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Low Cost Offline Route Learning System

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Abstract— A low cost portable device consisting accelerometer, digital compass, Real time clock, microcontroller and flash memory records the route travelled by a vehicle. This is offline device used to keep the path recorded, so that we can retrieve it to know the route between two points. The path can be retraced by excel software which is much common. This can be considered as an alternative for costly GPS systems. It records the movement of person in two dimensions and path is retraced using Microsoft excel software. The accelerometer gives acceleration details and digital compass gives direction details. The device is based on commercially available sensors.

Index Terms— Accelerometer, digital compass, fixed interval algorithm, I^2C, offline, real time clock, route learning.

1 Introduction

An offline and low cost alternative for existing route learning system is considered in this paper. It can support pedestrians and vehicles to learn on way route and even retrace the return route. The advantage of the system is its offline nature and considerably reduced cost. It can be powered by a rechargeable battery. Expensive route learning systems are available commercially, but it is limited with data connectivity throughout and its operating cost is also more. This device is intended for very much localized application.

This is a standalone system, which registers the acceleration of a moving person or vehicle, with time stamp and direction. The embedded accelerometers and digital compass provide the motion data and RTC provides time stamp to the microcontroller. It will guide the information to EEPROM for storage, in order to record the trace points of the touring route of the device [1]. The stored data is retrieved and processed using the most popular Microsoft Excel software, and travel route is retraced.

Following the introduction we consider the background in which we considered this system and its motivation. It is succeeded by the system overview, which gives general idea about the working of device. Then the implementation part gives details on how the system is implemented. The paper is concluded there after.

2 BACKGROUND AND MOTIVATION

We have many advanced route navigation systems which are working online with GPS connectivity [2]. These types of system need expensive hardware and it cannot be used in areas without data connectivity. The GPS data volume and frequency resources are more and it proportionally increases the operating cost of the device. This offline route learning system is a low cost alternative, with capability to learn the route offline. It makes use of very simple algorithm and of course with certain limitations. This offline device cannot suggest a new route as the advanced one, but can help on a route once learned. It can be used by pedestrians or vehicles in an expedition or touring. In case of lost way, they can use this system to come back to a familiar point. It can be used in trucks or taxi to keep record of it's track. Inexpensive solution for track lost and a simpler track log for expeditions, resulted in this Low cost offline route learning system.

3 System Overview

The Route learning system has two sensors, one Real Time Clock, a storage device, a Microcontroller and power supply as outlined in Fig.1.

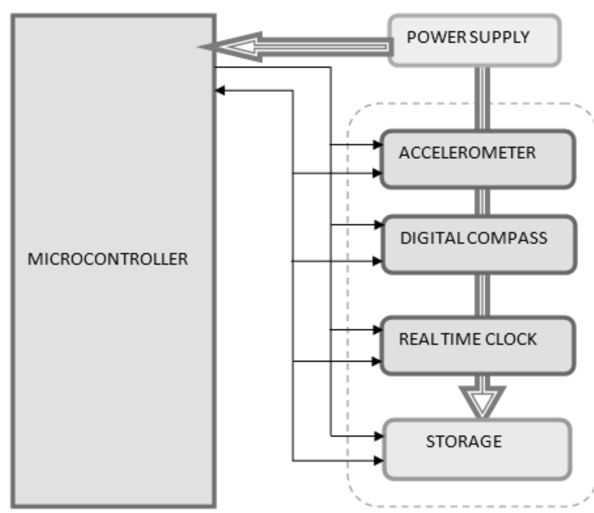

Fig 1. Overview of Route learning system

An external power source or battery can power all units of the system. Accelerometer gives the acceleration of the unit in three axes X, Y and Z. But we need only two axes X and Y readings. The digital compass gives direction details at which the unit headed. RTC gives the time stamping to the readings. These data stored in an EEPROM is retrieved later to a PC. The calculations for retrieving speed of travel, distance travelled and direction is performed in Microsoft Excel. Integrating the accelerometer readings with respect to time once will

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give speed and twice will give distance covered. The compass readings give direction. Each range of readings denote a particular direction.

4 Implementation

4.1 Sensor Design

Commonly available, low cost Commercial sensors such as the ADXL345, tri-axial accelerometer, HMC5883L digital compass and DS3232 Real Time Clock with inbuilt oscillator are used to design the sensor section [6].

The acceleration data of the device along each orthogonal axis is recorded using ADXL345, tri-axial accelerometer. It can give digital output upto13 bits, but our task need only 10 bit output. With a measurement range of ±2g, the sensor allows for a sensitivity of 15.6mg/LSB when operating with a 2.5V supply [10]. The sensor has three different digital outputs, available in separate registers corresponding to each orthogonal axis, and these outputs are given to the microcontroller through I2C interface.

The HMC5883L digital compass has 3-Axis magneto resistive sensors. It works in dependence with earth's magnetic field. It gives out 12 bit digital output with full scale range of ±8 Guass and 4.35 milli guass resolution when operating with 3V. The data is read out by microcontroller through I2C interface. It can give out data at a maximum of 400 kHz, as decided by the master, which is microcontroller in this case.

The time at which above device readings are taken is recorded by the microcontroller by registering the RTC readings in an external EEPROM. DS3232 is a Real Time Clock equipped with built in oscillator and I2C interface. It supports up to 400 kHz data rate in I2C communication. The time values for hour and minute is read from its internal registers. It has battery backup input for continuous time keeping.

4.2 Data Acquisition and Processing Module Design

All these data collection and controlling is done by the microcontroller PIC18F452. It is a low power microcontroller which consumes <1.6mA @ 5V, 4MHz. It is equipped with 32Kb flash memory. It has Master Synchronous Serial Port MSSP to provide I2C interfacing facility. It is self programmable under software control. It is done using 5V single supply In Circuit Serial Programming, ICSP via two pins. The data stored in external EEPROM is downloaded to computer through microcontroller using USART through RS232.

The values read from all these sensors are recorded in a two wire serial EEPROM, 24C1024 with I2C connectivity [8]. It has a capacity of 1Mb. A location of this EEPROM is accessed using 17 bits. It supports random and sequential access of address locations. Bidirectional data transfer is supported. It can operate in a range from 2.7V to 5.5 V. It is powered by 3.3V supply in the system. It supports 400kHz read and write data rate, which matches with other peripherals.

The devices used in the system are compatible for I2C communication which can support a maximum of 128 devices at a time. Only 2 pins are required for communication between all these devices. Each device in this connection willhave dedicated address and master will control the communication procedure. The address for each device has seven bits and eighth bit indicates read or write. In effect read and write address for same device is different. The device who generates the synchronizing clock for I2C communication is termed as 'master' and others in the line are slaves.

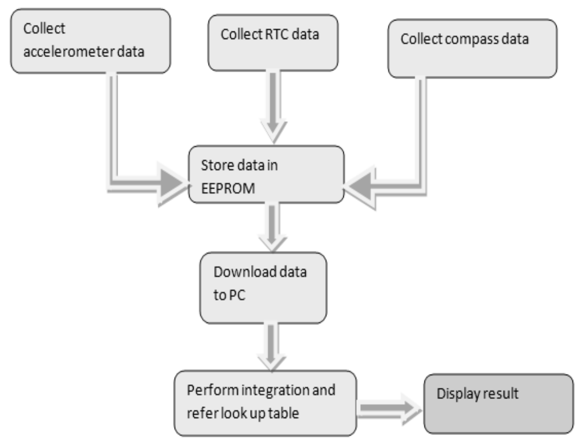

Fig 2. System control flow diagram

The data from the sensors are collected once in 10 seconds which is adequate for a vehicle route tracing. From the two sensor readings and the time of recording the event, the required parameters can be found out. The acceleration readings between fixed time intervals give speed on single integration and distance travelled on double integration with respect to time. The look up table generated for particular digital ranges give direction in terms of North, South, East, West or intermediate. The calculations required for this can be performed by Microsoft Excel after downloading the data to a computer via serial interface.

4.3 Power Supply Design

The main input supply voltage of 5V was meant for microcontroller operation. The sensors and EEPROM are comfortable with 3.3V for their normal operation. The Real Time Clock required an additional battery backup of 3.3V. An internal voltage regulator is maintained to meet various voltage requirements. Since the device is portable and not meant for prolonged operation, we can power it with normal battery. Provisions are also given to supply power using output of a DC adapter. The whole system has two important power rails. Power saving features are also enabled with properties of each peripherals used in the system. This design makes it a standalone system.

4.4 Performance

The device should be placed such that the marked portion on it's housing points toward direction of progress of vehicle or moving body. The device will not register any readings if the body is stationary. The rotational motion of device can be measured more precisely by using a gyroscope. The use of gyroscope is exempted in order to reduce cost of equipment. The effective combination of accelerometer and compass can give satisfactory results. This device makes use of relatively simpler fixed interval algorithm, in which readings are taken at fixed time intervals [2].

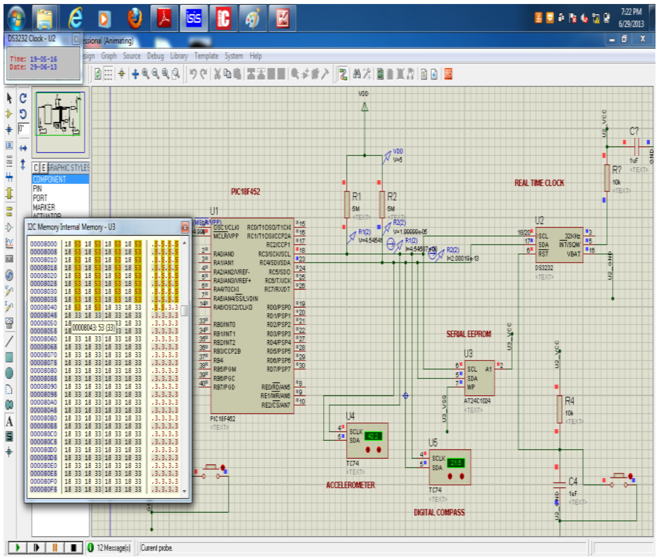

Fig 3.Sample simulation for data loging

5 Conclusion and Recommendations

The experiment setup has returned values successfully. Even though the result is with certain limitations, it can be improved by considering more error correction techniques. The selected components consume only low power. The system can be improved by sampling more values taken from sensors. This system accuracy is increased by solving the compass reading correction on tilt. The calculation steps can be performed inside the system and the end result can be displayed using a LCD. This is the improvement that can be considered for next level.

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