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ESET 369 Final Term Project Report

Robert J. Jones
Multidisciplinary Engineering Department
Texas A&M University

Kaleb McCutcheon
Multidisciplinary Engineering Department
Texas A&M University

Warren Watts
Engineering Technology & Industrial Distribution Department
Texas A&M University

Patrick Apgar
Engineering Technology & Industrial Distribution Department
Texas A&M University

Abstract

This paper is to discuss the process of learning, setting up, and building a small robot that runs off of an MSP432 Launchpad. The purpose of this project was to create a robot that, with a reflectance sensor, could follow a black line on a white piece of paper. This project would in turn also require the programming of the two motors acting as wheels, a servo motor, a buzzer, an ultrasonic sensor, and the aforementioned reflectance sensor. Part A was the initial coding process to design functions that would later be used for the robot to complete its tasks in Part B. However, UART was used in order to activate some of these functions so as to cover UART material from lectures in a lab setting. The ultrasonic sensor would be the one piece of hardware whose implementation would be left for Part B in order to cover time measurement lecture material in a lab environment as well. The purpose of Part B's program was to have the motors react in accordance with the reflectance sensor in order for the robot to follow the black line on the test-pad. After the program was loaded to the Launchpad, the robot was to beep three times, open and close the servo three times (ending closed), and then follow a curved black line from Point A to Point B. Once reaching Point B, the ultrasonic sensor would detect a wall placed at the track's end, stopping the robot. The robot would again buzz three times, open and close the servo three times (ending open), and then rotate 180 degrees. The robot would then follow the black line once more from Point B to Point A. Although the goal was to have the robot successfully carry out each of these tasks (each completed task earning a group more chips in a mini-competition), most groups were not successful in even following the black line to Point B. Part C of the term project involved having groups of three to four conceptually design an embedded system utilizing the MSP432 Launchpad. In our group's case, a schematic for a lock mechanism that included a Keypad, LEDs, an LCD screen, and the Launchpad's timers was created.

Introduction

For Part A of the final project, the goals/tasks that needed to be accomplished consisted of writing programs for the MSP432P401R board and peripherals that would only activate according to the user's keyboard or keypad input. Specifically the servo motors and the motors that drove the wheels would be strictly keyboard inputs whereas the buzzer and text would be echoed in accordance with the up and down buttons on the keypad respectively. These tasks primarily call upon the manipulation and modification of motor controls and user inputs per C/C++ programming in addition to understanding the network between the MSP432P401R board and its adjacent components. This lab will prepare individuals for embedded systems software development with user input as well as debugging in real-time.

For Part B of the final project, the goals/tasks that needed to be accomplished consisted of making an autonomous vehicle travel on a given path and one at the end, detect an object, activate a manipulator arm and then return back to its starting point. These tasks primarily call upon the manipulation and modification of the motor controls, reflectance sensors, and the ultrasonic sensor. This will require the BH-EDU kit, an ultrasonic sensor, two motors, reflectance sensors, MSP432P401R board, as well as other key components. This lab will prepare individuals for low level autonomous C/C++ programming as well as debugging and coding chained logic gates in C/C++.

For Part C of the final project, the goal/tasks that needed to be accomplished consisted of developing another use for the MSP432P401R board with the BH-EDU kit that may be applicable to the real world. These tasks were able to include everything that the class had learned up to this point, including LEDs, LCD screen, timers, buzzers, keypads, user-input and echoing, servos and motors, different sensors, and any component that is compatible and may be connected. This part didn't require the physical building of the 'invented' system, however did require the wiring and schematic that would be necessary for appropriate use and functionality. This lab will prepare individuals to expand their perspective on the utilizations for computer boards and peripheral components as well as daily implementation.

Term Projects Parts

The term project this year in ESET 369 fell into three parts: Part A, Part B, and Part C. Since for Part B of the term project one group was able to complete more of the required tasks for the robot than the other, the subsequent discussion for this portion of the project will be from the perspective of the group that completed more of Part B.

Term Project Part A

For Part A of the term project, both lab groups were able to correctly implement all required functions/parts by the end of the lab. However, one lab group encountered a number of problems before completing this part of the project. The first error encountered stemmed from the faulty lab kits (a broken reflectance sensor to be more precise). Once this lab kit was swapped for another, the problem resolved itself. The next error stemmed from the group in question using a Launchpad based interrupt for the up and down arrows on the keypad, instead of adding an input reading to the while loop that read UART inputs as well. This led to a number of functions not working properly, most notably the ADC values from the reflectance sensor being read nonstop. Once the interrupt was removed and the keypad input readings were added to the aforementioned while loop, all functions began working as desired, and Part A of the term project was able to be completed with full marks.

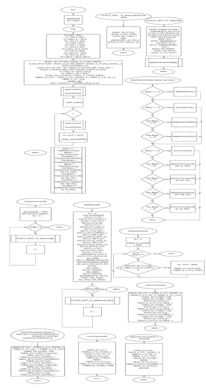

Figure 1. Program Flowchart for Term Project Part A

Term Project Part B

For Part B, the vehicle performed all necessary actions during initial testing, however, in practice it experienced difficulties in following the line as well as some unknown errors possibly stemming from the ultrasonic sensor or the faulty lab kits themselves. Outside of this, the vehicle conducted every other action without issue. The line following issue first appeared to be due to the vehicle's inability to make a gradual turn. This was alleviated by changing PWMs motor speeds to have a greater difference, thus creating a sharper turn. The next issue encountered was never fully resolved since the source of the problem was never determined. This issue seemed to be stemming most likely from the ultrasonic sensor and servo motors being on the same timer. Whatever it may have been, something was causing the robot to seemingly sense the wall early, turning it around before it needed to. I firmly believe that if we were allowed to use the actual track instead of the small test track, the cause of this error may have been able to have been resolved. This may have allowed our group to narrow down whether it was a faulty kit, a timer issue, or something else entirely. Other possible solutions would have been to recode the entire program from the beginning, making sure that each function would work as desired. However, due to lack of time and the fact that our project was already functioning to some extent, this was not done. In the end, our robot was able to make it around Point 12 to Point 13 before the ultrasonic sensor tripped, causing it to turn around and make its trek all the way back to Point A. This in turn lost our group a great deal of points overall and frustrated our members to no end.

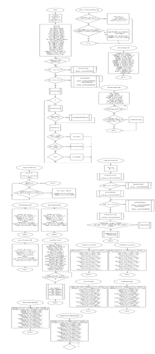

Figure 2. Program Flowchart for Term Project Part B

Term Project Part C

Part C of the term project saw two lab groups combining in order to create a conceptual design for an embedded system that had the only requirement of using the Launchpad to implement said embedded system. Our group, believing that we might be designing an embedded system that could be utilized as a future lab for this class, designed our project around the Launchpad, BH-EDU board, servo motor, Launchpad timers, and a power supply (all components that we had previously used/been provided with for other labs). This design would be a simple locking mechanism, which could serve as an introduction to such systems. It would start out waiting for an input to be read. Once an input was read, an asterisk representing the number of button presses would appear on the LCD screen. If a button was not pressed after a certain period of time (after one was previously pressed), the program would clear itself and wait for a button press again. If the code (4-digit code) was entered incorrectly a red LED would temporarily appear and the program would reset and wait. If the code was entered correctly, however, the servo motor (representing the lock) would activate and turn 180 degrees. After 20 seconds, both the servo and the program would reset. In the eyes of our group members, this simple embedded system would serve as a good teaching tool for future students of this class.

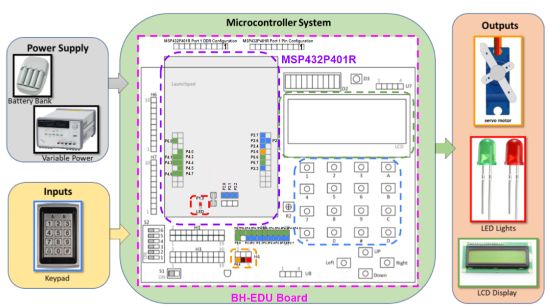

Figure 3. Embedded System Smart Lock Block Diagram

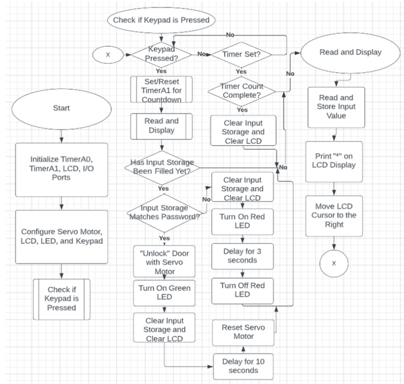

Figure 4. Smart Lock Flowchart

Summary and Conclusions

In summary, part A was successfully completed unanimously by both lab groups. With exception of a few minor confusions, mostly pertaining to proper configuration of the code, the first part of the term project was completed. The purpose for part A was to serve as both a means of implementing user keyboard input for manual control. The user, or we, the lab students, utilized the keyboard input protocols to control the robot before refactoring the code for part B. Additionally, one key issue encountered in both parts A and B were faulty lab kits and the inconvenience they caused. It is worth reiterating the issue of these lab kits so as to spread awareness in the hope that future groups will hopefully not be as affected whilst they are completing their term project.

As for part B, the main functionality was refactoring all of the code written in part A to now utilize the input features of the BH-EDU board to control the robotic vehicle. Although the core functions were working properly, it was difficult to understand what was causing the issues aforementioned in the discussion of part B. No doubt had the lab groups been given slightly more time, these issues would have been resolved, but not without their challenges. Lastly, part C of this project was to combine the collective knowledge of two lab groups to brainstorm and devise an embedded system using the MSP432 controller. Needless to say, part C went off without a hitch and the results can also be seen above, but the primary challenge was implementing the full schematic design. As it usually goes, the conceptual part is quite straightforward, but in hindsight the schematic design was by far the most time consuming.

To conclude, the term project overall consisted of three parts, each with their unique challenges within the given tasks. Collectively, we all performed well but not without unique challenges we were forced to address along the way. Albeit, some areas of the development process could have been improved, but given the time constraints and the parameters of each individual task, it is safe to say that the project was concluded successfully.

References

1. Hur, Byul. Learning Embedded Systems with MSP432 Microcontrollers: MSP432P401R with Code Composer Studio. 4th ed., Byul Hur, 2022.