DESIGN OF A STAND ALONE NAVIGATION SYSTEM USING POSITION ESTIMATION ALGORITHM

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ABSTRACT

Pilot has to navigate the aircraft even when GPS is non-operational or when there is GPS drop-out. The major contribution in this paper is to provide the navigation information to the pilot on a cockpit display unit by using a standalone attitude and heading reference system and position estimation algorithm. To implement this using low-cost sensor for the navigation of aircraft is an extremely challenging area.

This paper presents an approach called as dead reckoning by which aircrafts present position may be calculated from the knowledge of initial position and measurements of speed and acceleration. The navigation loop provides continuous and reliable navigation solutions to the guidance and flight control loop of the flight. The whole navigation algorithm shall be implemented within an embedded display system that receives attitude information.

Fig.1 shows the block diagram of the proposed stand alone navigation system. An Attitude and Heading Reference System (AHRS) that gives information about attitude and heading angles, angular rates and angular accelerations is employed. The AHRS provides the roll angle, pitch angle, yaw angle, roll angular rates, pitch angular rates, yaw angular rates, x-accelerations, y-accelerations and z-accelerations parameters to the cockpit display unit in digital RS422 format. A self-customized RS422-to-RS232 level converter is designed [1] due to shortage of RS422 channels and availability of free RS232 channels in the cockpit display unit. The advantage of the converter is that it can be potted like a cable and can be used along with the wire harness. The cockpit display unit receives the information about the height of the aircraft above earth from the radio altimeter (RADALT) connected to it using analog input. The initial latitude and longitude information is also provided to the cockpit display unit from the flight control system of the aircraft. The parameters from various interfaces are used by the navigation algorithm proposed in this paper which when implemented in the cockpit display unit and the navigation page on the cockpit display unit displays latitude vs longitude information with the aircraft current position as dot. It may be noted that the display on the cockpit screen can be changed using switches on the front panel of display system to display various pages such as for target recognition [2], radar page and for navigation parameters based on the press of a switch. The cockpit display unit referred here is a stand-alone display, often called as Get-U-Home, whose interfaces are independent and is used by the pilot to return to the base when other cockpit displays doesn't work.

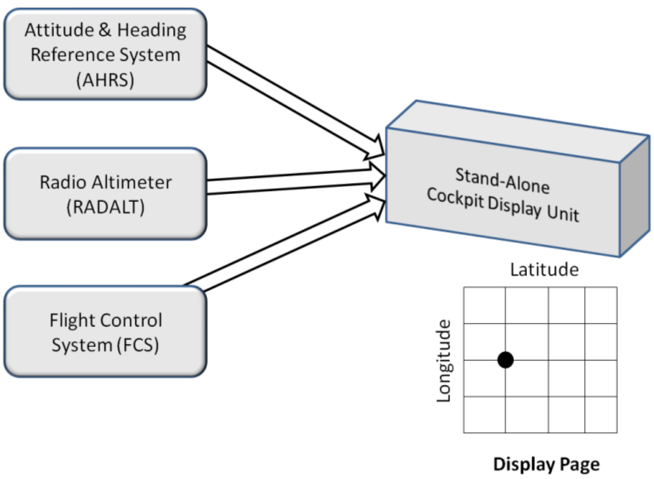

Fig. 1. Block Diagram of proposed Stand-alone Navigation System

Dead reckoning allows a pilot to determine the aircraft's present position by projecting its past courses steered and speeds over ground from a known past position. It also determines the future position by projecting an ordered course and speed of advance from a known present position. The dead reckoning position is only an approximate position because it does not allow for the effect of errors such as maneuvering or gyro error. In

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order to estimate the current position of aircrafts latitude and longitude information after GPS drop out, a position estimation algorithm is discussed in this paper. One of the sections describes the functionality of the AHRS [3] containing inbuilt MEMS gyroscopes [4] and accelermoters [5] and the way they take advantage of Coriolis effect [6]. One of the sections is dedicated to position estimation algorithm to estimate the velocity vector of the aircraft, current Latitude and Longitude position of the aircraft from the parameters available. In order to navigate over large distances around the Earth using the position estimation algorithm, the navigation information is required in the local geographic or navigation axes set i.e., in terms of north and east velocity components, latitude, longitude and height above the Earth. The rate of change of velocity, with respect to the surface of the Earth, is computed using the following terms: specific force acting on the vehicle, correction for the acceleration caused by the vehicle's velocity over the surface of a rotating Earth, correction for the centripetal acceleration of the vehicle and the compensation for the apparent gravitational force acting on the vehicle [7].

The entire simulation for the position estimation algorithm is done using MATLAB. The data logged during a flight is used as test input to the position estimation algorithm. During simulation with the stationary test case, it was noticed that errors were building up over a long duration. In order to avoid such huge error getting generated, the specific force acting on the accelerometer was analyzed and then the position estimation algorithm is enabled appropriately because the change in latitude and longitude plays role only during flight. Table 1 gives the specific force acting on the accelerometer during different phases of the flight.

Table 1. Force Acting on Accelerometer during different phases of the flight

Axis	**Specific Force acting on the Accelerometer (in g's)**		
	Stationary	**Taxi @ 150 kmph**	**Take off**
f_x	0	0.45	0.5
f_y	0	0	0
f_z	1	1	1.6

The Latitude-Longitude update on the cockpit display unit is currently done for two cases. In the first case, when GPS is available, the information is passed via other interface and the current position is accurate. In the second case, when GPS fails or is non-operational, the position estimation algorithm is enabled and the display position is updated based on this estimation. Once GPS data is restored or available again, the estimated parameters are corrected and the exact info is displayed. This approach is also applicable for other navigation applications including unmanned aerial vehicle and self-guided-rockets, where additional air-data and engine thrust data can be used for guidance and flight control.

CONCLUSION AND FUTURE SCOPE

This paper presents a viable approach of dead reckoning by which aircrafts present position may be calculated from the knowledge of initial position and measurements of speed and acceleration. This technique is helpful in navigation when GPS is non-operational or drops out. This approach is also applicable for other navigation applications including unmanned aerial vehicle and self-guided-rockets, where additional air-data and engine thrust data can be used for guidance and flight control. The future scope is to superimpose the on-board sensor images of ground with landmarks onto the display page showing estimated navigation parameters for better navigation.

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