Introduction to imu essay

IMU Inertial Measurement Unit Help you measure tilt angle and angular velocity… Topics We'll cover today… • • • • • • • • What is an IMU… ? Few Examples and Videos Accelerometer Gyrometer Magnetometer Filters Euler Angles Demos By:- Vivek Kumar Vipul Gupta () So… Lets Start… ? • What is an IMU…? • • • • • • • Few Examples and Videos Accelerometer Gyrometer Magnetometer Filters Euler Angles Demos Why do we need IMU… • One of the main problems during autonomous mobile objects' development is the problem of precise navigation. In order to navigate the object it is required to know the exact position and orientation of the object in relation to the known environment. • Size of an MEMS IMU… What is an IMU… ? • Inertial Measurement Unit (IMU) is an electronic device that measures a body's velocity, orientation and gravitational forces using a combination of accelerometers, gyroscopes and sometimes magnetometers. 9dof Razor IMU 6dof IMU https://www. sparkfun. com/products/10736 https://www. sparkfun. com/products/10121 MEMS Sensors • MICRO ELECTRO-MECHANICAL SYSTEMS Currently, most of the manufactured inertial measurement units are based on MEMS technology. • Regardless of easy usability, the main advantage of such devices is considerably its small size. Next… • What is an IMU? • Few Examples and Videos… • • • • • • Accelerometer Gyrometer Magnetometer Filters Euler Angles Demos Examples… Applications • Used in navigation of mobile platforms and vehicles, for autopilots of aerial ships, boats or ground units, to detect collisions and in PCs for HDD security during fall. It is also used in photo cameras for elimination of vibration effects. • Accelerometers are for instance used for collision detection, object's orientation measurement or as user interface like in android mobile games. Next… • What is an IMU? • Few

Examples and Videos • Accelerometer… • • • • • Gyrometer Magnetometer Filters Euler Angles Demos Accelerometer Measures net Linear Acceleration acting on the object. And outputs values along its axis in its body frame. Questions… Q. Do you like when your screen rotate automatically when you rotate your phone? Like this :

Q. How many of you say Nokia 1100 has an accelerometer…? Common Types of Accelerometers Sensor Category Capacitive Key Technologies change in capacitance related to acceleration Piezoelectric Piezoresistive Hall Effect Magnetoresistive Change in pressure induces voltage converted to acceleration resistance changes with acceleration Motion converted to electrical signal by sensing of changing magnetic fields Material resistivity changes in presence of magnetic field Location of heated mass tracked during acceleration by sensing temperature Heat Transfer ADXL345 The accelerometer which we'll use is ADXL345 • A small, thin, low power, threeaxis accelerometer with high resolution (13-bit) measurement up to ±16g. Features: 1. 8V to 3. 6V supply Low Power: 25 to 130uA @ 2. 5V SPI and I2C interfaces Up to 13bit resolution at +/-16g Tap/Double Tap detection Activity/Inactivity monitoring Free-Fall detection Dimensions: 3 x 5 x 1 mm • Digital output data is formatted as 16-bit twos complement and is accessible through either a SPI (3- or 4-wire) or I2C digital interface. https://www. sparkfun. com/datasheets/Sensors/Accelerometer/ADXL345. df What do Accelerometer measure…? • An accelerometer at rest on the surface of the earth will measure an acceleration g= 9. 81 m/s2 due to its weight. • By contrast, accelerometers in free fall or at rest in outer space will measure zero. When It's in free fall, It gives 0. When at rest , It gives 9. 8 Questions…

Q. What is the value of accelerations in X, Y, Z axes of accelerometer 1.) if its Z-axis making an angle of 90? with horizontal plane. Along X-axis Along Y-axis Along Z-axis 2.) if its Z-axis making an angle of 45? with horizontal plane.

Along X-axis Along Y-axis Along Z-axis Questions... Q. What is the value of accelerations in X, Y, Z axes of accelerometer 1.) if its Z-axis making an angle of 90? with horizontal plane. Along X-axis Along Y-axis Along Z-axis 0 0 g 2.) if its Z-axis making an angle of 45? with horizontal plane. Along X-axis Depends Along Y-axis Depends Along Z-axis g/v2 Internal Structure... Internal Structure... When at Rest Measure Pseudo Acceleration Internal Structure Tilted at 45 degrees Questions... Q. Problem with using Accelerometer alone? Q. Can we measure Yaw from accelerometer?

If yes, then How? Questions... Q. Problem with using Accelerometer alone? A. So much Noisy, Sensitive and measure unnecessary accelerations. Q. Can we measure Yaw from accelerometer? If yes, then How? A. No, there is no change in acceleration of X and Y components Next... • What is an IMU? • Few Examples and Videos • Accelerometer • Gyroscope... • • • • Magnetometer Filters Euler Angles Demos Gyroscope • Gyroscopes are sensors which also measure angular velocity. • There are three types of measurements – o yaw, pitch and roll. Roll, Pitch n Yaw... Gyroscope(2 DOF) Rxz – is the projection of the inertial force vector R on the XZ plane • Ryz – is the projection of the inertial force vector R on the YZ plane • Axz – is the angle between the Rxz (projection of R on XZ plane) and Z axis • Ayz – is the angle between the Ryz (projection of R on YZ plane) and Z axis Gyroscope measures the rate of change of the angles defined above. • The rate of

change of angle will be calculated as follows: • RateAxz = (Axz1 – Axz0) / (t1 – t0). • RateAyz = (Ayz1 – Ayz0) / (t1 – t0). • Gyroscope will output a value that is linearly related to the rate of change of these angles.

Calculations • RateAxz = (AdcGyroXZ * Vref / 1023 – VzeroRate) / Sensitivity • RateAyz = (AdcGyroYZ * Vref / 1023 – VzeroRate) / Sensitivity • The above formula is for a 10-bit ADC. • Each ADC module will have a reference voltage. • VzeroRate – is the zero-rate voltage, in other words the voltage that the gyroscope outputs when it is not subject to any rotation. • Sensitivity – is the sensitivity of your gyroscope it is expressed in mV/(deg/s). • The value of sensitivity and VzeroRate will be provided in specs. Next... • • • • • What is an IMU? Few Examples and Videos Accelerometer Gryometer • Magnetometer... Filters • Euler Angles • Demos Need of Magnetometer • Inertial measurement units using magnetometers are called 9-DOF IMU. • It is useful to relate coordination systems to external, known reference coordinate system. • Such reference coordinate system might be magnetic field of the Earth. Next... • • • • • What is an IMU? Few Examples and Videos Accelerometer Gryometer Magnetometer • Filters... • Euler Angles • Demos Filters – Why?? • Output from accelerometer suffers from high frequency noise • Output from Gyroscope gets deviated from the actual value and the difference (called as Drift) increases with time. Outputs of accelerometer and gyroscope are combined together to give a more accurate value. Complementary filter • Filtered_angle = a* gyro_angle + (1-a)*Acc_angle; • where ‘ a’ is some constant • The value of ‘ a’ is generally greater than 0. 75. KALMAN FILTER • It is being used for the fusion of the outputs of the two sensors used • Will reduce the noise of the two sensors by taking

appropriate weightage which will vary according to time • Estimate the optimal state using the prediction from the last stage and current state measurement • X(k)= AX(k-1)+BU(k-1)+W(k-1) • Z(k)= HX(k)+V(k)

Why KALMAN FILTER?? • Based on recursive process so consume less memory of processor • Gives theoretically and practically accurate data • It is based on weighted average giving more weightage to the reading which is more certain Next… • • • • • • What is an IMU? Few Examples and Videos Accelerometer Gryometer Magnetometer Filters • Euler Angles… • Demos Euler Transformation • For Gyroscope, we need to convert the angular rates from the IMU frame to fixed ground frame using Euler's transformation matrix for angular rates as given below: Where ? , ? , ? are Euler angular rates and p, q, r are gyro roll, pitch and yaw. Questions… • Why complementary filter is a low pass filter? • Whose weightage is higher? Next… • • • • • • • What is an IMU? Few Examples and Videos Accelerometer Gryometer Magnetometer Filters Euler Angles • Demos… Thanks… ? For any doubts, Contact: Abhishek sharma Vivek Kumar Vipul Gupta 8726533960 9621260360 9161863123