Agenda

- Project Summary
- Recap
- Schedule
- Completed Work
- Next Steps
- Questions
Project Summary

- **Purpose:** To create a USB (Universal Serial Bus) Virtual Reality HID (Human Interface Device). This USB HID will interface with personal computers and their programs by emulating a USB gamepad.

- **Overall Goal:** To translate user movements into on-screen actions to provide a more realistic interactive platform for PC games and other virtual environments.
Recap

- Stationary INS (Inertial Navigation System)
  - No Linear Acceleration
  - Only Angular Acceleration (Pitch, Yaw)
  - Gyroscopes measure angular acceleration
Recap

• Gyroscopes
  – Measure °/sec
  – 1 integration to get position (absolute angle)

• Integration Drift
  – Compounded Error
  – Pitch Drift Correction (accelerometer)
  – Yaw Drift Correction (electronic compass)
### Schedule

- **Pair Programming**

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
<th>Predecessor</th>
<th>Resource</th>
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<tr>
<td>USB Gamepad Conversion</td>
<td>5 days?</td>
<td>Thu 1/22/09</td>
<td>Wed 1/28/09</td>
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Completed Work

- Completed or In Progress:
  - USB Gamepad
  - UART Functionality
  - Gyroscope Testing
USB

- Mouse and Keyboard Working
- Gamepad or Game Controller
  – Error Code 10
UART / RS232

- Collect Sensor Data
  - MATLAB
- Debug
Gyroscope Testing

• Test Platform
  – Yaw = 0° – 360° Rotation
  – Pitch = 0° – 90° Rotation
Gyroscope Testing

- Hardware Schematic
Gyroscope Testing

- Software – Conversion Factors / Constants
  - Conversion from A/D Value to °/s:
    \[
    \frac{3.3 \, \text{V}}{4096 \, \text{steps}} \times \frac{1^\circ/\text{s}}{2.0 \, \text{mV}} = \frac{1500^\circ/\text{s}}{4096 \, \text{steps}}
    \]
  - Gyro Angular Position = Integration of A/D Data
    \[
    \int \frac{1500^\circ/\text{s}}{4096 \, \text{steps}} \, (\text{ADC}) \, dt = \frac{1500^\circ/\text{s}}{4096 \, \text{steps}} \, (\text{ADC}) \, t
    \]
  - Summation As Approximation of Integration
    \[
    \int \frac{1500^\circ/\text{s}}{4096 \, \text{steps}} \, (\text{ADC}) \, dt = \frac{1500^\circ/\text{s}}{4096 \, \text{steps}} \, (\text{ADC}) \, t \approx \sum \frac{1500^\circ/\text{s}}{4096 \, \text{steps}} \, (\text{ADC}) \, \Delta t
    \]
  - \( \Delta T = 1/200\text{Hz} = 0.005 \) so Position Approx. is:
    - Angular Position = Previous Position + (Current ADC/546)
void ADC0_ISR (void) interrupt 15
{
    // Variables for storage of ADC data
    long yaw = 0;
    static long yaw_integration = 0; // yaw integration variable
    static int zero_rate_const = 2095; // Zero Rate Constant
    static int counter_cal = 0;
    static long cal_sum;

    counter++;
    // 12-bit conversion value
    yaw = ADC0H;
    yaw = yaw<<8;
    yaw |= ADC0L;

    // Takes 10 seconds to do this calibration section
    if(counter_cal < 1000) {
        counter_cal++;
        cal_sum += yaw;
    }
}

} else if(counter_cal == 1000) {
    yaw_integration = 0;
    counter_cal = 1001;
    zero_rate_const = cal_sum / 1000; // New zero_rate_const
    cal_sum = 0; // clear variable
}
} else if(counter_cal < 2001) {
    counter_cal++;
    cal_sum += yaw - zero_rate_const;
}
} else if(counter_cal == 2001) {
    yaw_integration = 0;
    counter_cal = 2200;
    zero_rate_const += cal_sum / 1000; // New zero_rate_const
}

// Get rid of DC (zero-rate) offset
// yaw = yaw - zero_rate_const / cosf(PI/6); // use with pitch
yaw = yaw - zero_rate_const; // subtract off Zero-Rate Voltage

// Window Filter - gets rid of worst noise causing drift
if(yaw < 8 && yaw > -9) yaw = 0;

// Integration
yaw_integration = yaw_integration + yaw;

// Conversion to degrees
yaw_degrees = yaw_integration/496; // Divides by 496 = 2.48 steps/deg * 200 /sec to get to degree

// Switch Analog Mux for Axis
//AH305L = 0x30;
ADC0INT = 0; // clear ADC conversion complete indicator - must be done manually
Gyroscope Testing

- Started with ST Micro LISY300AL Gyro
  - 5 DOF Board was on backorder
  - 300 °/s gyro (real one is 500 °/s)
  - Yaw Testing
  - Drift
Gyroscope Testing

- Drift Analysis
  - HyperTerminal (.txt) → MATLAB
  - Raw A/D Data
Gyroscope Testing

- Drift Analysis
  - After Offset Correction / Calibration (1000 samples)
  - Problem – possibly Zero-Rate Settling Time = 200ms
  - Drifting @ ≈ 1 °/s
Gyroscope Testing

- Drift Analysis
  - Frequency Spectrum (200 Hz Sampling)
  - Spike at DC = Offset → problem
Gyroscope Testing

- Our Drift Solutions:
  - Second Calibration

```c
// Takes 10 seconds to do this calibration section
if(counter_cal < 1000) {
    counter_cal++;
    cal_sun += yaw;
} else if(counter_cal == 1000) {
    yaw_integration = 0;
    counter_cal = 1001;
    zero_rate_const = cal_sun / 1000;  // New zero_rate_const
    cal_sun = 0;  // clear variable
} else if(counter_cal < 2001) {
    counter_cal++;
    cal_sun += yaw - zero_rate_const;
} else if(counter_cal == 2001) {
    yaw_integration = 0;
    counter_cal = 2200;
    zero_rate_const += cal_sun / 1000;  // New zero_rate_const
}
```

- Window Filter

```c
// Window Filter - gets rid of worst noise causing drift
if(yaw < 8 && yaw > -8) yaw = 0;

// Integration
yaw_integration = yaw_integration + yaw;
```

- Now Drift ≈ 1° / 15 seconds
5 DOF

- Just Received Last Tuesday (2/10/09)
- Confirmed that code still works
  - With altered constants / conversion factors
Next Steps

• Frames of Reference Conversions
  – Trig Functions
• Feedback (with still / zero-rate detection)
  – Accelerometers – calculate pitch
  – Electronic Compass – I²C
• Gyro scales different for +/- → calibrate
• Trig Functions Execution Time
  – In interrupt? Need FPU?
Questions