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Realization Of Flight Control System For Simulated Flight Using Gps With Kalman Filter On Fpga

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Abstract: Kalman Filter Is an Algorithm Used for Data Estimation.It's Application Is Very Important in Several Projects, Especially in Aerospace Industry. This Paper Shows Kalman Filter Use In The Estimation Of Horizontal Attitude Of A Simulated Flight, The Experiments Were Done In Xilinx ISE Simulator Which Takes The Data Gathered From GPS.Finally Results Before &After The Application Of Kalman Filter Are Compared.

1. INTRODUCTION:

Kalman filter was introdused by Hungarian engineer & mathematician Rudolf Emil Kalman in 1960.That's why that algorithm got the name as Kalman filter. it's main purpose is estimating the data from different sensors and synthesis that data.

The main aim of this paper is taking the Uncertain and Inaccurate data from GPS & applied that data to Kalman filter inside the Xilinx ISE simulator.

In order to present a logical and coherent steps sequence taken to develop this work, this paper is divided as follows: section II explains the aircraft attitude control; section III addresses the Xilinx ISE simulator; the basic concepts of the Kalman filter are explained in section IV; Simplified Kalman filter for latitude and longitude estimation from GPS is explained in section V; finally, section VI brings the final considerations for this paper.

2. FLIGHT ATTITUDE:

A flight can be explained by the co-ordinate system having three axis namely X, Yand Z. And it also makes some angles with these axes. X-axis is located in plane head &tail direction and positive towards head direction Y-axis is located in gravitational centre (middle of plane) and become positive towards flight right wing direction;Z-axis is located at gravity centre and positive towards ground. Together with linear velocities u, v&w it also having some angular velocities namely p, q&r.

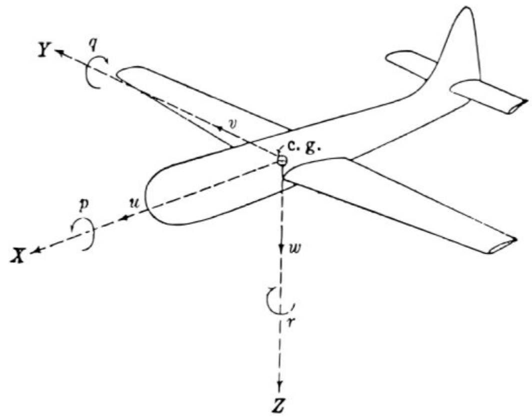

Fig 1: Aircraft coordinate system.

Plane attitude is defined by its angles. The angle which represents the movement around x-axis is called as Roll angle, similarly y-axis is called as pitch angle,& z-axis is called as yaw angle. It is also having some angular momentum depending on these angle values,we will get this values by GPS(in terms of latitude longitude).But due to flight dynamics these angles are getting changed. For proper working of flight we should get them by GPS and soon correct. if not flight may get deviate from its trajectory & may get accident with an other flight. But whatever the values we are getting by GPS are not accurate, to get exact values we should take some measurements & take average of those measurements, but it is very time consuming process, to overcome this we can use this algorithm, within the less time it reaches to the correct (exact) value. As we got the exact values that trajectory will be corrected by pilot by applying some forces through aileron, rudder & elevator.

3. FLIGHT DYNAMICS:

Different types of forces act upon the flight when the flight is in motion they are

Weight: it is represented by W.it is a force which is directed towards the centre of earth. The magnitude of weight is depends on the mass of airplane parts plus any payload on board

Thrust: it is represented by T.to overcome drag, airplane use its propulsion system to generate a force called thrust. The direction of the thrust force depends on how the engines are attached to the aircrafts

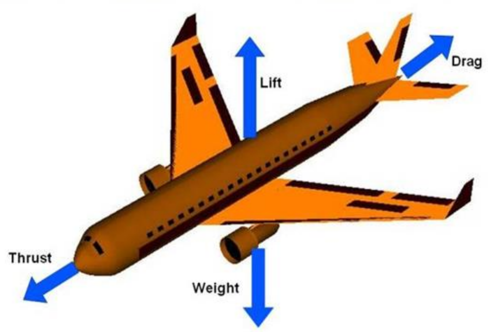

Fig 2:Forces in aircraft

Drag: it is represented by D.As the plane moves through the air, there is another dynamic force present, the air resist the motion of aircraft, and the resistance force e is called drag. It is directed along &opposed to the flight direction.

Lift: it is represented By L.to overcome the weight force, airplane generates an opposing force that is called lift. Lift is directed perpendicular to flight direction. It's magnitude depends on shape, size & velocity of aircraft.

Flight structure is capable of controlling the aircraft attitude are:

Aileron: Ailerons are found on the trailing edge of the wing, and they work opposite to each

other *i.e.* when one aileron moves up, the other one moves down and vice versa. Ailerons are used to control the lift.

Elevators: control the horizontal pitch attitude of the airplane. Elevators found at the tail of airplane.

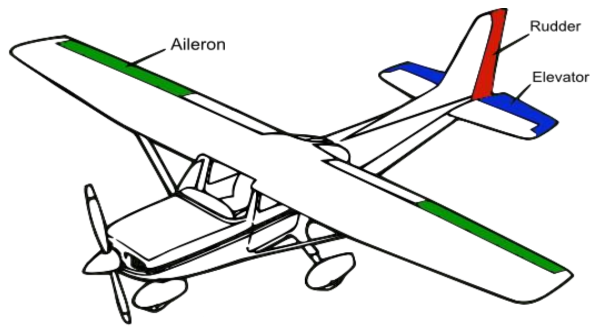

Fig 3: Regular fixed-wing control surfaces

Rudder: The rudder is the hinged section of the fin, or vertical stabiliser. It's used for directional control by changing the yaw of the airplane.

4. SOFTWARE DESCRIPTION

Xilinx ISE Simulator:

Xilinx ISE (**I**ntegrated **S**ynthesis **E**nvironment) is a software tool produced by Xilinx for synthesis and analysis of HDL designs. Designer can be able to observe the RTL Diagrams. Verilog is a HARDWARE DESCRIPTION LANGUAGE (HDL). It is a language used for describing a digital system like a network switch or a microprocessor or a memory or a flip−flop. It means, by using a HDL we can describe any digital hardware at any level. Designs, which are described in HDL are independent of technology, very easy for designing and debugging, and are normally more useful than schematics, particularly for large circuits.

5. KALMAN FILTER:

Zk is the measured value from sensors, by this it calculates the estimated output.

$$Xk = Axk + wk$$

$$Zk = Hxk + vk \qquad (1)$$

Wk& vk represents the process & measurement noise respectively. Where

Wk~N (0,Q); vk~N(0, R)

In Kalman filtering there are five steps to get exact data, and four of them are .repeated,

Step 0 represents the initialization of the values used by the algorithm: $\hat{X}0$ and P0.
In step 1, by using step0 values it calculate the predicted state & error covariance,

$\hat{X}\overline{k} = A\ \hat{X}k\text{-}1$

$\hat{P}k = A\ \hat{P}k\text{-}1(\text{transpose }(A)) + Q$ (2)

In step2 kalman gain is calculating by taking into consideration of process co-variance& measurement noise

$Kk = P^{-}k\ H\ (H\ P^{-}k\ (\text{transpose }(H))) + R)$ (3)

In step3 updated estimate &error in the updated estimate will be calculate by the help of predicted value, measured value ,kalman gain & error co-variance values

$\hat{X}k = \hat{X}\overline{k} + Kk\ (zk - H\ \hat{X}\overline{k})$

$Pk = (1 - Kk\ H)\ Pk^{-}$ (4)

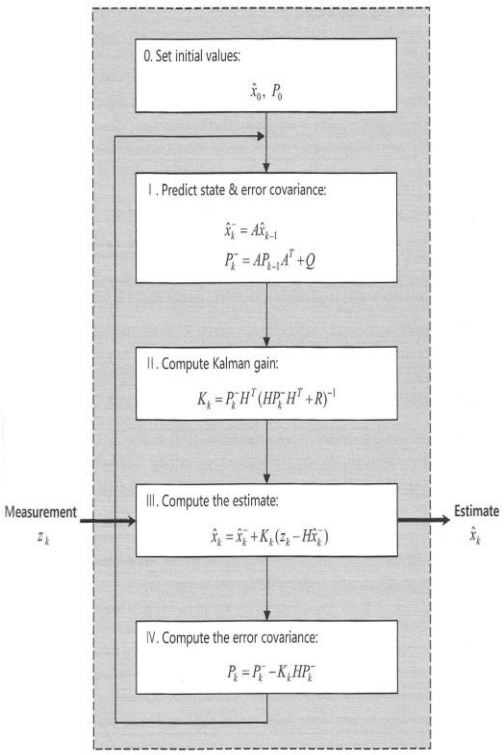

Fig 4: Kalman algorithm

6. Simplified Kalman filter

Here is the Simplified Kalman filter for latitude and longitude estimation from GPS.

1: procedure KALMANGPS

2: if accuracy < 1 then

3: accuracy ← 1 . 1 is the minimum value for accuracy

4: if variance < 0 then . First filter iteration: data initialization

5: last Time ← current Time

6: lat Kalman ← lat Measured

7: long Kalman ← long Measured

8: variance ← accuracy^2

9: else- if it is not the first iteration, applies the filter data

10: past Time ← current Time – last Time.

11: if past Time > 0 then

12: variance ← variance+ past Time$*$ std^2÷ 1000

13: last time← current time

14: kalman gain ←variance ÷ (variance + accuracy) ^{2}

15: lat kalman←lat kalman + kalman gain × (latmeasured-lat kalman)

16: long kalman← long kalman + kalman gain × (long measured-long kalman)

17: variance:(1-kalman gain)*variance

7. CONCLUSION:

Here we have shown the theoretical & practical results

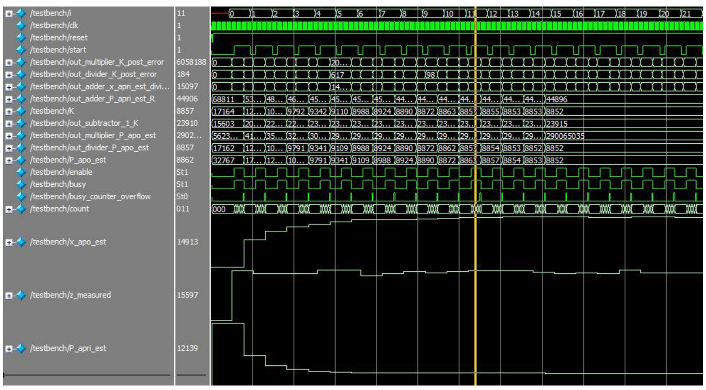

Fig 5: Simulations in ISE Simulator

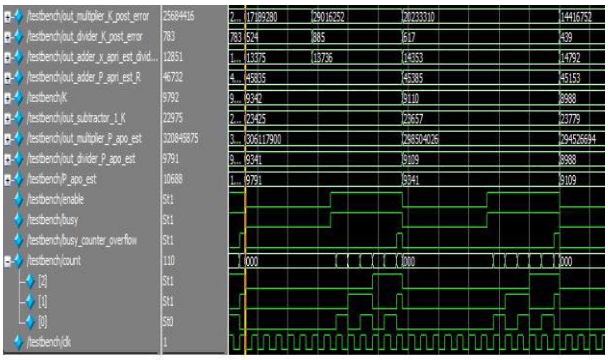

Fig 6 : Simulations in ISE Simulator

Results has a noticeable accuracy and smoothing improvement even though there is a abrupt changes in the measurements

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