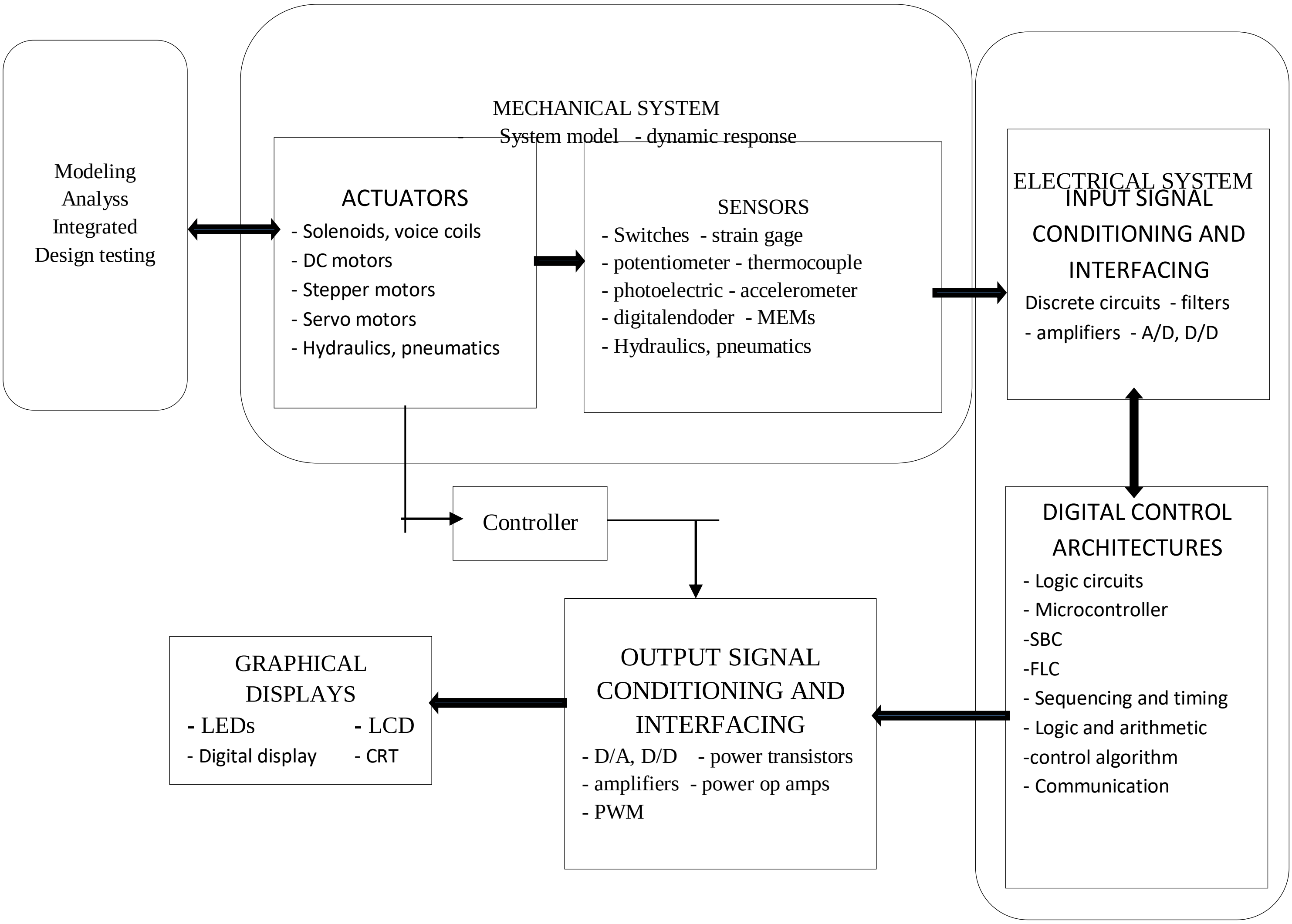

Fig. 5: Architecture of modern automation systems with sensors, actuators, and controllers

- **How the system works**

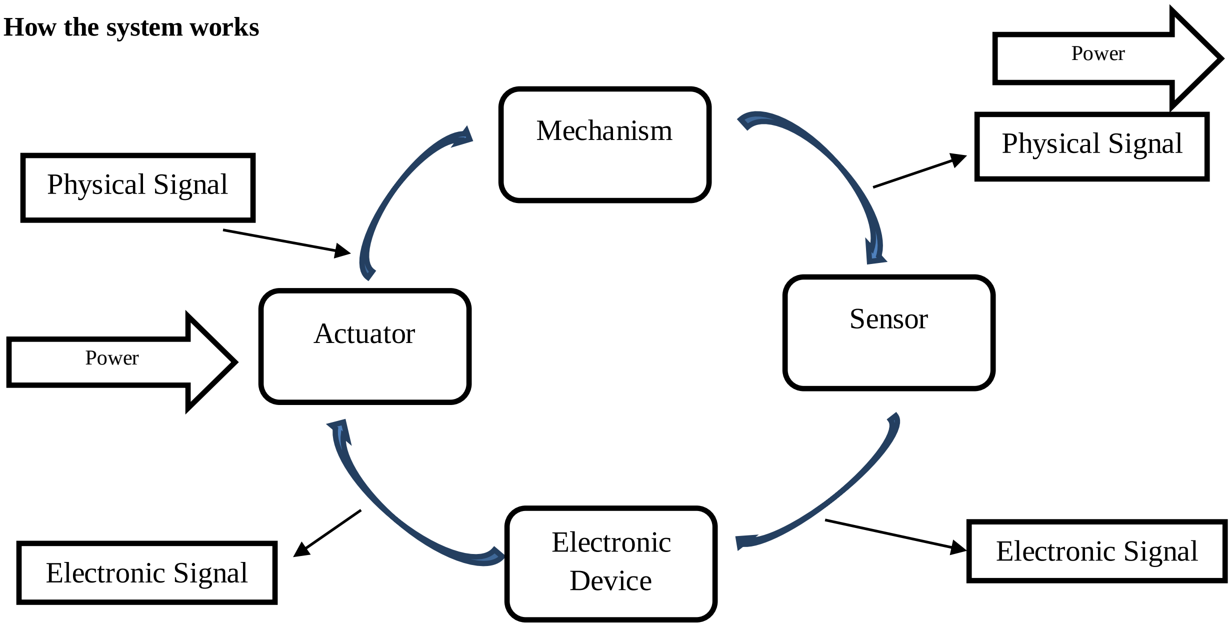

Fig. 6: Data Flow Diagram of the proposed system

Fig. 7: Sample chassis of the Mechatronic based waste collection

E. ADVANTAGES OF THE NEW SYSTEM

- Increased technology, functionality and better designed waste collection
- Use of artificial intelligence and intelligent process control
- Assume responsibility for a process and operation with little interference of operators
- Multisensory and programmed environments
- High degree of flexibility
- Greater productivity and more effective waste collection solution
- The integration of sensor and control system in a complex system reduces capital expenses

F. DISADVANTAGES

- The initial cost is very high
- The complicated design and system
- The repair and maintenance is complex
- Its replacement is difficult, that it is difficult to change old system to new system.
- Imperative to have knowledge of different engineering fields for design and implementation
- Specific problem of various systems will have to be addressed separately and properly[15][16][17][18][19][20]

G. Arduino DC Motor Control

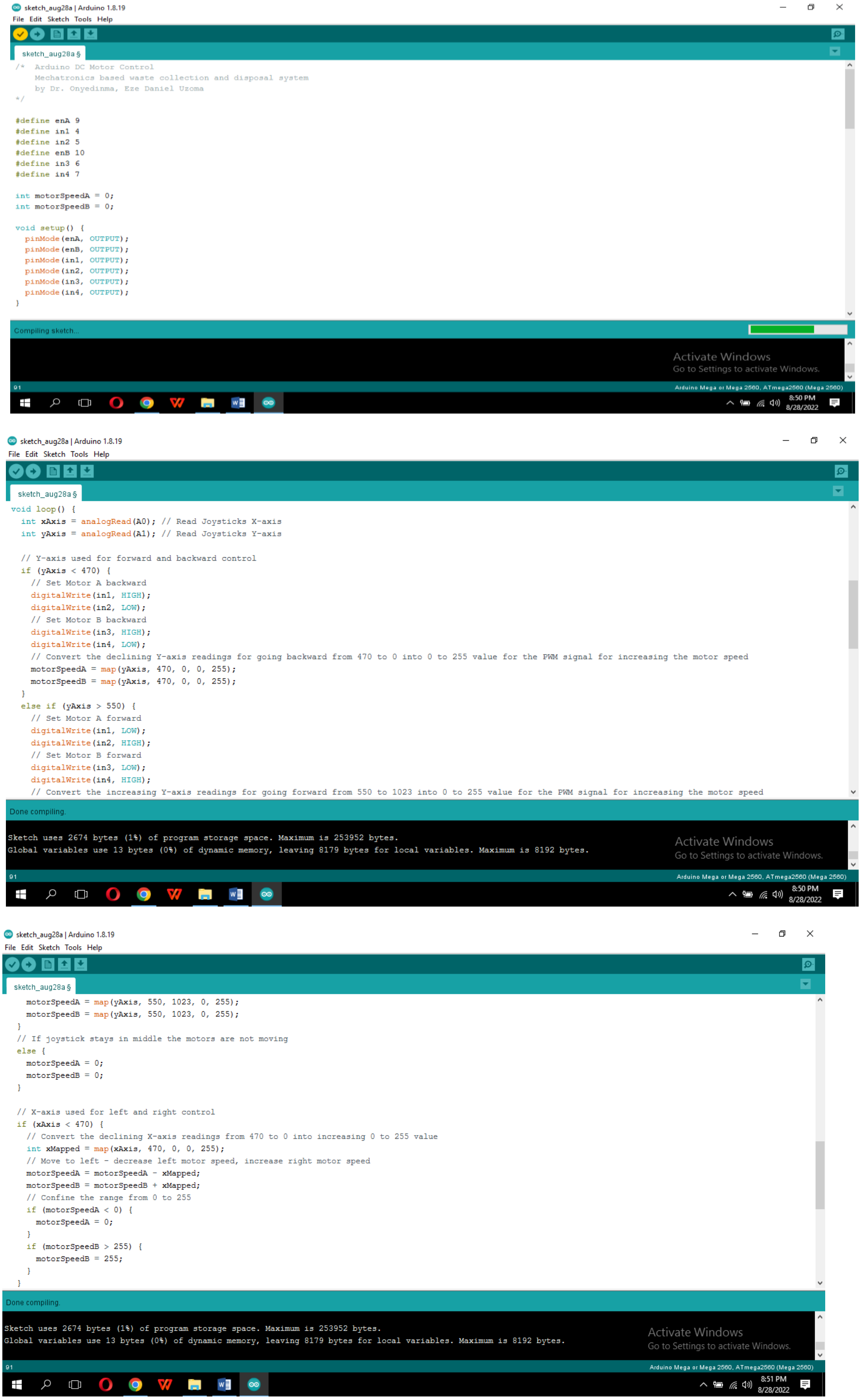

Fig. 8: Arduino DC Motor Code

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