Chapter 16

Attitude and Heading Reference System for Unmanned Aerial Vehicles

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ABSTRACT

The methods that have been used in navigation over the centuries have changed as have the goals they serve. One of these methods is inertial navigation. Nowadays inertial navigation offers many advantages over other types of navigation. A major advantage is the lack of dependence on external transmitters or other devices, which means independence of the system. With the development of new technologies, the accuracy of these systems is increasing, which increases their applicability. An important aspect is the reduction in the price of sensors, which is a prerequisite for their application in new areas where they have not yet been offered. An important advantage of inertial navigation is the ability to give in real-time information about acceleration, speed, and location and the possibility of autonomous operation of the object.

INTRODUCTION

The Attitude and heading reference system (AHRS) will be build over inertial measurement unit (IMU) sensor based on MEMS technology, consisting of a 3 axis accelerometer, a 3 axis gyroscope, a 3 axis magnetometer and an Atmega microcontroller. Before we can use the data from the sensors, they have to be transformed into a common coordinate system, which in this case is connected to the ground. The co-ordinate system rotates with the ground with center that matched the center of the earth. The measurements obtained in the inertial system by accelerometers and gyroscopes have to be transformed into a common coordinate system (Titterton, D. H., 2004). An important step is to know the nature of the errors of these sensors and to take measures for their compensation and filtration.

DOI: 10.4018/978-1-5225-7879-6.ch016
In the chapter I present various methods of crossing between the coordinate systems (Euler, Quaternions, DCM) and their drawbacks, a linear Kalman filter will be considered, calibration and navigation algorithms will be proposed and experimental results will demonstrate the performance of the system and its accuracy.

**Coordinate Systems**

**Earth Centered, Earth Fixed (ECEF)**

Its origin is in the center of the earth and rotates with it. Oz is parallel to the main axis of rotation of the ground, Ox points to the main meridian, Oy completes a right-oriented orthogonal frame.

**Earth Surface North-East-Down (NED)**

The origin of the coordinate system coincides with the instrumental frame, but Ox always points to the geodesic north, Oz pointing to the start point of the Earth-oriented coordinate system, Oy completes a right-oriented orthogonal frame. It is also called the North-East-Down system.

**Inertial Coordinate System (ICS)**

In this coordinate system, Newton’s laws of motion are applied and it is not accelerating. It can be chosen arbitrarily, but it is more convenient to start and coincide with the Earth-connected system (it becomes pseudo-inertial).

**Connected Coordinate System (CCS)**

This coordinate system matches the center of body gravity with Ox pointing forward, Oz is pointing down to the lower body, and Oy is oriented in a way that form a right-oriented orthogonal system. If the instrument platform is not aligned with the body frame, additional transformation must be done.

**Navigation Coordinate System (NCS)**

The center of this system is the particular object that been studying, the axes are orientated in the directions east / west, north / south and respectively vertically/ zenith / nadir state. The rotation speed of the navigation coordinate system relative to the Earth’s fixed is determined by the motion of the object relative to the ground.

**Switching Between Coordinate Systems**

The state of the unmanned aerial vehicle (UAV) referenced to the reference coordinate system can be written as a sequence of numbers. The saved state is updated with each UAV rotation using gyro measurements.

Changing the state of a body is the consist of a series of rotations around different axes and a function of the angles through which it rotates.
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