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Patient Spine Data Wireless Transmission and Monitoring

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ABSTRACT*:* Now a days, poor posture or extra stress on the spine has been shown to lead to a variety of spinal disorders including chronic back pain, and to incur numerous health costs to society. So, it is important to monitor and analyze a person's spinal movement and strength. Making the individual continuously aware of any spine problem may reduce some poor tendencies and encourage healthy spinal habits. I have decided to develop a system which monitors spine stress in real-time and poor back posture or strain on the back can be detected using BLE, RFID, Wi-Fi, ADC modules and MSP430 controller.

KEYWORDS*:* BLE module, RFID, ADC, Wi-Fi module, MSP430 controller.

I. INTRODUCTION

The purpose of this project was to develop an embedded solution which transfer requested strength data from strain gauge, direction of strain, degree of rotation and direction of rotation data from pulse encoder to Android device wirelessly. These data are sent to the end user through a wireless device. This project allows the end user to monitor and analyze patient's strength and spine data in real time. It takes patient's spine and strength data in real time and transfers this data to end user to monitor and analyze.

The overall hardware platform consists of an embedded micro controller board with Bluetooth, RFID, Wi-Fi, ADC modules. There is also strain gauge and pulse encoder hardware available in the system. The Firmware scope of the project is to develop firmware for hardware. The firmware will support communication between Android device and the hardware wirelessly via Bluetooth.

Firmware of this project is developed on MSP430F5419a micro controller. Firmware is designed to serve request stream from Android device on Bluetooth communication interface. Based on the received decoded request, firmware accesses required module via driver. There is a dedicated driver for each module.

Description

Pulse Encoder Driver: Pulse encoder driver is used to take input from 2 channels of pulse encoder to calculate degree of rotation and direction of rotation. These degree and direction of rotation can be measured by edge triggering both channels of the pulse encoder. These degree and direction data are further used by MCU firmware to send response to Android device over Bluetooth.RFID Driver: RFID driver works on UART protocol which is used to read RFID tag of the customer associated with doctor's profile. RFID driver the 12 character RFID tag whenever it is tagged to the system.Wi-Fi Driver: Wi-Fi driver works on UART protocol which is used to transmit scaled data of sensor's wirelessly (for diagnostic purpose only during manufacturing). Wi-Fi module provides another option of data transfer in the system.ADC Driver: ADC works on SPI protocol. ADC driver will take analog input from strain gauge, sampling and convert it into digital output measured in NM. This digital output is further used by MCU firmware to send to Android device over Bluetooth.Bluetooth Driver: Bluetooth driver works on UART protocol which is used to transmit data of sensor's wirelessly. As of now this is the main responsible module to communicate with Android device. Bluetooth driver is at the center of all module drivers which manages and controls all the drivers.The android application will communicate with above listed driver to read data on demand, calculate the data and send the same to Android device over Bluetooth. These data will be presented in graphical manner on android device through an android application.

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II. RELATED WORK

In [1] wireless mobile sensing system developed which monitors spine stress in real-time by detecting poor back posture and strain on the back due to excessive sitting or standing. This system provides a unique method of measuring spinal stress at both the back and the feet by integrating all posture sensors with strain sensors. Posture and strain data is collected by putting a posture sensor at the neck and weight sensors at the feet. Also, the position of the patient (sitting, standing, or walking) can be determined by analysis of the weight sensor data and is visualized in real-time, along with back posture, at the central station by a graphical animation. Thereafter, data from all sensors is stored in a database to enable post processing and data analysis, and a summary report of daily posture and physical activity is sent to user.

The use of centralized processing allows for high performance data analysis and storage at the central station which enables tracking of the individual's progress. It is demonstrated effectiveness of the system in simultaneously monitoring posture and position by testing in numerous situations.

III. SYSTEM

The top level system block diagram consists of an embedded micro controller board with Bluetooth, RFID, Wi-Fi, ADC modules. BLE, Wi-Fi and RFID modules are interfaced via UART interface, Pulse encoder module is interfaced via I2C interface and strain gauge is interfaced via SPI interface through ADC circuit.

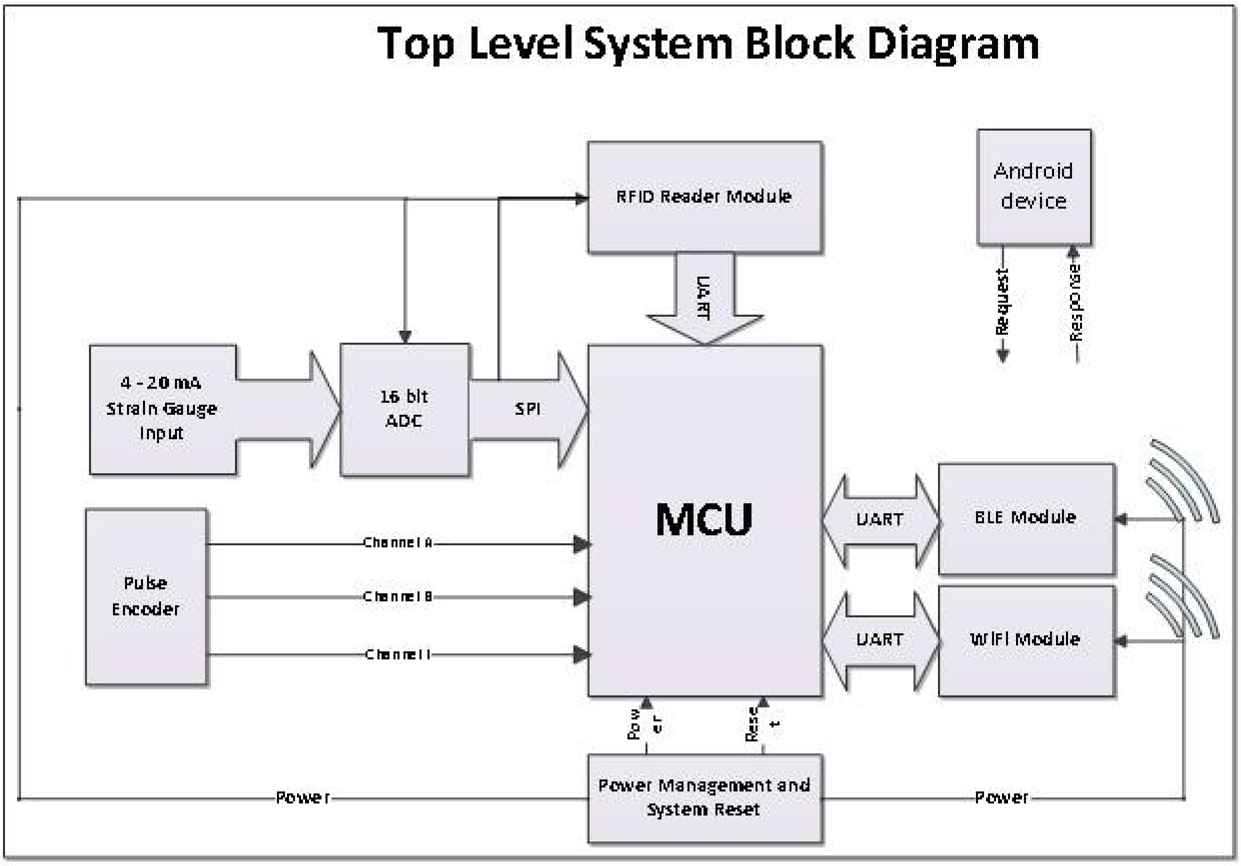

Fig. 1. Block diagram of the system

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Firmware overview:

The firmware provides wireless connectivity between board and Android device. The firmware uses protocol such as SPI and UART and drivers for pulse encoder, Bluetooth, RFID, Wi-Fi and ADC. Main application runs on top of hardware which uses low level API's to interact with modules and high level API's to interact with Android device.

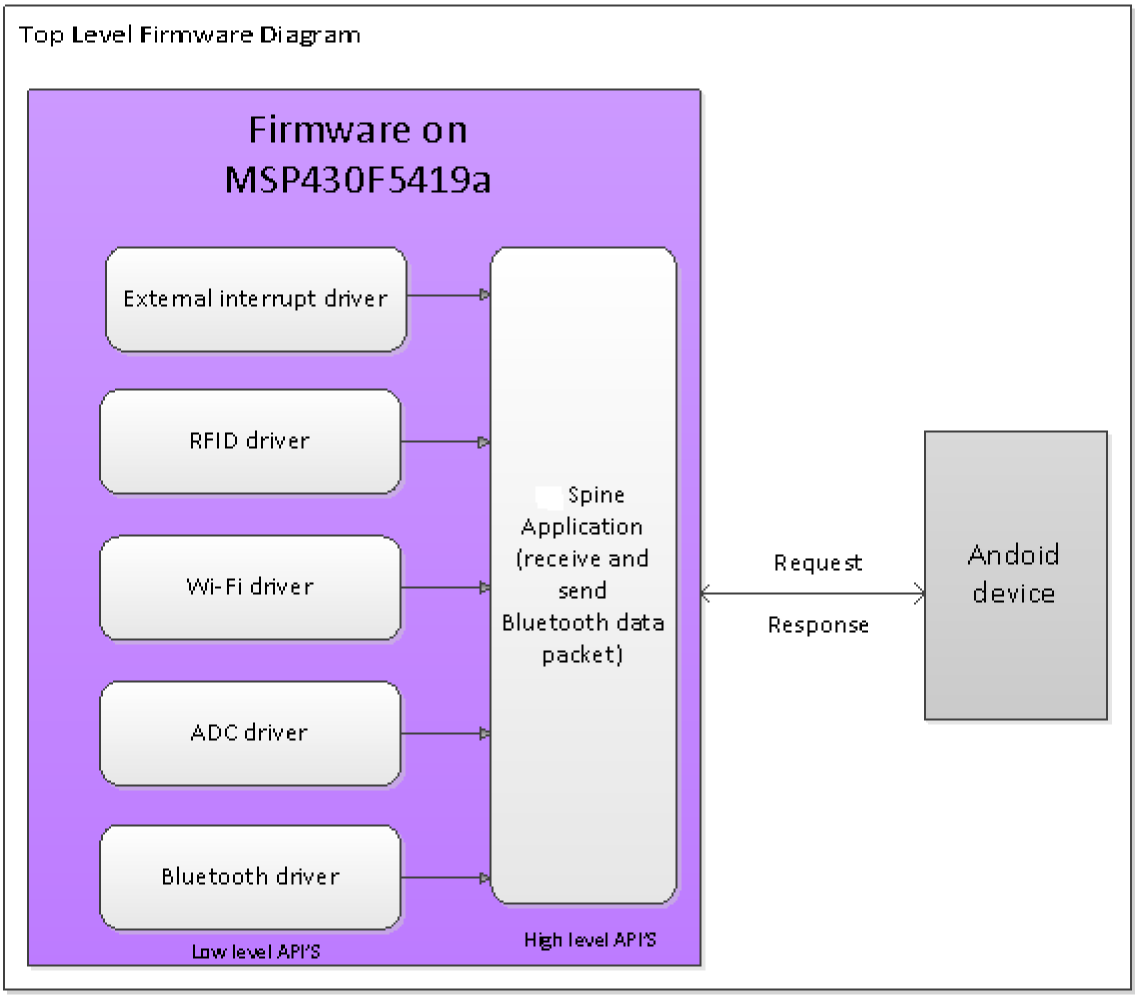

Fig. 2Top Level Block Diagram of Firmware

IV. IMPLEMENTATION

The firmware application program has been developed in C on MSP430 controller. Flowcharts of the working of firmware application are as follows.

Flowcharts

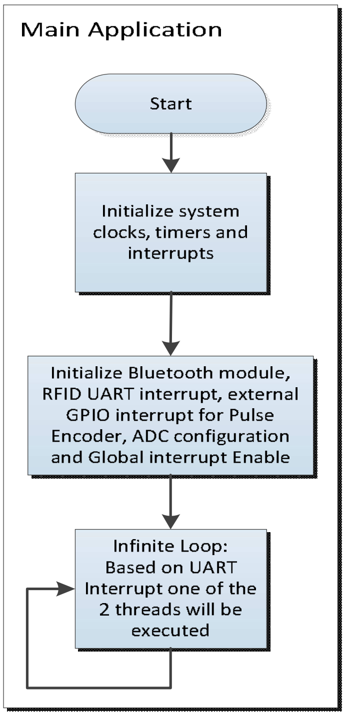

Fig. 3Main Application Flowchar

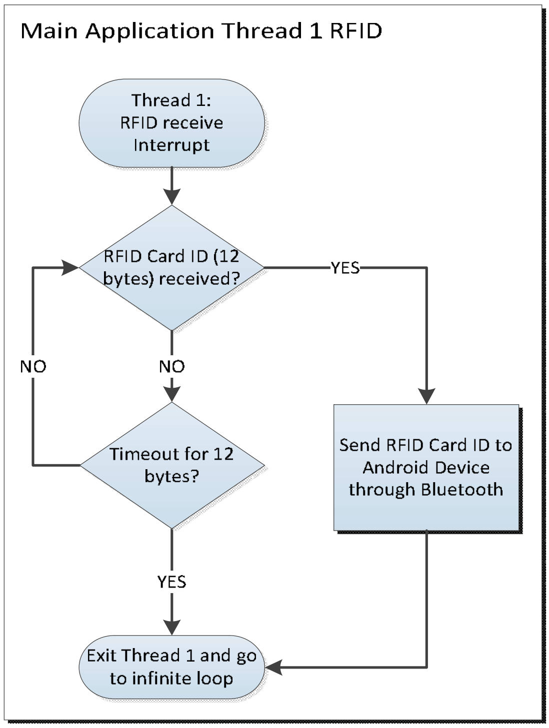

Fig. 4Application Thread 1 - RFID

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Flow of firmware application is as under,

- Firmware Application will first initialize the MCU and all modules.
- Then after successful initialization application will come into waiting loop (ready mode) where each module will get control according to the request send by Android device.
- Upon request receive over Bluetooth interface firmware will receive, parse and verify the request.
- If parsed request is for strength test, firmware will read the analog input from strain gauge via ADC with SPI interface, then calculate the strength and direction and send back the data to Android device over Bluetooth.
- If parsed request is to start mobility test, firmware will start to accumulate the pulses from pulse encoder via pulse encoder driver and keep accumulating the data until stop request.
  Whenever stop request will be initiated by Android device which will be catch by firmware.

If parsed request is to stop mobility test, firmware will stop reading data from pulse encoder and calculate the direction and degree of rotation using accumulated data and send back the scaled data to Android device over Bluetooth.

This is an OS less sequential design where all the events will be severed in sequence. However the communication with the external peripheral will be handled by Bluetooth module and its read and response sequence will be initiated by UART Rx interrupt.

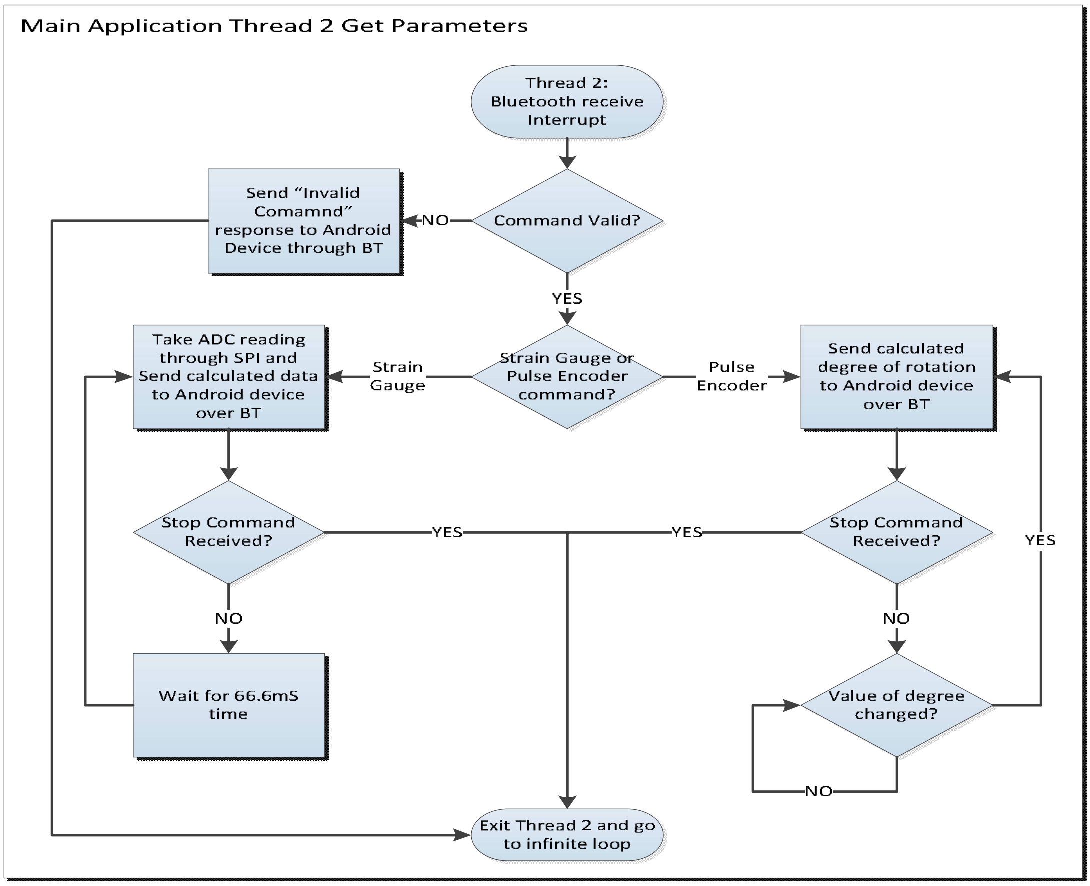

Fig. 5 Application Thread 2 – Get Data

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V. RESULTS

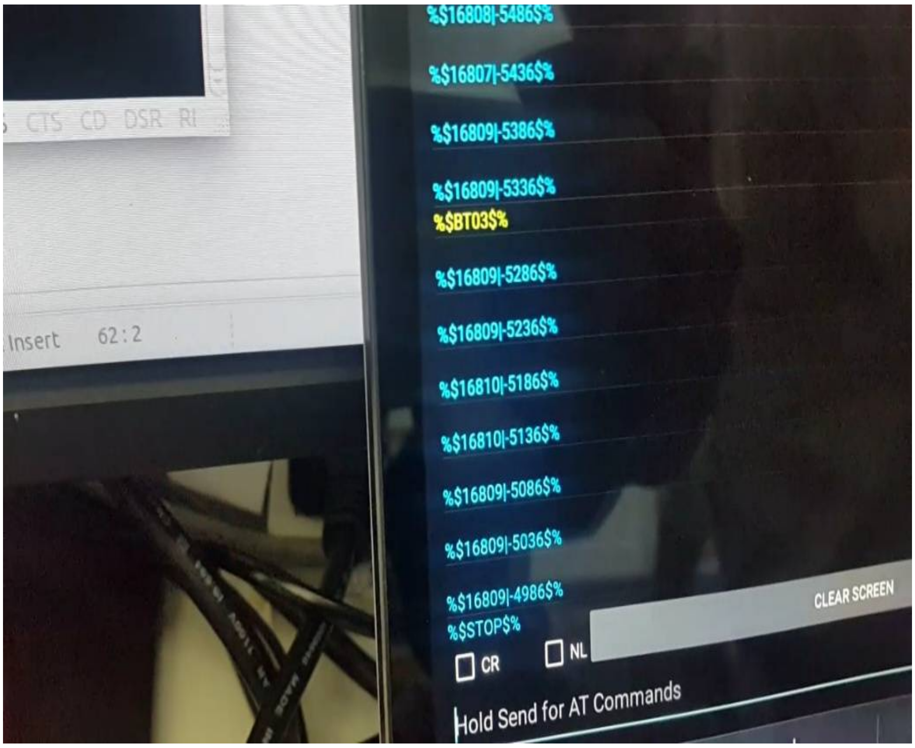

Fig. 5 Screenshot of Output of System

The screenshot of the output shows the output received on the android device. The string received is the combination of the output data with its time stamp. These date are transmitted through BLE module.

Communication protocol of the system

The table shows the communication protocol used in the system. It shows the command string received from the android device and according to the string received, the system starts processing and calculating the corresponding data and then sends these data to the android device.

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TABLE 1
COMMUNICATION PROTOCOL

<table>
<tr><th>Sr. No.</th><th>Command string from android device to board</th><th>Response string from board to device</th><th>Command name</th><th>Description</th></tr>
<tr><td>1</td><td>%$BT01$%</td><td>%$<NM Reading>|<time in mS>$%</td><td>Send Strain Gauge Data</td><td>This command will instruct to start sending calculated data of strain gauge from board every 66.6mS (15 values/sec).</td></tr>
<tr><td>2</td><td>%$BT02$%</td><td>%$<Degree>|<time in mS>$%</td><td>Send Pulse Encoder Data</td><td>This command will instruct board to start sending data from Pulse Encoder whenever there is a change in either degree of rotation i.e. we will consider 180 degree as reference, so for 10 degree clockwise rotation firmware will send 180+10=190 degree.
And for 10 degree anti clockwise rotation firmware will send 180-10=170 degree. The same way Android will able to detect degree and direction of rotation by subtracting 180 degree reference value.</td></tr>
<tr><td>3</td><td>%$BT03$%</td><td>%$STOP$%</td><td>Stop Sending Data</td><td>This command will instruct board to stop sending data from either Pulse Encoder or Strain Gauge whatever it is sending right now.</td></tr>
<tr><td>4</td><td>%$BT04|<SSID>|<PW>$%</td><td>%$WIFI$%</td><td>Wi-Fi credentials setting</td><td>This command will send Wi-Fi credential settings (SSID and Password) for Wi-Fi module on board.</td></tr>
<tr><td>5</td><td></td><td>%$RFID|<Card ID 12 Digit>$%</td><td>RFID Card ID response</td><td>Whenever there will be a RFID card scan to RFID Reader, The controller board will send the 12 characters Card ID in defined format.</td></tr>
<tr><td>6</td><td></td><td>%$INVALID$%</td><td>Invalid Command</td><td>Command received by MSP430 is in invalid format. It will send INVALID command response.</td></tr>
</table>

VI. CONCLUSION AND FUTURE WORK

This project successfully displays a patient's spinal strain and strength data on an android device which is transferred from the board via Bluetooth communication as these data are taken and calculated through various modules. There is also a Wi-Fi module available in the system, which can be used as communication device. But, in the places where there will be no internet facilities available, Bluetooth communication will be more useful. So, currently Bluetooth module is the main communication device in the system. In future we can make Wi-Fi module as a communication medium between the board and android device.

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BIOGRAPHY

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