Final Project - Principles of Embedded Software

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Objective

To Tie into the MMA8451Q accelerometer over I2C. Change the LED colors in response to the device orientation, and also use the LED (perhaps with a blinking pattern) to show sudden acceleration. Configure a GPIO interrupt so the MMA8451Q can trigger the KL25Z when it detects the sudden acceleration.

The over-arching goal for the final project is to integrate sensors for a sensor fusion routine through MARG (IMU) sensor fusion, implemented on bare metal Freescale FRDM-KL25Z.

Implementation Details

- Inertial Sensing
  - Tying into the MMA8451Q (accelerometer), and if possible into MPU6050 (accelerometer, gyroscope and temperature) sensor and HMC5883L (magnetometer) sensor over I2C. Interrupt-based update notification and polling.
- System Configuration
  - Clock in PLL engaged mode (PEE) with 48 MHz core, 24 MHz bus.
  - SysTick timer running at 0.25ms.
  - delay_ms() function with low power wait support (WFI).
  - RGB LED GPIO access using fast GPIO
- Communication and User Interface
  - I2C driver for I2C0. Arbiter that sets pin configurations on demand per requested device, required since the sensors updates work on different frequencies.
  - Configure a GPIO (LED) interrupt so as to trigger the KL25Z when it detects the sudden acceleration.
- Sensor Fusion (Entirely based on timeline and health).
  - Standard Kalman filter in 32bit Q16 fixed point using libfixkalman.
  - Direct estimation of DCM axes based on A DCM Based Orientation Estimation Algorithm with an Inertial Measurement Unit and a Magnetic Compass (Nguyen Ho Quoc Phuong et al., J.UCS 15.4), but using TRIAD approach instead of magnetometer tilt-compensation.
  - Quaternion conversion of angles, to prevent gimbal lock issues with Euler angles.

Sub-Goals

1. To Integrate MMA8451Q accelerometer sensor with KL25Z and output over LED to showcase change in Roll and Pitch. (Yaw calculations require extensive floating calculations and would be avoided).

2. To configure a GPIO so the MMA8451Q can trigger the KL25Z when it detects the sudden acceleration.

OVER-AMBITIOUS GOAL (based on Timeline and health)

3. To Integrate MPU6050 (accelerometer, gyroscope and temperature) sensor and HMC5883L (magnetometer) sensor to communicate with the KL25Z, (would require extensive data sheet reading and understanding for robust readings).
4. To Integrate a I2C Arbiter based integration to read and update the IMU status of the sensor.
5. (Ambitious Goal) To create a complete sensor fusion stack, with GUI for user to understand pose.