GPS Project

TM4C123GH6PM

Introduction to Embedded Systems

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Introduction

Project Overview:

Real-Time Positional Tracking and Landmark Identification System using TM4C123G LaunchPad. This project focuses on the development of an embedded system designed to track and display real-time positional coordinates of a moving microcontroller, the TM4C123G LaunchPad. The system, programmed in C, will acquire positional data and output location information to either a connected computer or an integrated LCD.

Key Objectives:

- **Real-Time Positional Data Acquisition:** Implement a system to continuously gather positional coordinates as the TM4C123G LaunchPad moves.
- **Coordinate Processing and Display:** Develop software to process the acquired positional data and display the location information on a connected computer or an LCD screen.
- **Landmark Storage and Identification:** Store a digital map containing coordinates and names of various landmarks within the system's memory.
- **Proximity-Based Landmark Display:** Implement a feature to automatically display the name of a landmark when the microcontroller approaches its vicinity. Besides, the system is continuously showing the current distance between the user and the nearest place in the campus.

Scopes and Limitations:

➔ **Scope:**
- Utilizes the TM4C123G microcontroller as the core processing unit.
- Integrates with a GPS module to acquire live coordinates.
- Stores a fixed map (hardcoded) of at least five faculty halls with their latitude and longitude.
- Displays the name of the nearest hall when within a threshold distance.
- Employs peripherals like UART for debugging/output and LCD/LEDs for local display.

➔ **Limitations:**

- The system relies on clear GPS signal reception, which may be weak or unavailable indoors.
- The hall coordinates are static and predefined; dynamic map updates are not supported.
- The detection radius for landmarks is fixed and may not account for physical barriers or precision errors.
- Autonomous operation depends on battery life, which is not optimized in this implementation.
- Accuracy is constrained by the resolution and quality of the GPS module use

Project Mechanism:

The project provides a simple but outstanding mechanism to use the functionality GPS-tracking system.

After turning on the microcontroller, the GPS module begins locating its current location directly from the satellite. The GPS module receives a code signal from the satellite representing the location. This signal code is sent to our program where it enters a function of our implementation whose goal is parsing the string code and extracting the longitude and the latitude. Then both parameters are passed to the distance calculation function in the C program which returns the distance between the current location and any other position in the campus.

The LCD is continuously displaying the name of the nearest location and the distance from it as long as the program is running. Increasing the distance indicates walking away from the location and decreasing the distance indicates approaching it.

While approaching the nearest location, the distance gradually decreases until it reaches a specific threshold distance of 7 meters. Once the distance goes down this threshold, the program automatically displays a message to inform the user that he reaches the place successfully. In parallel, the 3 colored LEDs in the microcontroller start blinking sequentially indicating the arrival of the user.

Hardware Used:

- ➔ **Tiva C Launchpad (TM4C123GH6PM):** Microcontroller

- ➔ **NEO 6M GPS Module:** To provide positional data

- ➔ **LCD (16x2)**: To display name of the closest landmark and displacement between it and current position

- ➔ Battery: for autonomous operation

Software Used:

Keil uVision 5 C-development environment.

Functional Requirements:

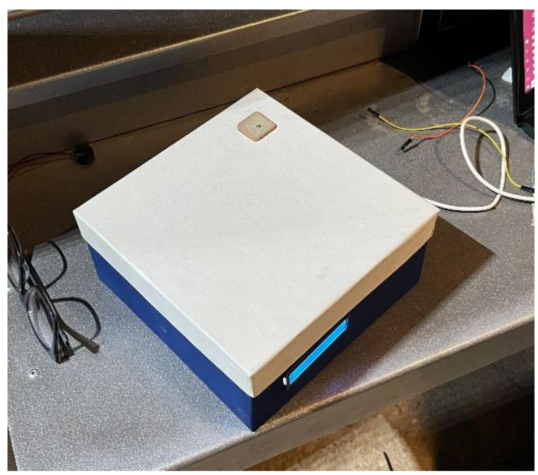
- Initialize system on power-on, read GPS module data, and wait for a GPS fix.
- After acquiring coordinates, display the name of the closest landmark from a preset list.
- Periodically update location information as the microcontroller moves.

Project milestones

➔ First Milestone:
- Successfully flash code from Keil IDE to the TM4C123G LaunchPad.
- Implement a function to initialize microcontroller ports (e.g., GPIO configuration).
- Develop a function to configure UART for communication with the GPS module.

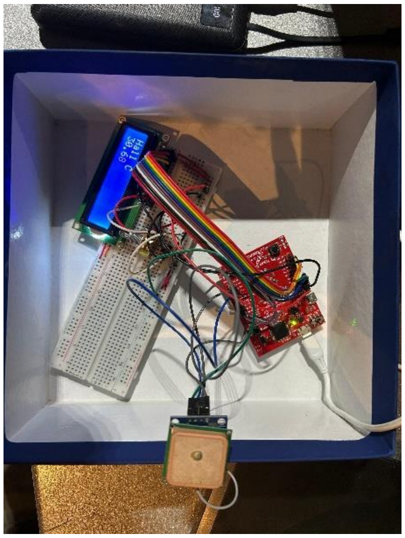
➔ Second Milestone (Final):
- Create a function to parse ASCII GPS coordinates and store them.
- Store a list of at least 5 faculty hall coordinates and names.
- Integrate all functions into a cohesive program and test the system.

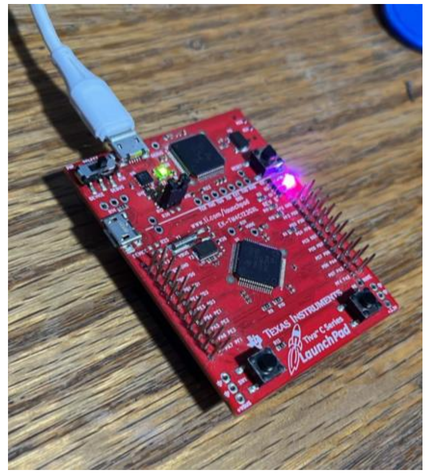
The final project Picture:



System design:

(1) Hardware Design





(2) Software Design:

Drivers Developed from Scratch:

- **GPIO (General purpose input/output):** Used for interfacing with external devices and peripherals by configuring microcontroller pins as digital input or output.

- **UART (Universal Asynchronous receiver/transmitter):** Enables serial communication between devices, such as between a microcontroller and GPS module or other peripherals by configuring UART registers, setting Baud rate, and handling data transfer.

- **LCD (Liquid Crystal Display) (bonus):** Displays characters or graphical information, commonly used for showing messages, sensor data, or user interfaces by Initializing LCD and providing functions to send strings.

- **Systick Timer:** It configures the ARM Cortex-M's built-in 24-bit timer to generate periodic Interrupts. The driver initializes the Systick timer by setting a reload value that determines the tick period, clearing the current value, and enabling the timer with interrupts using the core system clock.

Additional Features:

Some features are added to the project in order to enhance its performance and make its usage more reliable and high-grade.

The features are discussed in the following table:

Feature	Role in Project
LCD Driver	The driver is developed from scratch and it contributes to the project through showing the nearest place from the GPS.
Potentiometer	Adjusts the contrast and the visibility of the LCD through varying the voltage.
Battery	Serves as an independent, external power source to activate the microcontroller without the need to use a personal computer.
Internal Tiva LEDs	Serves as an indication that the user has actually reached the intended landmark.
Packaging	Makes the project in a good-looking shape and facilitates using it.
Distance Function	Displays the distance between the user and the nearest location on the LCD in order to assist him in directions.
A full coverage of the campus	Covered 10 places in the campus to guarantee including the most important places.
Professional organization of the program	Structured the program using neat architecture, organizing code into HAL, MCAL, libraries, and application layers to enhance its readability, maintainability, and reusability.

Contributions

Name	Id	contributions
Abanoub Osama Fawzy	2201329	• Main function implementation • GPS encoding • Testing and Error Handling • Systick
Karim Khaled Gamaleldin	2201356	• GPIO • LEDS • Managing git • GPS distance calculations
Karim Mohamed Elsayed	2200746	• UART • GPS Configuration • Packaging
Marina Bebawy Nasr	2200826	• GPIO • LCD • Packaging • Report Writing
Mohamed Hassan Abdelkhaleq	2200944	• Systick • Main function implementation • Report Writing
Mohamed Lotfy Mohamed	2200945	• LCD • GPIO • LEDS
Rawan Mohamed Ahmed	2200482	• UART • GPS Configuration • Report Writing

GitHub link:

https://github.com/KarimK-x/EmbeddedGPS

Video link

https://drive.google.com/file/d/1QystyX-IMX1AxH-a_GqYZ6ICAYKp0tfK/view?usp=drive_link