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Inertial Motion Tracking Systems

Introduction

Motion tracking is the process of recording movement of people or object. It is abundantly used in navigation, animation generation, athletically analysis and virtual reality. There are 3 major groups of approaches for motion tracking: optical motion tracking, magnetically motion tracking, and inertial motion tracking.Among the various technologies enable the measurement of motion of object, inertial based sensory systems have the advantage that the measurement entity is constrained neither in motion nor to any specific environment or location [1]. This paper is a briefly review of some commercially available systems of inertial motion tracking, provides introduction to technologies and implementation with regard to the subject.

Commercial Application of Inertial Motion Tracking

There are several products in the market that provide similar features. Inertia Technology produced ProMove 3D ($ 1,995) that features a suite of modern inertial and magnetic sensors, and a dedicated microcontroller for application-specific software. It samples wireless motion and orientation information from three-axial, fully-digital sensors: 3D acceleration, 3D turn rate (gyroscope) and 3-D magnetic field intensity (compass). It is capable of detect turn rate as small as 0.06°/s and magnetic field changes as small as 10mGuass [2].

Another competing design is the InertiaCube4™, InterSense. It samples at a rate of 200Hz and utilizes advanced Kalman filtering algorithms to produce 3DOF tracking with full 360° range. It is capable of measuring changes of 1° in yaw, 0.25° in pitch and roll. The power consumption of the device is 6VDC, 40mA [3]. This motion tracker is marketed at $994.

In addition to InertiaCube4™, InterSense also devised the IS-1200 Vistracker system ($ 9,950) that provides precise 6-DOF tracking data utilizing a fusion of inertial-optical technology. It has an update rate of 180Hz and a position accuracy of 2-5mm RMS. The system's power consumption is 1.7W at 6VDC [4].

Technology of Inertial Motion Tracking

Most of the recent Motion Tracking systems are implemented as strapdown ISN (inertial navigation system). To get position and orientation of the object, three linear accelerometers, affixed to the moving object, are utilized to measure the acceleration vector in body-frame. The acceleration vector is then transformed into navigation coordinates using the current rotation matrix as determined by the gyroscopes.

Inertial sensors are completely self-contained, so they have no line-of-sight requirements, no emitters to install, and no sensitivity to interfering electromagnetic fields or ambient noise. Also, they have very low latency. However, drifting is a main problem people face when using inertial sensors. If one of the accelerometers has a bias error of just 1 milli-G, the reported position output would diverge from the true position with an acceleration of 0.0098 m/s2. After a mere 30 seconds, the estimates would have drifted by 4.5 meters [5].

Therefore, technique called Kalman filter is used to reduce the amount of noises in the data. Kalman filter is an algorithm that uses a series of measurements observed over time, containing noise (random variations) and other inaccuracies, and produces estimates of unknown variables that tend to be more precise than those based on a single measurement alone. It is an optimum observer that estimates the states of linear Gaussian state-space models. KF and its variants are the most commonly used filtering techniques to integrate data from different components of the inertial sensors [6].

Implementation Inertial Motion Tracking

The inertial motion tracking system can be divided to the hardware installation and software implementation.

The hardware component of the system, the sensor for the inertial tracking system, is normally implemented as an IMU or an MARG. An IMU (inertial measurement unit) combines multiple accelerometers and gyros, usually three with mutually orthogonal sensitive axes, to produce a three-dimensional measurement of specific force and angular rate. And a MARG (Magnetic, Angular Rate, and Gravity) sensor is a hybrid IMU which incorporates a tri-axis magnetometer [7].

An orientation estimation algorithm is a fundamental component of any IMU or MARG system. It is required to fuse together the separate sensor data into a single, optimal estimate of orientation. And the Kalman filter has become the accepted basis for the majority of orientation algorithms [1].

By combining the hardware and software components, a robust motion tracking system can be created.

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