Universidad Rey Juan Carlos

DEGREE IN AEROSPACE ENGINEERING IN AIR NAVIGATION

Collection of Laboratories
Air Navigation

Academic year 2012/2013

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Contents

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Laboratory 1: Inertial navigation

Using Simulink:

1 Build a bi-dimensional model in order to simulation the course, acceleration, velocity, and position (referred to a local horizon coordinates) in every instant of time based on the measurements of acceleration (longitudinal and transversal) and angular velocity (in the vertical axis) obtained directly from the inertial platform (which is attached to an aircraft axis reference) and the initial conditions of course, velocity and position. See Figure 4.4 Navegación aérea, Saéz Nieto, Garceta.

2 Build a three-dimensional model in order to simulate the attitude of an aircraft based on the measurements of the three gyroscopes in a strap-down platform. See Figure 4.5 Navegación aérea, Saéz Nieto, Garceta.

3 Combining model [1] (a three-dimensional version) and model [2], build a model in order to simulate a calculator of an inertial navigation system capable to provide attitude, acceleration, velocity, and position. See Figure 4.6 Navegación aérea, Saéz Nieto, Garceta.

The students are allowed to team up in work groups formed by 3 people each. A laboratory memory should be completed and submitted in time and form.

Goals and competences:

- Understanding the potentiality of Simulink for solving engineering problems.

- Acquire abilities to work in teams, discuss and reach to conclusions.

- Acquire abilities to write a laboratory memory.

- Understanding the fundamentals of inertial navigation systems.

Constraints:

- There is NO limitation on the number of pages.

Recommendations:

- Use any of the available text editors, for instance Microsoft Word. However, it is **strongly recommended to use Latex**.

- Structure the memory as usual: section, subsections; include an index of contents, an index of figures and tables, and a bibliography.

- Try to very briefly introduce and motivate the topic.

- Try to very briefly wrap up and make some conclusions.

- Dedicate a brief section to material, software, hardware, etc.

- Use figures and tables to expose experimental data and results.

- Try to discuss all achieved results, both when you obtained the expected and when you did not. If not, discuss why?

- The implemented code must go into an appendix.

Evaluation

The evaluator will consider:

- Quality of the content of the laboratory memory (around 60%).

- Originality of the work (around 40%).

Administrative issues:

- Assignment date: February the 11th, 2013; Monday.

- Report submission (only pdf allowed): February the 18th, 2013; Monday.

2

Laboratory 2: Filtering techniques

Consider an aircraft flying in unidimensional, stationary flight. Using different filtering techniques, we want to estimate the position and the velocity of the aircraft.

We can assume:

- The initial position of the aircraft corresponds to 40° latitude, 0° longitude, and 11.000 [m] altitude.

- The aircraft flies eastwards with velocity V=800 Km/h.

- Measurement of the position are taken every two seconds with an error that can be characterized with a standard deviation of 20 [m]

- The standard deviations of the predictions (associated to the dynamic model) of the position and velocity are 2 [m] and 0.5 [m/s], respectively.

1 In order to estimate the position and velocity of the aircraft after the first hour of flight, design:

    1.a A 5-measurements filter.

    1.b An $\alpha - \beta$ filter.

    1.c A Kalman filter.

2 Compare the three filters and, based on the errors, discuss the particularities of each filter.

3 Using the same dynamic model, but assuming now that the aircraft accelerates in the first 10 seconds with constant acceleration $a = 2m/s^2$, calculate the errors of the three filters and discuss the particularities of each filter.

The students are allowed to team up in work groups formed by 3 people each. A laboratory memory should be completed and submitted in time and form.

Goals and competences:

- Understanding the potentiality of Matlab for solving engineering problems.

- Acquire abilities to work in teams, discuss and reach to conclusions.

- Acquire abilities to write a laboratory memory.

- Understanding the fundamentals of filtering techniques.

Constraints:

- There is NO limitation on the number of pages.

Recommendations:

- Use any of the available text editors, for instance Microsoft Word. However, it is **strongly recommended to use Latex**.

- Structure the memory as usual: section, subsections; include an index of contents, an index of figures and tables, and a bibliography.

- Try to very briefly introduce and motivate the topic.

- Try to very briefly wrap up and make some conclusions.

- Dedicate a brief section to material, software, hardware, etc.

- Use figures and tables to expose experimental data and results.

- Try to discuss all achieved results, both when you obtained the expected and when you did not. If not, discuss why?

- The implemented code must go into an appendix.

Evaluation

The evaluator will consider:

- Quality of the content of the laboratory memory (around 60%).

- Originality of the work (around 40%).

Administrative issues:

- Assignment date: February the 25th, 2013; Monday.

- Report submission (only pdf allowed): March the 7th, 2013; Thursday.

3

Laboratory 3: Guidance and control

The laboratory consists in designing a guidance and control system for the approach and landing of a typical commercial aircraft. The approach and landing will be based on the ILS Z RWY 18L approximation chart in Madrid Barajas. The approach and landing will be simplified into the following three phases:

1. From any of the IAFs proceed in horizontal flight and reach waypoint BERUC.

2. From BERUC proceed in vertical flight under a constant vertical speed guidance law and reach the FAP.

3. From the FAP proceed in vertical flight under a constant geometric flight path angle and land.

Using Matlab and Simulink:

1. Design a block diagram for the lateral guidance with bank angle control. See [? , Fig. 5.9].

2. Design a block diagram for the vertical guidance with ground speed control. See [? , Fig. 5.25].

3. Design a block diagram for the vertical guidance with ground speed control. See [? , Fig. 5.25].

Each group will choose an aircraft type among those in BADA database (See [?]), writing down all needed parameter of the selected aircraft. Notice that BADA defines the variation of mass equation as

$$\dot{m} = -\eta T \tag{3.1}$$

where $\eta = \left(\frac{C_{f1}}{(1000*60)}\right) * \left(1 + \frac{V}{C_{f2}}\right)$, with V in knots.

The initial state of the aircraft is also to be selected by the students.

Assumptions:

- In the horizontal flight, wind is not considered.

- In the vertical flight, we will consider a wind component in the direction of motion of the aircraft of 5 m/s. Vertical wind is neglected.

- The equations for vertical and horizontal motion are as in [**?**].

The students are allowed to team up in work groups formed by 3 people each. A laboratory memory should be completed and submitted in time and form.

Goals and competences:

- Understanding the potentiality of Matlab and simulink for solving engineering problems.

- Acquire abilities to work in teams, discuss and reach to conclusions.

- Acquire abilities to write a laboratory memory.

- Understanding the fundamentals of control and guidance.

Constraints:

- There is NO limitation on the number of pages.

Recommendations:

- Use any of the available text editors, for instance Microsoft Word. However, it is **strongly recommended to use Latex**.

- Structure the memory as usual: section, subsections; include an index of contents, an index of figures and tables, and a bibliography.

- Try to very briefly introduce and motivate the topic.

- Try to very briefly wrap up and make some conclusions.

- Dedicate a brief section to material, software, hardware, etc.

- Use figures and tables to expose experimental data and results.

- Try to discuss all achieved results, both when you obtained the expected and when you did not. If not, discuss why?

- The implemented code must go into an appendix.

Evaluation

The evaluator will consider:

- Quality of the content of the laboratory memory (around 60%).

- Originality of the work (around 40%).

Administrative issues:

- Assignment date: March the 11th, 2013; Monday.

- Report submission (only pdf allowed): April the 2nd, 2013; Tuesday.