The Nomad Digital Pen

ENSC 440/305

School of Engineering Science
Simon Fraser University

2009.05.15

Outline

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- Roles in the Project
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- Project Specifics
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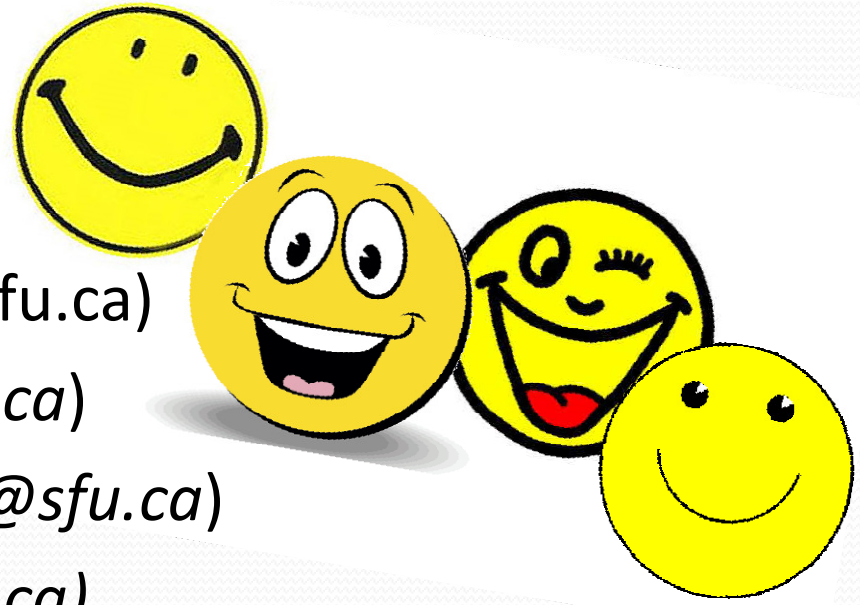
- Problems & Challenges
- Conclusion & Future work

TechStyles
Incorporated



Team Members:

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Behzad Jazizadeh (*bjazizad@sfu.ca*)

Unnati Sapre (*uss@sfu.ca)*

Roles in the project

- **Two teams of two:**
  - Hardware design: ***Zhen & Behzad***
    - HW/FW design & programming
    - Electrical design
  - Software development: ***Simran & Unnati***
    - User interface
    - HW/SW interface
- **As a team:**
  - Algorithm implementation
  - HW & SW Integration
  - Validation & testing

Team Dynamics

- Weekly Meetings
- Communication over internet
- Lab work at Burnaby Campus (Phase I)
- Lab work at Surrey Campus (Phase II)

Motivation

- Want pen that is more than just a pen
- Archive / Digitalize handwritten notes
- Portable
- Eco-friendly, “Go Paperless”

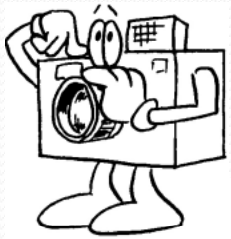
Existing Technology

- **Ultra Sound Technology**
  - Capture the motion by detecting the reflective signature

  - E.g. **EPOS Digital Pen**
    - Require a transmission base

Existing Technology

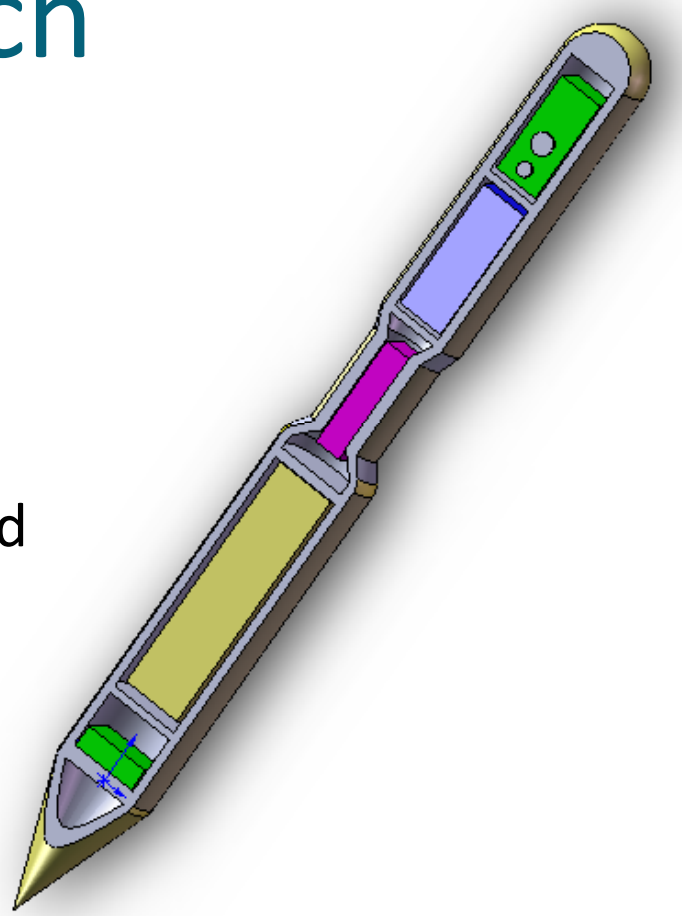
- **Optical Sensing Technology**
  - Image Capturing



  - E.g. **LiveScribe Pulse**
    - A tiny camera is embedded in the tip of the pen
    - Require special paper

Techstyles' Approach

- **New Approach:**
  - Capturing motion with Accelerometer
- **Main Advantage:**
  - All components can be integrated inside an ordinary size pen
  - Write on any surface



Goal for ENSC440/305

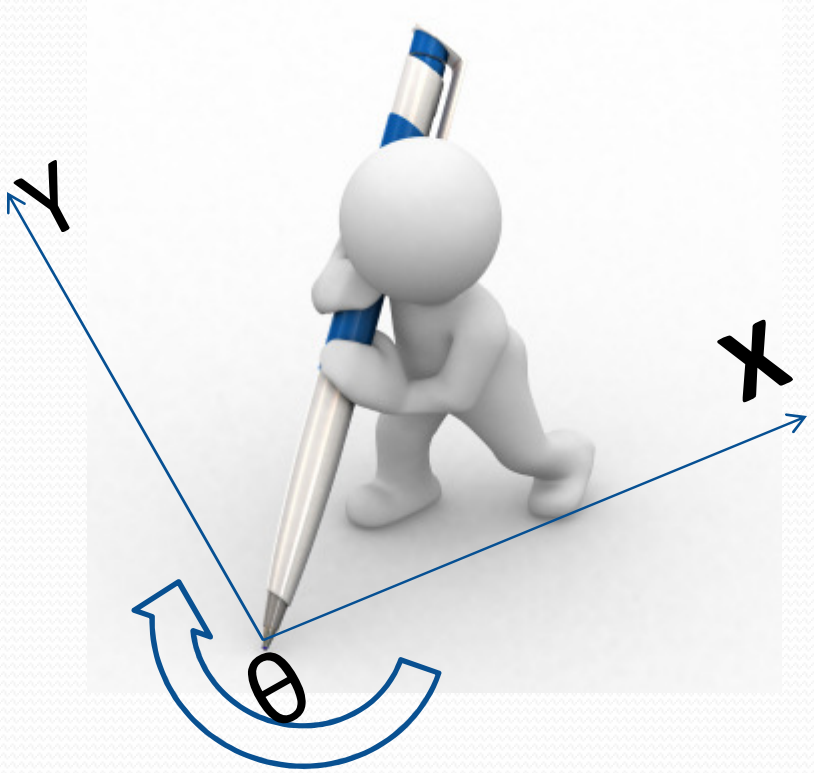
- **Proof of concept**
  - Research
  - Experiment
  - Analysis
- **Goal to achieve:**
  - To be able to display/save writing on the screen using accelerometer

NEXT…

…Technical

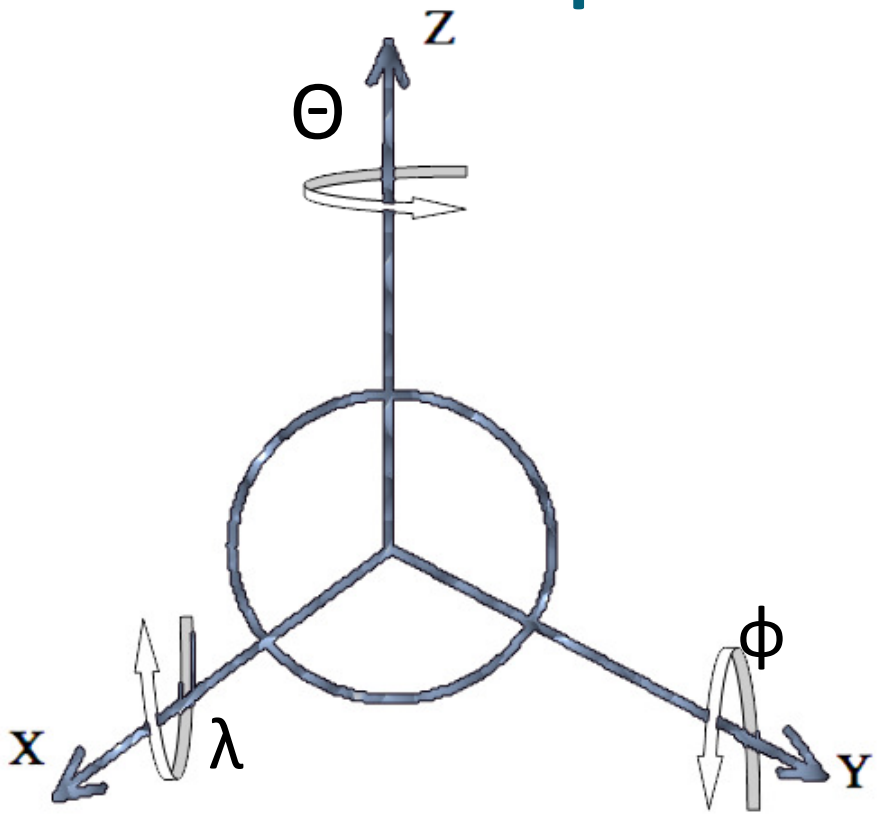
Writing on the 2D Surface

- Three main parameters:
  - X, Y for translation movement
  - Θ for the rotational movement



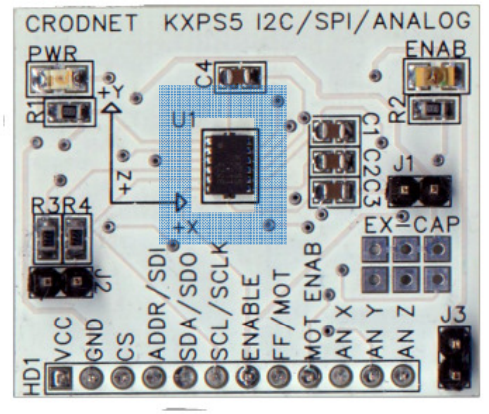
Move the Pen in the 3D Space

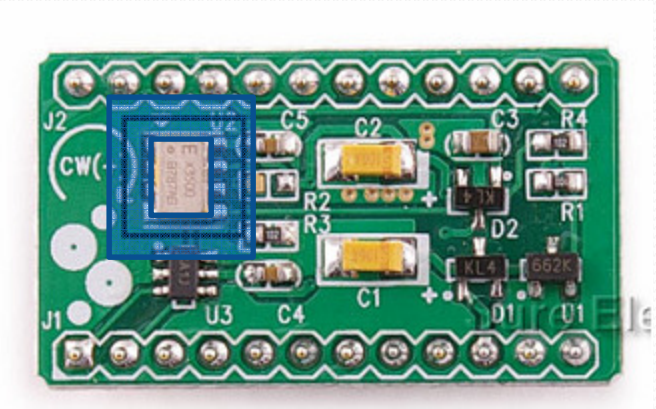
- 6 Degree of Freedom
- 6 Parameters
  - X, Y, Z
  - λ,ϕ,Θ



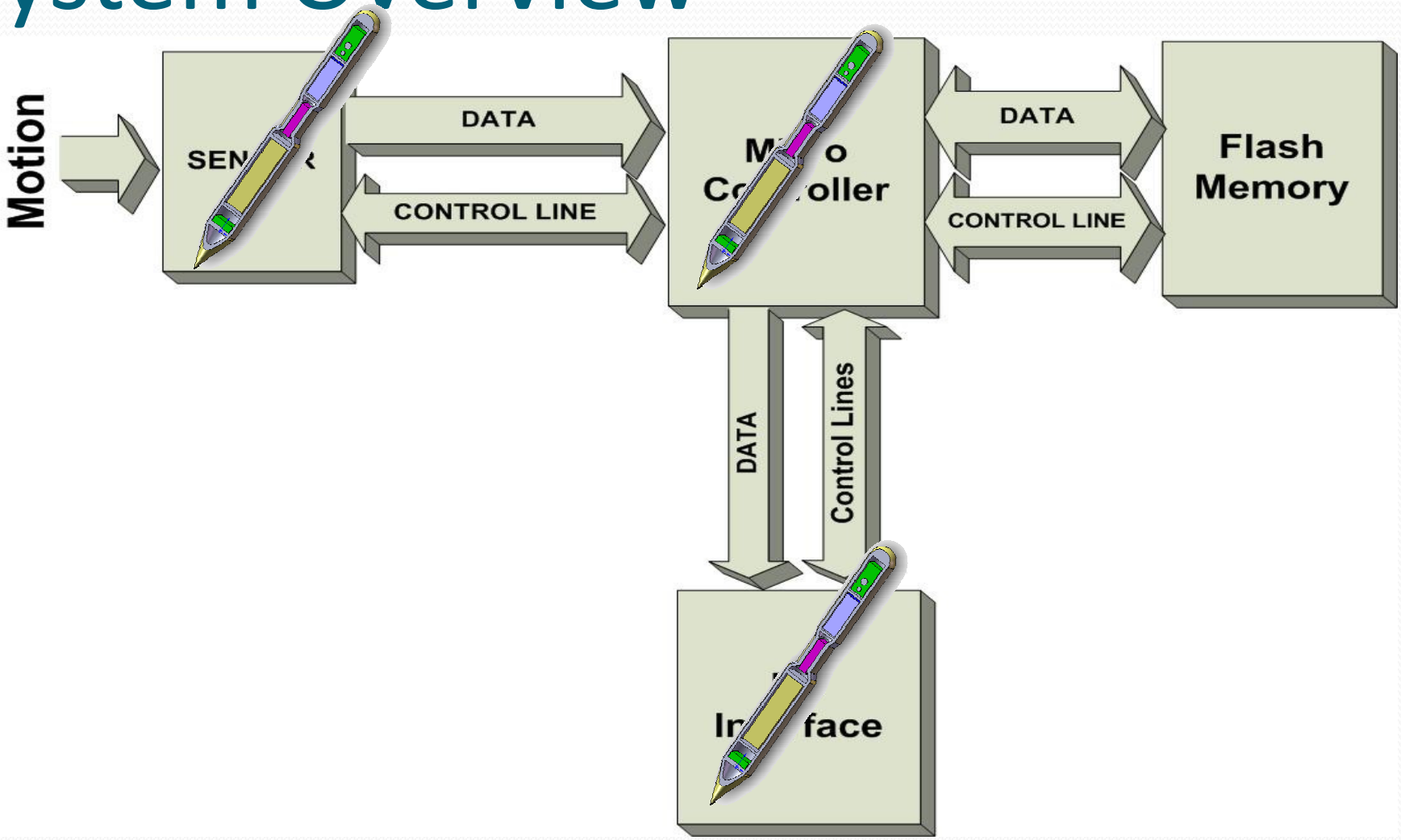
Sense the Motion

- **One Three-Axis Accelerometer**
  - Sense the translational acceleration
  - Receive the position data by double integration
- **Three single axis angular rate sensors**
  - Sense the angular velocity
  - Compute the angular movement by single integration

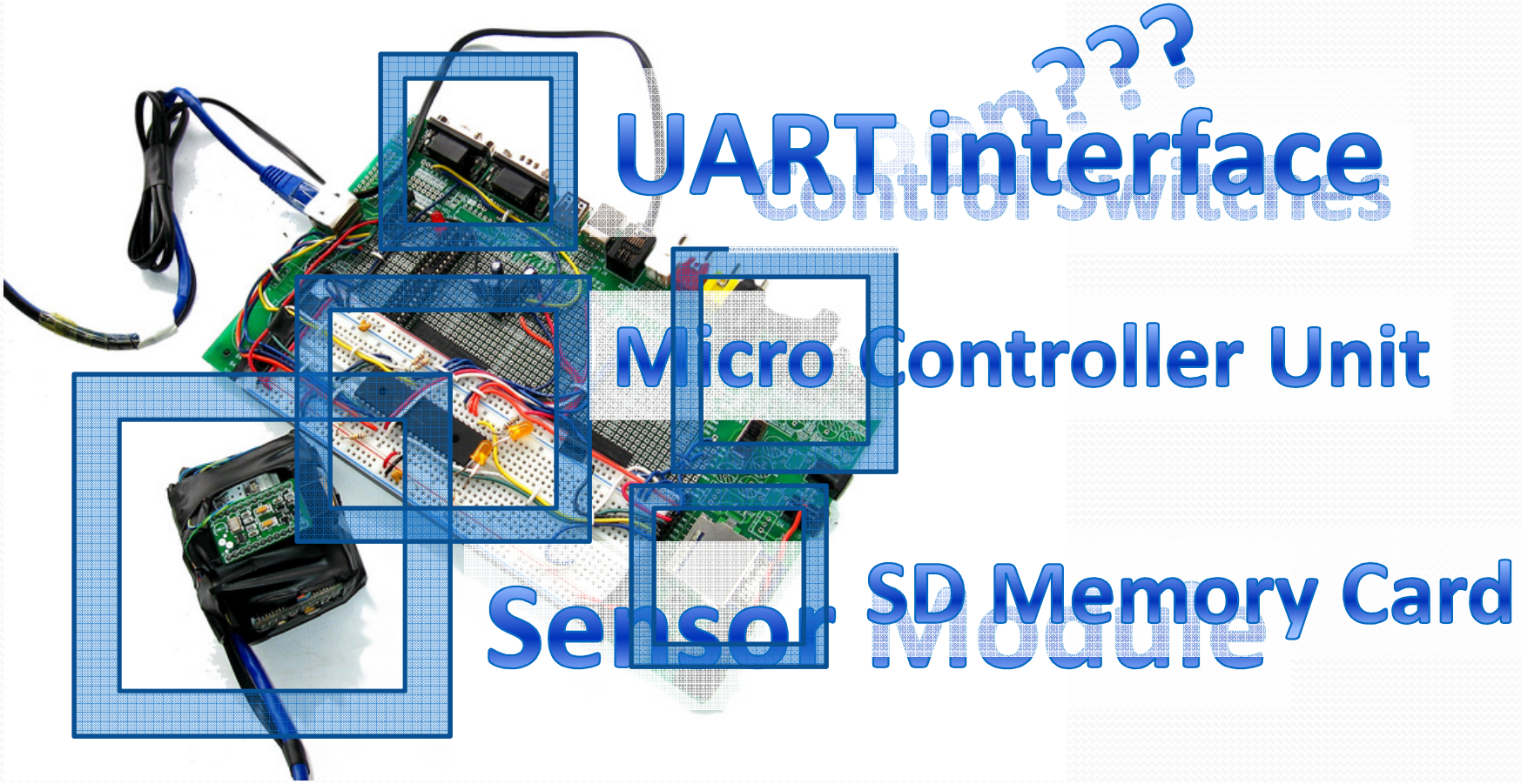




System Overview



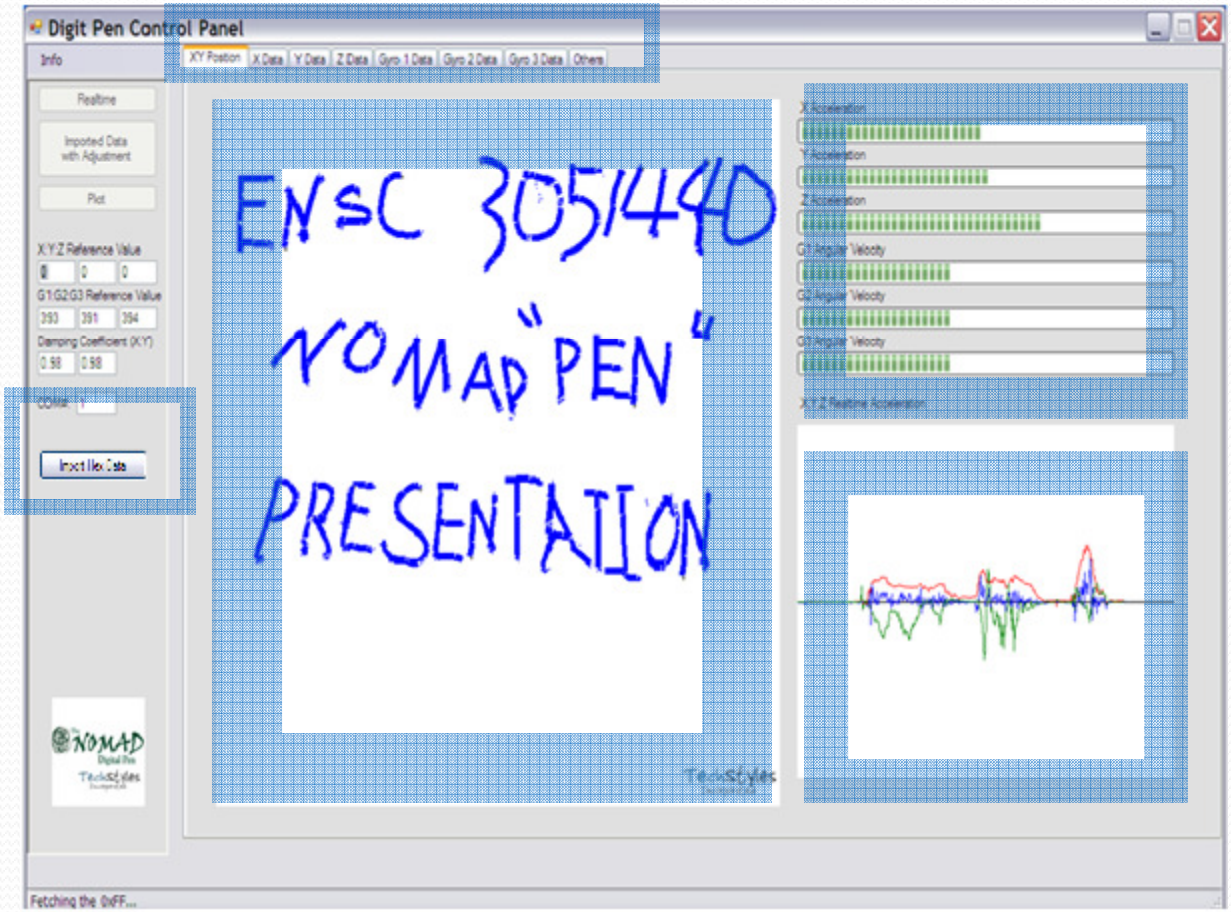
The Hardware Module



The Software

Features:

- Real-time Writing Display
- Acceleration and Angular Velocity Indicator
- Real-time Acceleration Plot
- Motion Data Capturing Tab
- Raw Data Import



NEXT…

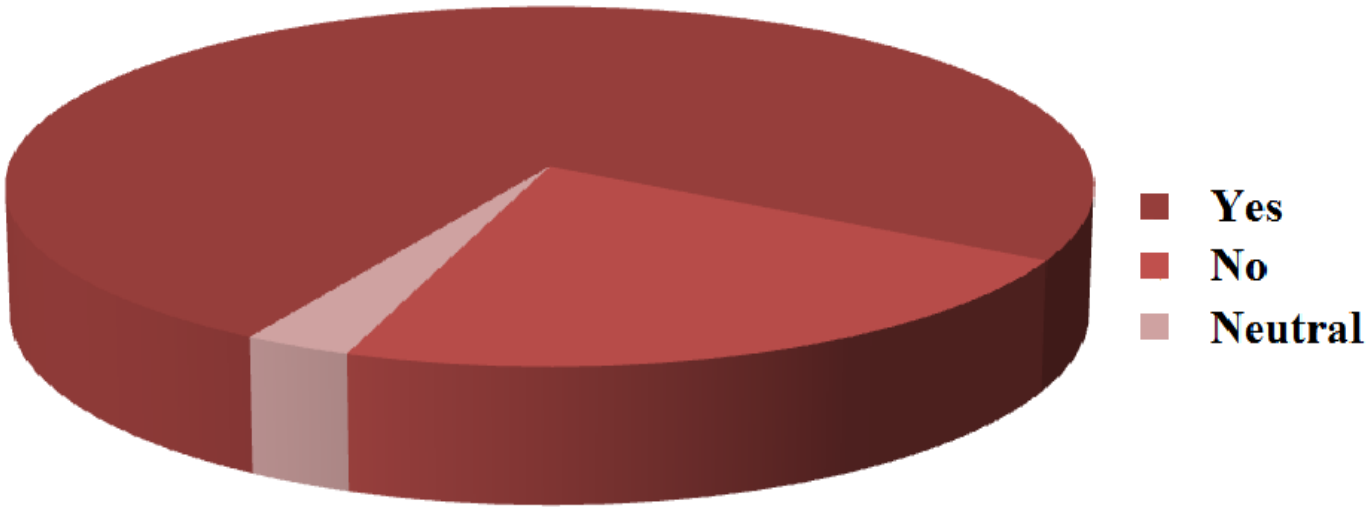
…Business

Business Case

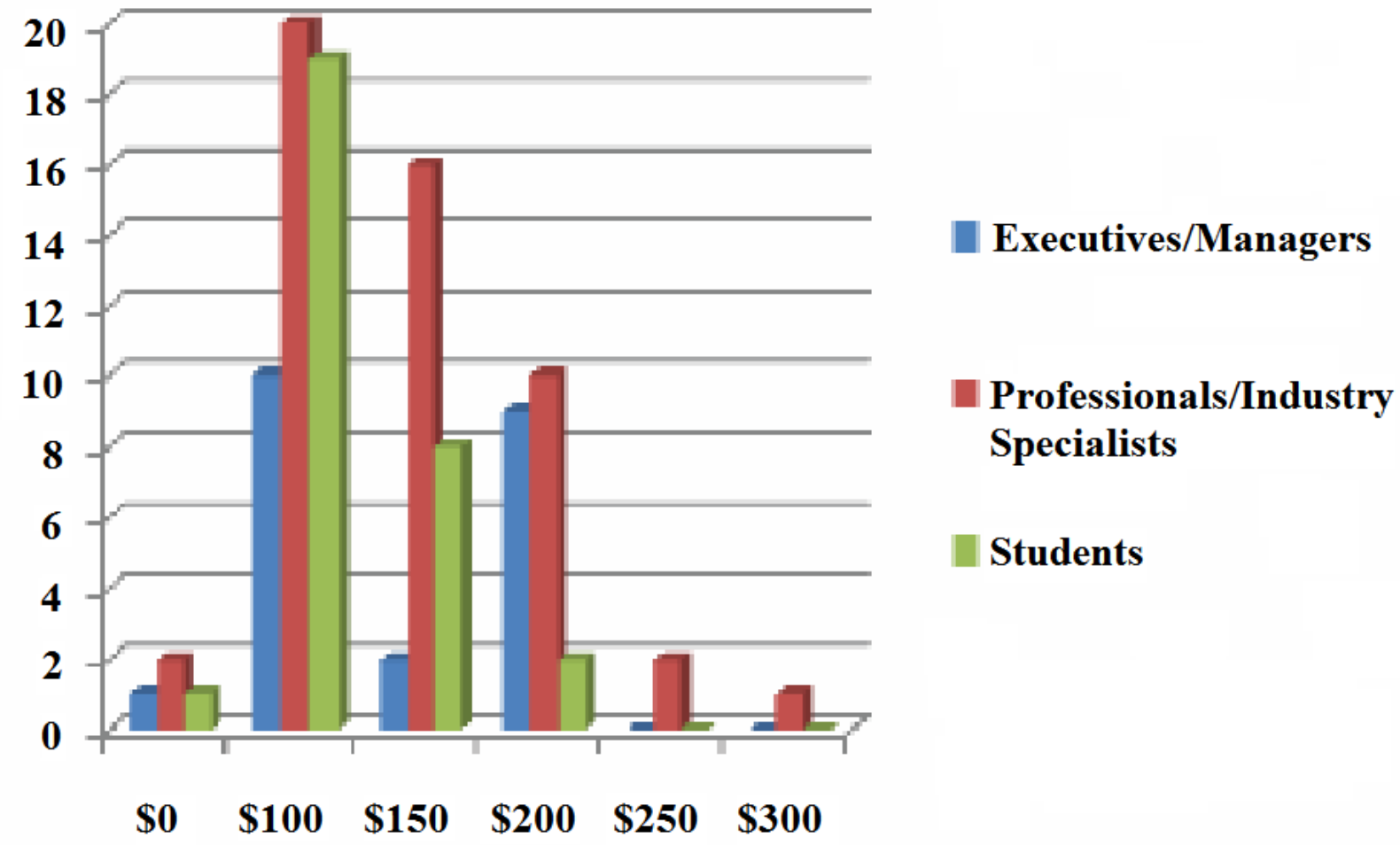
- **Market**:
  - Market Target:
    - Students,
    - Managers/Execs
    - Professionals
  - Marketing Plan:
    - Canada & U.S.A. (ages vary from 18 to 55)
    - Best Buy > Staples > London Drugs > Online Purchase > SFU Book Store

Business Case (Cont'd.)

- **Out of 103 cases…**
  - **75%: Yes, they would buy the Nomad pen**
  - **22.1%: No, they are not interested in it**
  - **2.9%: Neutral, they were indecisive**



Business Case (Cont'd.)



Business Case (Cont'd.)

- **Suggested Price**: **$133.98 CAD**

- **Cost**:
  - Proof of concept: so far **$420.00 CAD**
  - Prototype: estimated to be above **$500.00 CAD**
  - Mass production: average of **$23.00 CAD** *(@ breakeven point)*

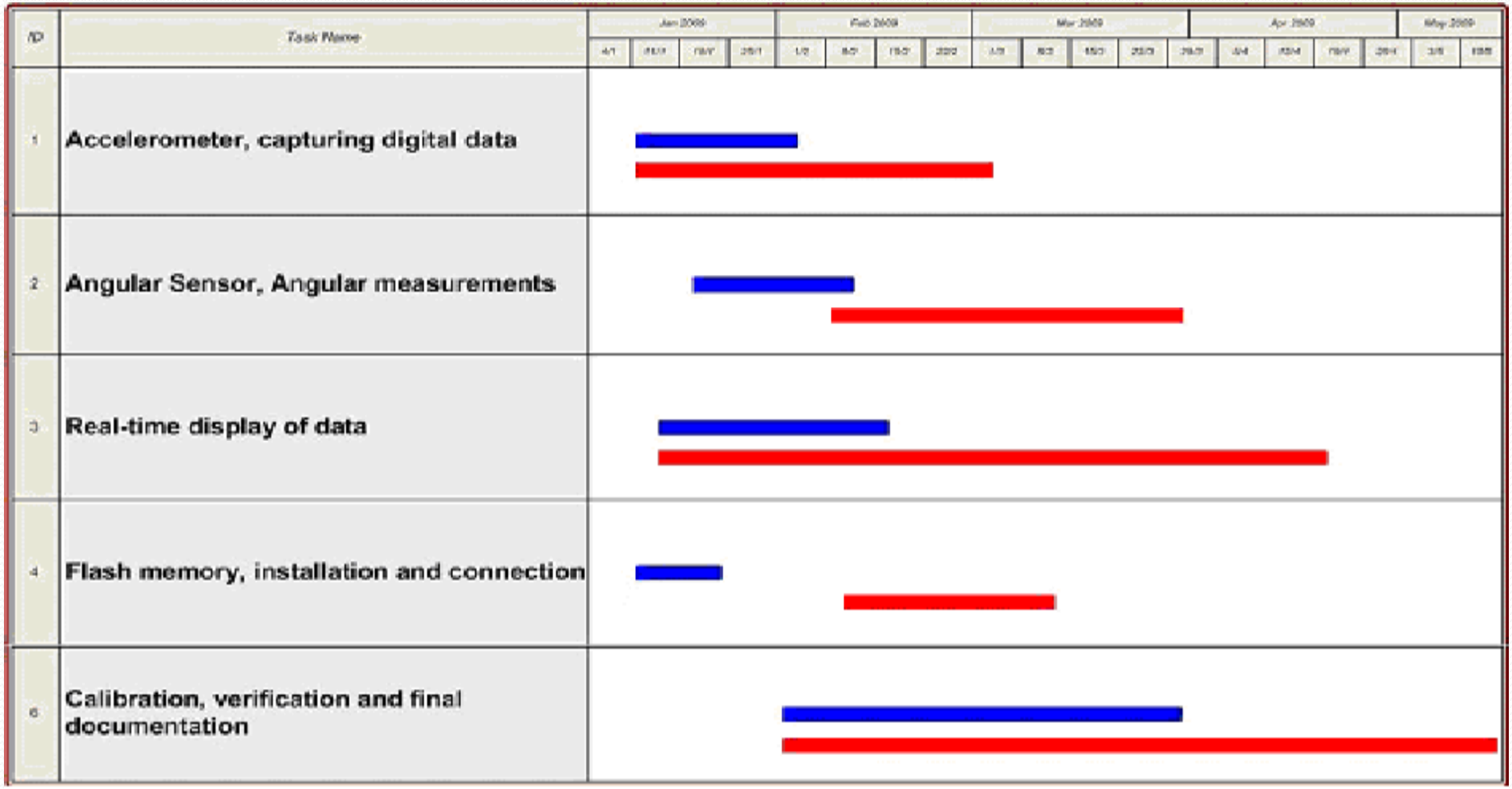
Business Case (Cont'd.)

- **Financing**
  - **Proof of concept:**
    - **Group Members**
    - **ESSEF**
    - **Ken Spencer 2nd prize**
  - **Prototype:**
    - **ESSEF**
    - **University Funding (Future proposal)**
    - **Angel investors**

Business Case (Cont'd.)

- **Competition**
  - Keep the vibe in the market and promote the brand
  - Protect the Nomad Pen via patents and licenses
  - Improve the Nomad constantly and add new features and sides

Project Specifics



Project Specifics (Cont'd.)

- **Timeline**
  - Ordered some of the components before the semester start
  - Self-studied project related material
  - Design from scratch
  - Underestimated the levels of complexity
  - Long shipment time periods

Project Specifics (Cont'd.)

- **Budget**
  - Ken Spencer 2nd prize
  - ESSEF (ESSS fund)
  - Free Samples

Project Specifics (Cont'd.)

Required Material	Estimated Cost (in Canadian)	Actual Cost (in Canadian)
Tri-Axis Accelerometer	$50	$132
Tri-Axis Gyro-meter	$100	$88
MCU	$50	$0
MCU Programmer	$50	$100
Cables/Connectors	$100	$30
Serial Interface chip	$50	$5
PCB/Signal Processing components	$200	$35
Other	$500	$22
Total	$1100	$412

NEXT…

…What we learned

What was learned……

- **Hardware coding two different models of MCUs from Microchip**:

  PIC18F2550

  PIC18F4685

- **Software coding**:

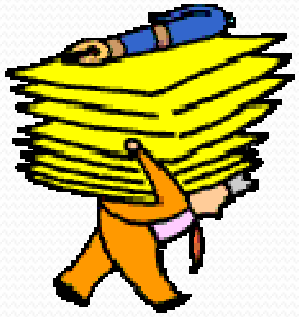
  RS232 Driver

  GUI

- **Sensor applications**:

  Accelerometer

  Gyro-meter



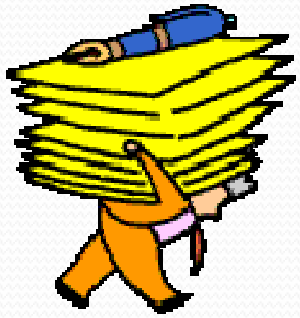
What was learned… (Cont'd.)

- **Hardware communication protocols**:

  SPI

  I^2C

  RS232



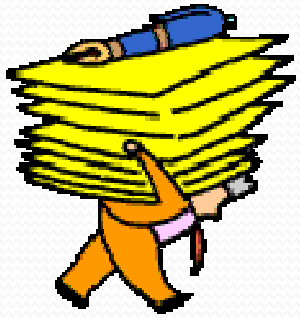
- **Analog to Digital converter**
- **SD-Memory Card**
- **A variety of compilers**:

  MPLAB

  MikroC

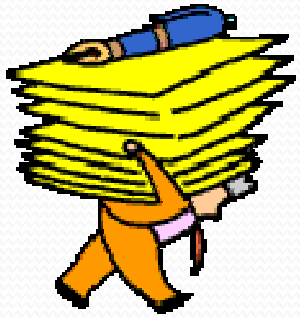
What was learned… (Cont'd.)

- **Console programming**:
  - TurboC
  - CXL
- **Windows programming**:
  - API
  - Visual C++
- **Windows form design**
- **Schematics design**
- **Testing and Validation**
- **Soldering skills**



What was learned… (Cont'd.)

- **Time management**
- **Task division / Multi-tasking**
- **Team division**
- **Documentation**
- **Technical writing**



Current Challenges

- Poor sensitivity of accelerometer at low acceleration
  - Proposed solution: replace acc. with higher sensitivity one
- Large change in acceleration when tilting, due to gravity
  - Proposed solution: replace gyro with magnetic sensor to detect the orientation with respect to the earth's reference
- Nonlinear relation between acc. Data and writing speed
  - Proposed solution: further investigate nonlinear characteristics of acc.

Future Work

- Continuing research
- Implementation of the USB or Bluetooth module
- Mechanical design for the compact NOMAD PEN
- Implementation of the first prototype for field trial

Conclusion

- **Background and motivation**
- **Project goal**
- **What we learned**
- **Proved that concept is feasible**
- **Challenges**
- **Future work**

Acknowledgement

- **Prof. Patrick Leung**
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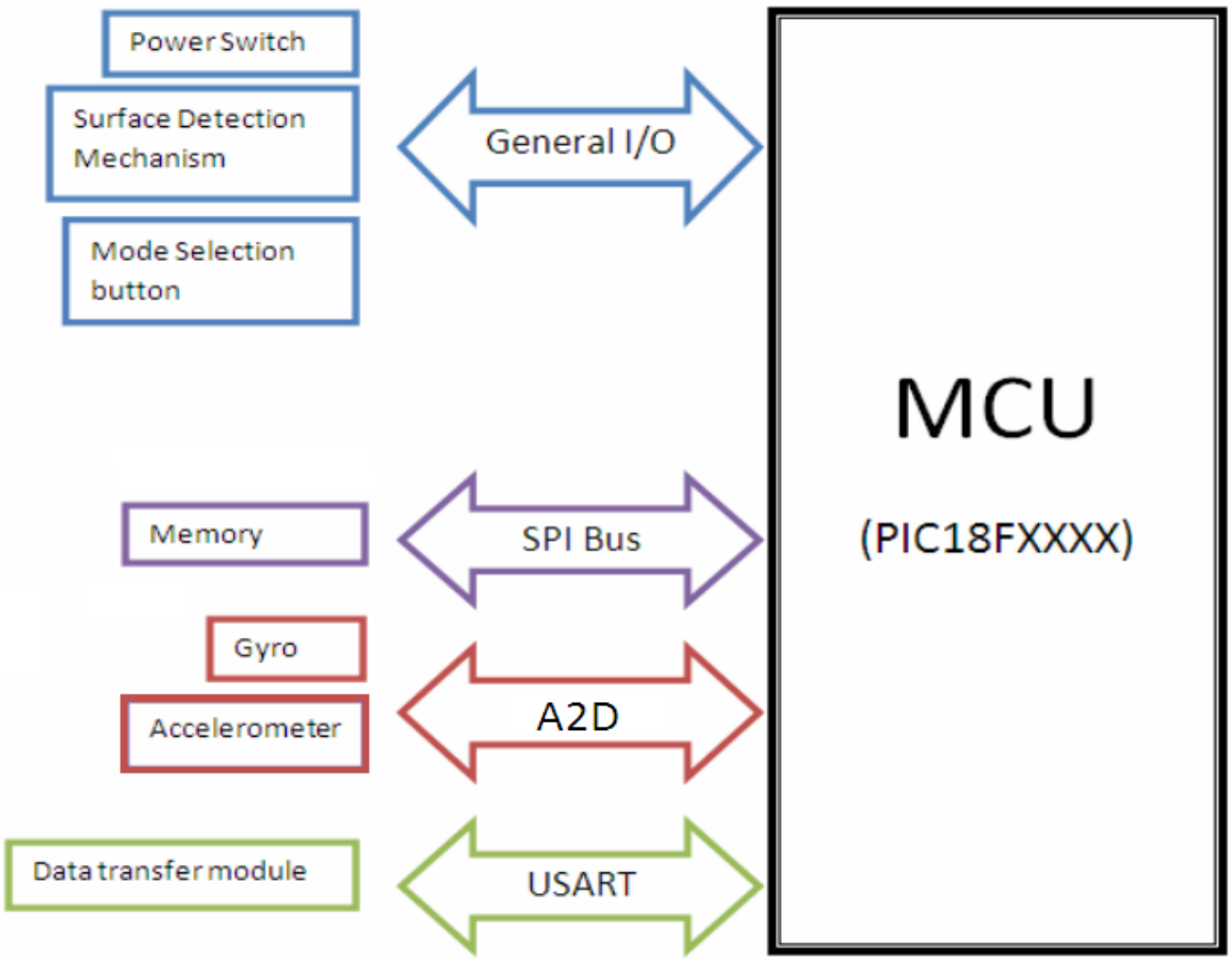
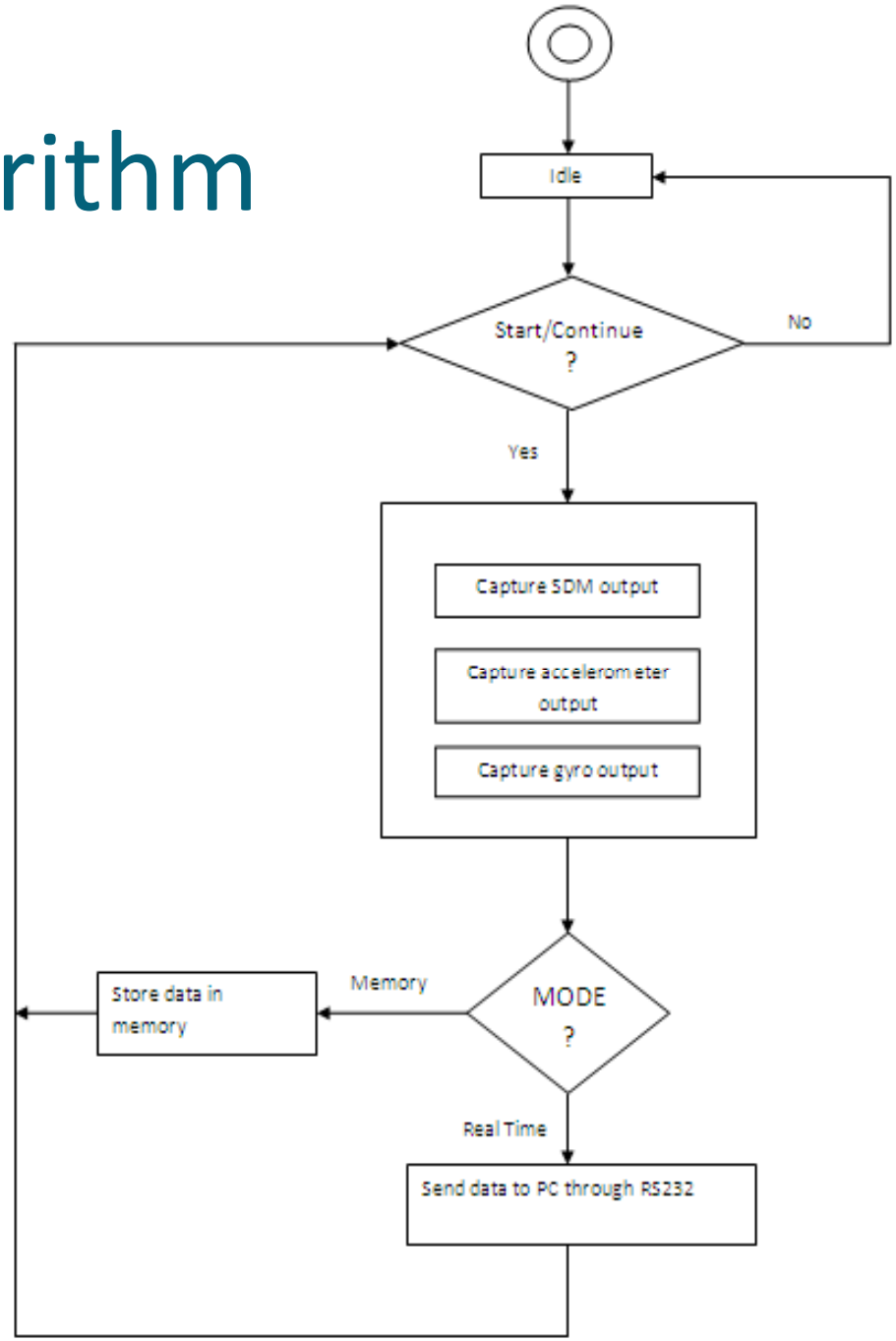
- **Mr. Khosrow Mossannen**
- **Mr. Fred Heep**

Hardware Connection



Software Algorithm



Other Information

- Sampling Rate for real-time mode: 24 sample/sec
- Sampling Rate for memory mode: 6 sample/sec

- Operational velocity range: 0.13m/sec
- Sensitivity of the accelerometer: +/- 3g
- Sensitivity of the angular rate sensor: 100 degrees/sec

- Optimal operating voltage 3.4 V – 3.6V

Resolved Challenges

- **Dependence of zero-acceleration on each trial**

  Solution: