MINI PROJECT REPORT

MCTA 3203

SECTION 1

GROUP D

Autonomous Washing Machine

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Abstract

Designing a thorough washing machine simulator focusing on I2C Arduino, Pixy camera, RFID and servo were the objectives of this experiment. The goal was to implement mechatronics principles and investigate a variety of the mechatronic interfacing systems, stressing uniformity standards as well as communication protocols for easy integration. The application included the use of Python, Arduino and Open PLC technologies.

A focus on sensor and actuator skills was clear by the inclusion of microprocessors, PLCs and microcontrollers in order to prove designing practicing control for complex automated processes. The integration of mechatronics was accomplished by fusing the IoT and mechatronics, learning to design integrated systems with varying degrees.

All these components such as GSM 900 module, RFID, servo, OLED etc., including the motor and water sensor could be integrated in successfully with a washing machine simulator. First of all, one master and two slave devices were connected via its I2C communication; Python was used to show real-time values on a laptop. The experiment offered a practical implementation of theoretical ideas, revealing the difficulties and opportunities inherent in organizing systems unification within mechatronics sphere.

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Introduction

Integration between multiple microcontrollers such as Arduino has been applied to various applications in this modern world. The integration between Arduino is usually connected using I2C communication which contains master and slave. Packet-switched serial communication protocols commonly used to connect low-speed peripherals in embedded systems. I2C allows multiple communication between masters and slaves using two-wire serial interfaces: TX and RX.

In this mini project, we are tasked with building one sample of a washer machine by using I2C communication between Arduinos. From that, we learn to set circuits with I2C communication using Arduino UNO R3 as master, and both Arduino MEGA and Arduino UNO R3 as slaves. We also use various types of equipment and materials provided by the instructor. In addition, we also use our materials such as OLED displays, DC motors, and many more.

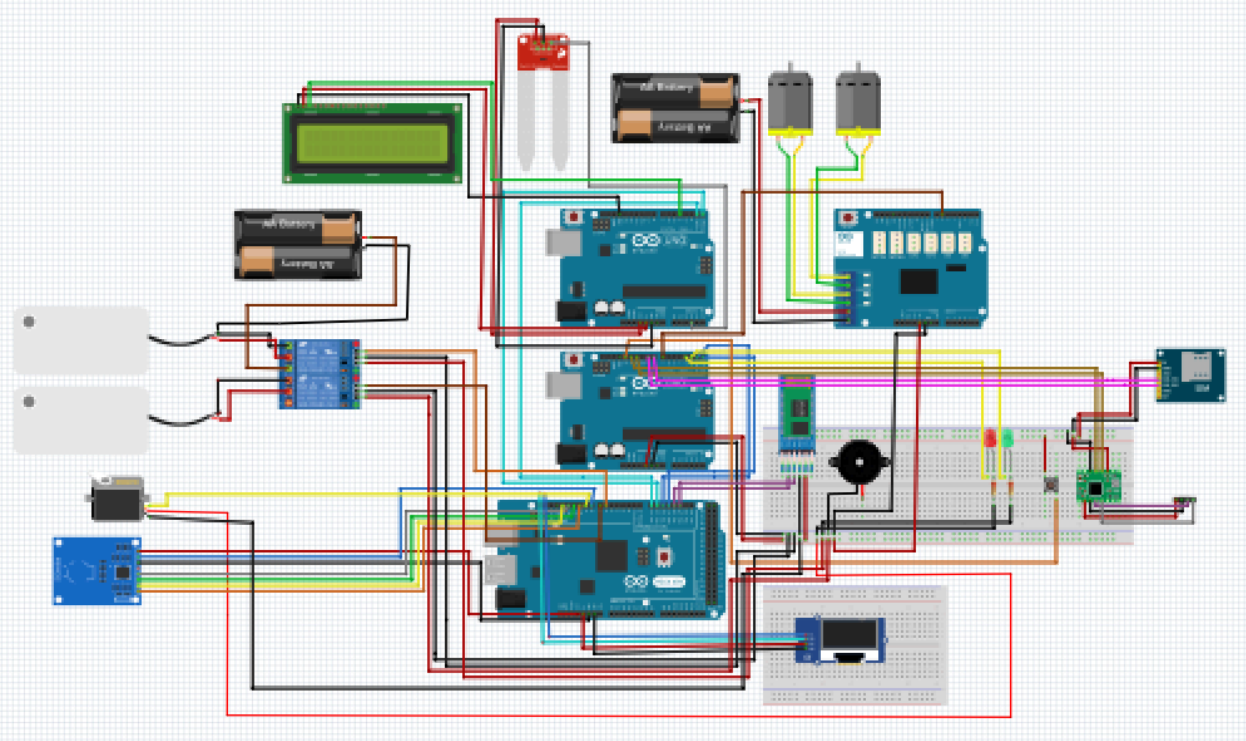
In conclusion, the application of I2C communication can be shown in various fields of engineering and one example is in the washer machine mechanism and operation. There are a lot of things that need to be integrated to optimise the washer machine operational system. Last but not least, it is essential to know how the system works and how to integrate between microcontrollers.

Materials and Equipment

1. Arduino Uno (Master)
2. Arduino Uno (Slave)
3. Arduino Mega 2560 (Slave)
4. 2 12V 24 RPM Brushed DC Geared Motor
5. 2 Water Pump
6. GSM Module
7. 10kg Load Cell with HX711 Amplifier
8. Pushbutton
9. MFRC522
10. OLED Display
11. Servo Motor
12. Relay Module
13. LEDs
14. Buzzer
15. HC-05 Bluetooth Module
16. 0.8Amp 5V-26V DC Motor Driver Shield
17. LCD Display
18. Water Level Sensor
19. Smartphone
20. Breadboard
21. Small Breadboard
22. Jumper Wires
23. USB Cables
24. 9V Battery
25. 1.5V Batteries

Circuit Setup

1) Arduino UNO R3 was connected to Arduino Mega and Arduino UNO using I2C serial communication which connects the RX and TX pins.
2) OLED displays, RFID detector, Bluetooth HC-05, buzzer, weight sensor, LED, pushbutton, GSM module and motor driver were connected to Arduino Mega which functions as a slave.
3) LCD and water sensor are connected to another slave which is Arduino UNO R3 to detect water level.
4) DC motors are connected to the master which is Arduin UNO R3 while water pumps are connected to the motor driver.



Methodology

The methodology employed in this project involves integrating various components (as stated in the materials and equipment section) using Arduino Uno as master and Arduino Uno and Arduino Mega 2560 as slaves, utilising I2C communication. The implementation can be divided into two main components: the coding part and the wiring part.

1. Coding Part:
    - The master code for Arduino Uno is written to initialise the communication and control the overall logic of the integrated system.
    - The slave code for Arduino Uno is written to initialise the slave address, handle received data and respond to master requests.
    - The slave code for Arduino Mega 2560 is written to initialise a different slave address, handle received data and respond to master requests.
2. Wiring Part:
    - All the components are connected and attached to the breadboard, relay or motor driver shield and their respective Arduino for either master or slaves as explained in the circuit setup part.

Results (Observation)

1. When the user approaches the washing machine with laundry, the OLED display (Slave 1) shows a greeting message.
2. When the user taps the RFID card to the MFRC522 (Slave 1), it reads the RFID card's ID:
    - If the card is registered, (Slave 1) the system opens the door using the servo motor and sends an "access granted" signal to the master. Which at the same time, displays "*ACCESS GRANTED*" on the OLED screen and the buzzer plays a two-tone beep. The green LED turns on and the red LED turns off.
    - If the card is unregistered, (Slave 1) the system keeps the door closed and sends an "access denied" signal to the master. Which at the same time, displays "*ACCESS DENIED*" on the OLED screen and the buzzer plays a long beep. The red LED turns on and the green LED turns off.
3. After the user loads the laundry and presses the start button (push button), the load cell (weight sensor) (Master) measures the laundry weight and sends the mass data to Slave 1 which initiates the washing process. The system (Slave 1) closes the door using the servo motor and the buzzer plays a two-tone beep sequence.
4. Water filling process:
    - The system (Slave 1) then receives the mass data from the Master and converts it into a water-fill delay.
    - The OLED screen (Slave 1) displays "*FILL IN WATER*" and at the same time (Slave 1) activates the water inlet valve of the water pump (Relay 1).
    - Slave 1 sends a signal to the water level sensor (Slave 2) to start the water level monitoring and displays the readings on the LCD. If the value exceeds a threshold (130), the LCD prints a "*Warning!*" message for safety purposes.
    - After the calculated delay, the system (Slave 1) closes the water inlet valve of the water pump (Relay 1) and completes the water-filling process.
5. During the washing process, the motor (Master) rotates the agitator in a forward-reverse-stop pattern for three cycles to stimulate washing cycles.
6. Water draining process:

- The system (Slave 1) then receives the signal from the Master.
- The OLED screen (Slave 1) displays "*FILL OUT WATER*" and at the same time (Slave 1) activates the water outlet valve of the water pump (Relay 2).
- After the fixed duration or receiving a signal from the Master, the system (Slave 1) closes the water outlet valve of the water pump (Relay 2) and completes the water draining process.

7. During the spinning process, the motor (Master) rotates the inner drum in a different pattern (forward-reverse-spinning) to stimulate spinning cycles.
8. When the spinning process ends, the Master sends a signal to Slave 1 to open the door using a servo motor.
9. The system (Master) sends an SMS notification, *"HAI BAJU ANDA DAH SIAP! BILA NAK AMBIL ?"* using the GSM module indicating that the process is completed.

Implement Chapter

In the implementation phase, it involved practical applications of ideas discussed extensively during this comprehensive analysis to involve sensor interfacing and data acquisition systems. The first chapters were a prologue describing sensor interfacing and primitive logic systems, which invited further developments. The project provided interfacing techniques as serial, parallel and USB in which microcontrollers were coupled with computer systems for connection to sensors and actuators.

The practical implementation entailed DAQ interfacing microcontroller embedded systems response. Wireless data interfacing utilized Bluetooth, XBee and WiFi to show the practicality of utilities in real-world applications. In addition, the interface of image and video input was addressing issues related to processing visual data in terms of both technical resources as well as software capabilities. It was emphasized during the project on microcontrollers integration with PLCs and computer-based systems. It also had the remote robotic control training, automatic trend tracking, and emergency alerts. In the second stage of implementation, it had Digital Signal Processing (DSP) interfacing on both software and hardware side that delves into complex signal-processing systems. The full-fledged implementation not only demonstrated mastery over individual topics but also showed the dynamics of interacting themes representing sensor interfacing, logic systems and data acquisition strategies. Through the use of every chapter's subject matter in practical terms, it was possible to create a complex system that solved complicated problems around mechatronics and automation.

We incorporated elements from all the other chapters (Week 1 to Week 11), excluding Week 5 (OPEN PLC) and 9 (Image and Video using camera), into our project implementation. Each chapter has contributed to the development of a comprehensive mechatronics system, covering aspects such as sensor interfacing, data acquisition, digital logic systems, parallel/serial/USB interfacing, embedded systems, wireless data interfacing, system integration, and digital signal processing.

Discussion

In this experiment, we aim to develop a washing machine that is comprehensive and involves various components to automate the washing process. There were several issues we encountered while attempting to complete this project. Initially, we used a Mini DC Motor with low torque, 1.37mN.m to spin the agitator and the drum but that motor could not spin due to the weight of both the agitator and the drum. Knowing that the motors were the main problem here, we took the alternative of replacing the motor with the 12V Brushed DC Geared Motor with high torque, 27.45mN.m and finally, we managed to spin both the agitator and the drum without any further problem.

Next, after running the code, we noticed that the code kept repeating the same function halfway and it would not finish the entire code. We expected the reason the system resets itself is either a mistake in coding or the current supply is not enough. So, we tried to troubleshoot by investigating the loop of the coding line by line. We found out that our *if-else* statement in the code is in the wrong placement, and the 'true' condition took the system to repeat looping at the same function without proceeding to the next instruction.

Subsequently, we observed that all the wire connections and the coding as well are in the correct state but somehow the system ran without following the sequence of the coding. We expected the problem to happen due to the damage of any wire or bad wire management so that the currents mixed with each other. The only solution for this issue is to check the wires one by one and improve the wire management in a few ways. Among them are using the right wire lengths to avoid the risk of signal interference, using labels or colour-coding to identify different types of wires or signal paths, bundling wire neatly using cable ties, wire wraps, or cable organisers, and much more.

Safety Issue

Firstly, RFID access control. The use of RFID access control raises serious security issues since it puts the system's integrity at risk of unauthorised access. It is essential to give the security of RFID transmission a top priority to address this. The system will be strengthened against potential unauthorised access by utilising encryption techniques and routinely updating access credentials, guaranteeing that only authorised users may operate the washing machine simulator.

Secondly, water level detection. To avoid flooding and related risks, precise water level control is essential. Continuous monitoring is made possible by the system's integration of a water level sensor. An automatic shutdown and alert system will be triggered if the water level rises above the predetermined limit. This will stop any potential overflow and notify users to take immediate action.

Next, safety interlocks. There is a chance of injury because of the agitator and drum's motor movements, which could cause unanticipated actions. Safety interlocks had been put in place to ensure that motors only run when doors are firmly closed to remedy this.

Lastly, the Messaging System. To prevent unexpected effects, the communications system's dependability is essential. This makes it possible for users to receive timely and accurate notifications about the washing machine simulator's state, which enhances user security as well as reliability. Therefore, the user will be alerted to take the cloth and not leave it for too long if they go somewhere else, in case this occurs in the laundry for the benefit of other users. However, if doing this at home, the user can adjust the time to prevent the fabric from becoming overly wet in the machine and ruining the shirt.

Conclusion

This experiment can be said to be a successful integration of Mechatronics systems including RFID technology, I2C Arduino communication protocol, GSM Module and much more. We managed to apply mechatronics principles and explore different mechatronics interfacing systems, emphasising standardisation and communication protocols for seamless integration. This Mini Project can represent a significant leap forward in the convergence of mechanical and electronic technologies. This innovative project enhanced the usability and efficacy of a standard home appliance by utilising sophisticated automation and intelligent communication features.

Recommendations

For our automatic washing machine, we can consider some energy efficiency recommendations. The use of energy-efficient components and sensors can contribute to more sustainable and cost-effective appliances. It is good to supply power to the sensors only while using them and turn them off afterwards. Other than that, there are better options than using plastic material for the drum and the reservoir as it lacks mechanical strength and releases harmful substances when subjected to heat. Therefore, using Acrylonitrile Butadiene Styrene (ABS) plastic is more encouraged because it is stronger and more chemical-resistant than other plastics.

Besides, instead of using the GSM Module that requires us to spend some money to send SMS to the users, we can use built-in WiFi in the ESP32 microcontroller to send messages through Telegram. In addition, it is highly recommended to switch to a more orderly and visually wiring arrangement rather than using jumper wires. This change makes the circuit seem better and makes the circuit maintainable where we can check if there are wrongly connected wires. Designing a Printed Circuit Board (PCB) is the best way to replace the jumper wires because it offers a more organised layout for the connection.

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Student's Declaration

Certificate of Originality and Authenticity

This is to certify that we are responsible for the work submitted in this report, that the original work is our own except as specified in the references and acknowledgement, and that the original work contained herein has not been untaken or done by unspecified sources or persons.

We hereby certify that this report has not been done by only one individual and all of us have contributed to the report. The length of contribution to the reports by Each individual is noted within this certificate.

We also hereby certify that we have read and understand the content of the total report and no further improvement on the reports is needed from any of the individual contributor to the report.

We, therefore, agreed unanimously that this report shall be submitted for marking and this final printed report has been verified by us

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