Note Title 5/7/2018

Module 4

Lecture 4

STM design for BLSRP - lab scale - II

- Sensors chosen with additional requirements
  1) reduced settling effects
  2) Control of sensor drift
- both fast/slow (acceleration, displacements)

Sensor modules feature user-programmable full scale range of ±250
±500
±1000
±2000°/s (dps) for the gyroscope

±2g
±4g for the accelerometer
±8g
±16g

present study ±2g range, sensitivity of 16302 LSB/g

Internal registers are enabled for accessibility

I2C @ 400 kHz (SPI @ 1 MHz)

- SDA - signal serial data
- SCL - a serial clock

- These lines are bi-directional
  - sensor module < slave / master | scalability

MPU 6050 - acts as a slave
but while communicating to the processor
it acts as a master node

- It is connected to the processor board through GPIO pins

Both sensor nodes to acquire data & also transmit the data to base station is parallel.
processing unit

MPU 6050 -

No	Name	description
8	VLOGIC	Digital I/O supply voltage VLOGIC ≤ VDD @ all times
9	AD0	I2C Slave address LSB
23	SCL	I2C serial clock
24	SDA	I2C serial data

- AFS_SEL is a 2-bit, unsigned value of accelerometer @ hex address 0x1C
  to select the full scale range of the accelerometer automatically

- Gyroscope configuration pin, allotted hex address 0x1B
  - is set to trigger the gyroscope self-test
  - also used to configure for full-scale-range.

- 0x6B is the Power Mgmt register (PWR_MGMT)
  - configures the device power mode & the clock source

While 6th bit of this register will reset the device when set to 1,

power mode can be either set to sleep or cycle mode automatically

- Device switches b/w sleep & cycle mode are also set to acquire a single sample rate specified by

LP_WAKE_CTRL register

I2C_MST_CTRL configures I2C bus for multi-master control & 8MHz internal clock

These registers are initialized @ the first step of configuration

- using an interface code, originally developed by us @ IITM

pin configuration for initializing the device is executed using the following code

```
self.bus.write_byte_data(0x68, 0x6b, 0x01)
self.bus.write_byte_data(0x68, 0x1B, 0x00)
self.bus.write_byte_data(0x68, 0x1C, 0x00)
```

For each axis offset values are computed

- error is the actual acquisition can be adjusted for the measurement

- actual error may occur due to offset and drift value

MPU 6050 module

3 # of 16-bit ADC are used to read the acc output on all (3) axes

for example,

to read x-axis output.

ACCEL_XOUT_H
ACCEL_XOUT_L | (2) registers 8-bits each.

- Data within the internal register is continuously updated @ the desired sample rate

- In case it fails, user can check whether it follows single-byte reads corresponds to single sample output

- All required Library fns are included to read/write bits to register values

all axes { 16- bit value is first read
- then the complete value is considered for data processing

Code used for reading the abscissa value from the ACCEL_OUT register is given below

```
high = self.bus.read_byte_data(0x68, 0x3b)
low = self.bus.read_byte_data(0x68, 0x3c)
val = (high << 8) | low
mask = (2 ** bitlength)-1
if val & (1 << (bitlength-1)):
        xval = val | ~mask
else:
        xval = val & mask
```

Two major factors - measurements obtained from sensor

(1) Noise reduction
(2) # of outliers

Both will degrade the validation of results

Source of noise

(i) presence of thermal noise
(ii) electromagnetic interference
(iii) sensor oscillation
(iv) Quantization noise

STM - design ②

These effects are reduced.

- Stained data from STM-2 will be also checked with wired data
- Effect of random noise, found in PSD @ 10Hz is 400 $M\Omega/\sqrt{Hz}$
- outliers are obtained by examining the spikes those appear in the RMS of the data, @ specific time interval

Time series of these spikes are checked for irrational measurements
- data is processed

- MEMS accelerometer - measure linear accelerations and local gravitational field

In the absence of local gravitational field, output of the value will give rotated gravitational field vector
- used to measure rotational response about the respective axis (pitch & roll)
y, x

Between the static acceleration & acc due to gravity || an inclined angle will be generated

- This corresponds to tilt of the sensor
- Raw value of the accelerometer is acquired and the corresponding 'g' value for the respective axis is calculated

pitch & roll estimates can be computed as below

$$Pitch = \arctan(Gy/\sqrt{(Gx2 + Gz2)})$$ —— (1)

$$Roll = \arctan(-Gx/Gz)$$

Where Gx, Gy, Gz are the linear acc in X, Y, Z axis respectively.

- Denominator of the pitch value is defined to be +ve
  - CPU provide the value in the range (−90 to +90)
- For roll response range (−180 to +180)
- When Gx, Gz are zero, roll becomes undefined
  - roll is considered as (arctan).
    - to compute the angle by accounting for the Quadrant.

Processing Unit

- Raspberry pi ARMv7 processor
- low-cost computing device
  ARMv7 processor
- RAM and other interfaces to connect the external devices - GPIO pins
- keyboard for command only
- display unit to function as a standalone device

- pi board, perfect processor device without any peripherals
  - can be remotely operated / connected to the server unit

Pi - board - 512MB RAM as internal programmable memory
- Secure digital (SD) flash memory
- 16 GB memory to enhance the storage capacity of the data

- Wi-fi adapter is connected through USB dongle
  - Pi - board is used for creating ad-hoc network
  - wireless network
  - This runs on a standard 802.11n protocol

As a computing device. it uses an OS

which has Raspbian Wheezy – operating system

– This is a Unix – based open source OS.

– connects the sensor unit & processor board is established by GPIO (General purpose Input output) pins.

– B+ Raspberry pi-board

40 GPIO pins

– supply &

ground pins

GPIO pins can accept Input & output
- programmed on the Raspberry Pi.

GPIO pins read the connected sensor unit
- also can be used as an Interface b/w the embedded protocols
I2C & SPI.

- processor unit deploys inter-integrated circuits & serial peripheral interface protocols to communicate with the external device

Summary

- more technical specification
  - processing unit
  - sensing unit
  - sensors
    - acc
    - accelerometer
  - power source
    - sleep
    - active // (input power to sensors)