CECS 346 Spring 2024

Project 3 - A Smart Home

By

Lorenzo Ceja, Jonathan Moran, Michelle Herrera Cuen, Juan Miguel Constantino

13 December 2024

This project uses the TM4C123GH6PM microcontroller alongside stepper motors and IR sensors to simulate an autonomous car going home and parking itself inside a self opening and closing garage.The garage will have different lights indicating open, closed, or moving.

Introduction:

In this project we will be utilizing embedded systems to create a smart home. The system combines a smart garage door and an autonomous car. The goal of this project is to create an autonomous car that will stop in front of a garage door. The garage door will be able to detect the car and open itself up and wait until the car is fully parked in the garage before closing the door. The skills and techniques implemented in this project included GPIO, edge-triggered interrupts, SysTick timers, FSM, stepper motors and sensors. This project is a culmination of all the topics and labs we have accomplished so far in the semester. Each previous lab demonstrates a skill required to implement this project. Systick timer will help us to create accurate timing delays and blinking LEDs, interrupts will enable the push buttons to move the stepper motors, FSM examines the the current state of the car and garage and determine next state, and ir sensors will be the eyes of the vehicle and garage door so they can communicate with each other. In the end, we get a

Theory:

The theory behind our project is embedded systems that can play a role in automation using components. Stepper motors provide an overview of stepper motor operation and how they can precisely control movement. We will be using full-step to power the car to provide highest torque since our car will be heavy with batteries and other electrical components. The car and garage work with IR sensors and detect trigger actions with the system. Timers and interrupts use SysTick timer for exact timing and flashing LEDs to display the movement of Stepper motors for the car and garage door.

Operations:

Video Link: IMG_4862.MOV

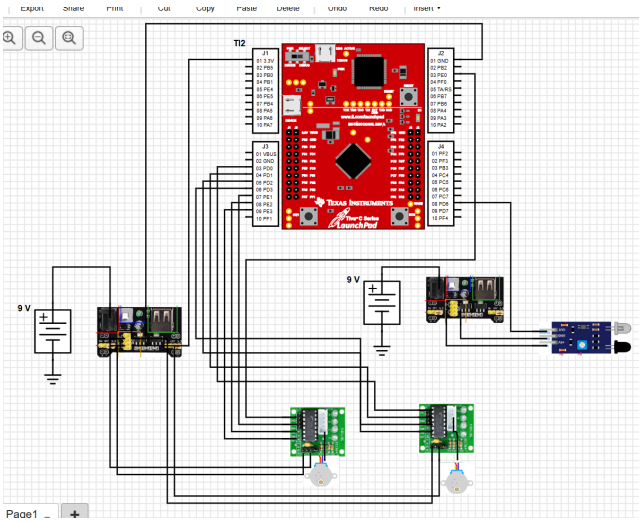
The smart house features garage door controls that would open the door with IR sensors. The behavior of the system is powered on and the garage door fully closes the door with a green light indicating the “closed state” When the IR detects the car the red light starts flashing and the door starts moving. Once the door is open, the red LED lights to the “open” state. We also implemented a push button SW2 that will close and open it.

Secondly, the autonomous stepper motor car is programmed to park inside the garage and reverse backwards and return to its initial state. We used a pushbutton (SW1) to start the trip. Once going forward the car moves a specific distance and the wheels rotate to make the car go 90 degrees. The IR sensor of the garage opens the door and the car stops. The car will then move backwards when the SW2 is pressed and turn the car at a 90 degree angle and make a right turn. We used a SysTick timer to make the motion of the car smooth as well as to create the 2kHz blinking red LED when the garage door is opening. We finish simulating the end of the trip when the smart car leaves the house and the garage door closes.

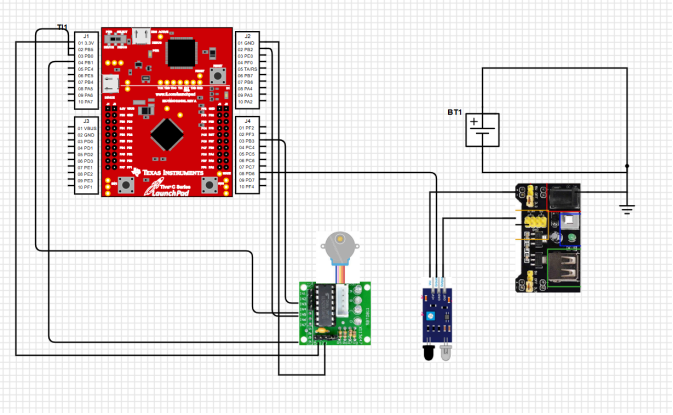
Hardware Design:

- Schematic

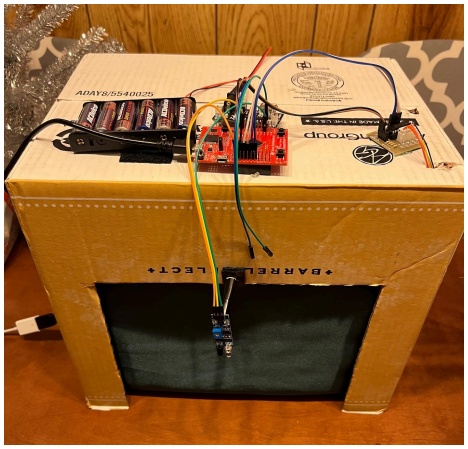
Stepper Motor Car

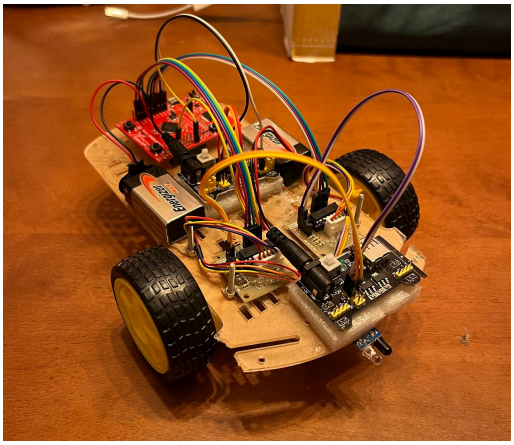


Stepper Motor Garage



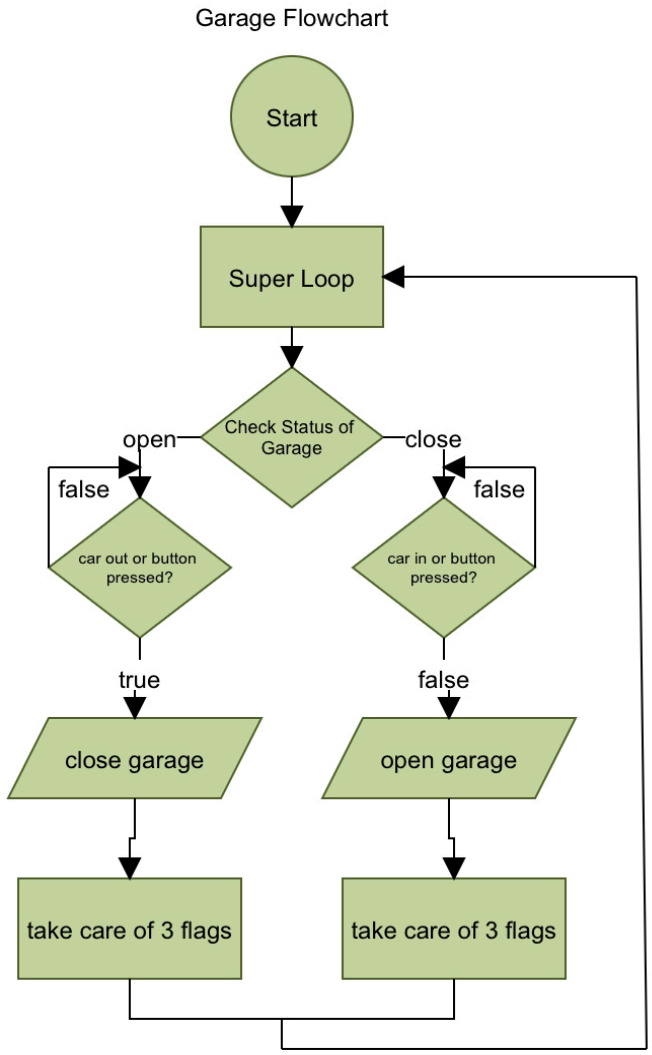
- Physical Prototype



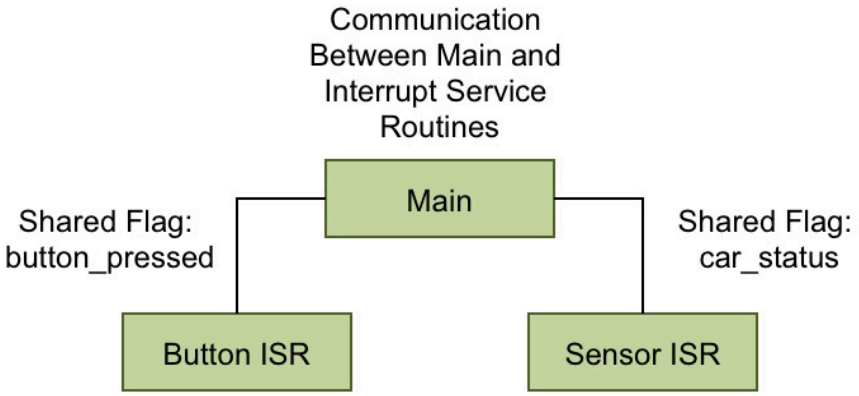


Software Design:

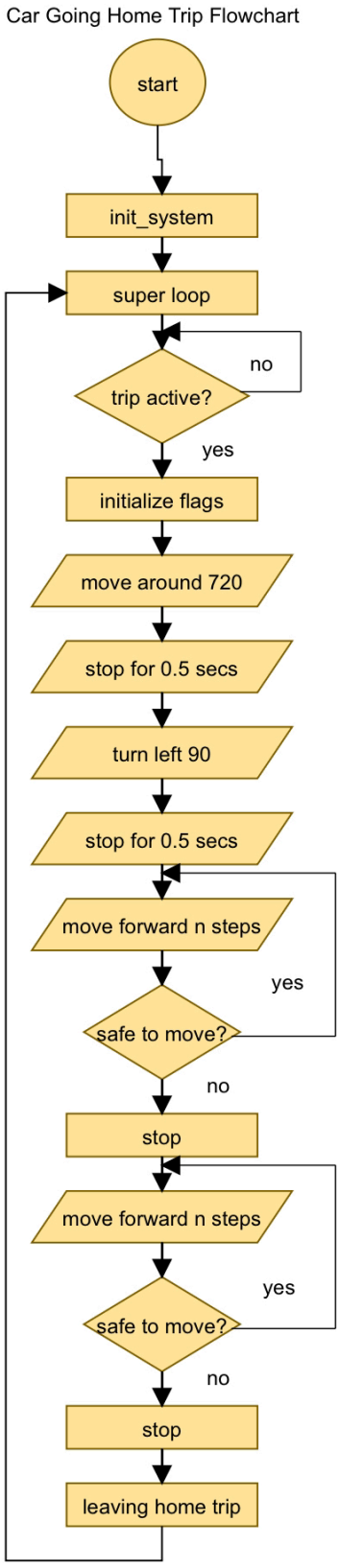
a. Garage Flowchart



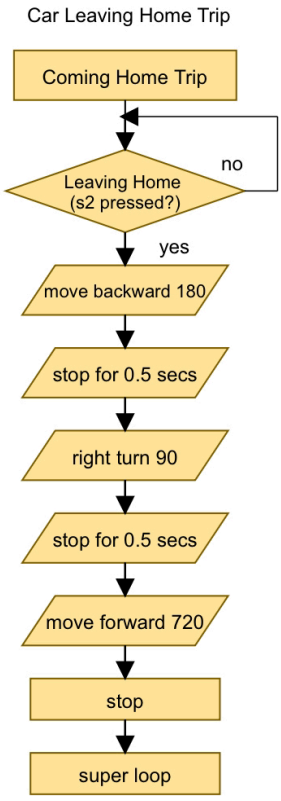
b. Communication Between Main and Interrupt Service Routines



c. Car Going Home Trip Flowchart



d. Car Leaving Home Trip Flowchart



Conclusion:

In conclusion, this project successfully implemented two embedded systems to create a smart house and used techniques such as GPIO control, SysTick timer, interrupts, and stepper motor operation. The smart house system demonstrated an interaction between an autonomous car and a garage door. During the development of the project we ran into many bugs and errors . In order to tackle these issues we utilized debugging methods mentioned in class. For example, our stepper motor car was not moving despite the team feeling confident the code was correct. We started with ensuring our GPIO initialization is correct, which we saw a few errors, but not the main cause of our issues. We then set up breakpoints of where we expect the code to execute and examine the behavior. We discovered that our stepper motor was moving, but only 0.18 degrees every few seconds. This led to our discovery of the incorrectly implemented SysTick timer. Through trial and error of observing how our stepper motors and IR sensors work, we were able to accomplish a full working smart home. If we had more time we would finetune the timing of the car moving with the garage door. In our example the door tends to close on the car because of an accidental trigger, but it does not affect the journey of the car to its destination. This project showcases an application of embedded systems in home automation and its functions.