ECEN 5813 PES FINAL PROJECT PROPOSAL

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Inertial Sensor signal processing

Objective:

To implement MMA8451Q, on-board inertial sensor over I2C for orientation and motion detection(acceleration) on KL25Z.

Technologies to be implemented:

- Circular buffers
- State Machines
- System Clock Configuration
- I2C
- UART
- MMA8451Q sensor setup
- PWM.
  The above technologies apart from I2C and MMA8451Q setup are learnt in the PES ECEN 5813 Class and are going to be reused with the required modification for the functionality.

Design and Implementation:

- This project is similar to the project ideas (No. 2) mentioned in the assignment pdf with the few changes such as using PWM for the angle to be indicated and addition of acceleration/jerk factor.
- MMA8451Q sensor is a 3-axis accelerometer with 14bits of precision which outputs acceleration values in X-axis, Y-axis and Z-axis.
- Initialize MMA8451Q sensor and implement to get the acceleration and gravity values from accelerometer over I2C.
- Based on the derived values of pitch, roll and acceleration. RGB LEDs should output the different colours for each one of the scenarios.
  Below is the formula to be used to calculate pitch and roll from the acceleration values
  Roll = atan2(aY, aZ) * 180/Pi;
  Pitch = atan2(aX, sqrt(aY*aY + aZ*aZ)) * 180/Pi;
  Where ax,ay,az are acceleration values from sensor in X,Y and Z axis.
  1. If the Pitch is changing, values can be seen on the UART and also Blue LED will be changing brightness according to the values.
  2. If the Roll is changing, values can be seen on the UART and also Green LED will be changing brightness according to the values.
  3. If the sudden acceleration is detected, LED starts blinking.
     Acceleration detection is based on the certain threshold which can be varied in the software. If the acceleration value crosses the certain threshold then LED starts to blink to indicate the sudden acceleration/jerk.
- Statemachine will be implemented for each of the different calculations based on the sensor input.
- Data logging and execution information can be seen from the implementation by the user through UART with the specified terminal parameters.

Both, roll and pitch values are displayed over the UART and also information regarding the sudden acceleration/Jerk detection.

Below is the list of sources which will be used to develop this project.

1. Tutorial: Accelerating the KL25Z Freedom Board | MCU on Eclipse
2. ESF/NXP/Code/Chapter_8/I2C-Demo at master · alexander-g-dean/ESF · GitHub
3. MMA8451Q 3-Axis, 14-bit/8-bit Digital Accelerometer, Data sheet (nxp.com)
4. Text Book: Embedded Systems Fundamentals with Arm Cortex-M based Microcontrollers: A Practical Approach: Chapter 8: Serial Communications.
5. Sam's Blog : Getting Roll, Pitch and Yaw from MPU-6050 (samselectronicsprojects.blogspot.com)

Few more resources may be added to the above list while developing the project.

- The above project does not require any other additional hardware for its functionality to be working other than KL25Z development board.
- This project demonstrates the additional learnings required for configuration of MMA8451Q sensor and implementing I2C apart from what has been taught over the course.
- This project requires deeper understanding of the functionalities such as UART, PWM in order to update the values real time.

Testing Strategy:

Manual test cases for the orientation output check will be written.
Below are the basic test cases which will be considered

1. Rotation around the front-to-back axis (roll).
2. Rotation around the side-to-side axis(pitch).
3. Placed on flat surface.

Future Development:

The following signal processing values obtained from this project can further be used to develop skid detection that is by comparing another acceleration sensor value mounted on the wheel with the acceleration values from MMA8451Q and also over steering and understeering conditions in the cars which helps to improve safety in automobiles.