Introduction to Flight Simulation (List 8)

Due: 04.02.2017

On the course homepage, you can find the 2 dimensional B737 simulator that I demonstrated in november in class.

First you should download and run the simulation. It works in room 137. In the beginning you see a phugoid, that damps very slowly. At 300 seconds, you see a short term oscillation, which damps very quickly. At 600 seconds, a change in elevator setting causes a new phugoid. Note that the simulation runs 10 times faster than real time.

1. What is the period of the phugoid in the first 300 seconds?

   To which speed and angle of attack does it converge? You can change to code and let it converge until you can read off the speed, or set the initial speed in the code, until you find the value where you see no phugoid. The current value is 90 $m.s^{-1}$.

2. After 600 seconds, with the new elevator setting, what is the period of the phugoid? To which speed and a.o.a. does it converge?

3. Add a function

   ```
   force_effect front_wheel( ) const
   ```

   that calculates force and torque originating from a front wheel.

   If the wheel is not on the ground, it has some air resistance which you may ignore. If the wheel is on the ground, it should push the plane upwards. This can be modeled like a spring. The spring coefficient should be chosen in such a way that the spring compresses approximately one meter under normal load. What is the spring coefficient? The front wheel should break approximately under twice the normal load. You can throw an exception when this happens. Make sure that the nose wheel has some damping, because otherwise the plane will bounce forever after landing. You may assume that the ground is always at altitude 0.

   You have computed normal load of the wheels in task 1 of list 6.

   You don't need to worry about the state transition between standing and rolling, although you may if you want.

4. Do the same for the main wheels: Write a function

```
force_effect main_wheel( ) const
```

   that calculates force and torque originating from the main wheels. Since the model is two dimensional, the two main wheels can be combined into a single wheel. The mail wheels should also be modeled as a spring that compresses one meter under normal load. Make sure that the wheels have damping, because otherwise the plane will bounce forever after a landing. Try to get a half time of about two seconds.

5. Now it should be possible to take off. Set the plane standing on the ground, give maximum throttle and hope for the best. Find elevator settings under which the plane takes off, but does not crash immediately.

   If you want, you can add state changes to reduce power after take off.

6. Landing should now be also possible. Find a start situation, under which the touches the ground softly enough, so that the wheels don't break.

7. What is the maximal vertical speed with which the plane can land without damaging the main gear? You can compute this number theoretically, or get a close approximation by simulation.

8. **Bonus Task**: Can you add an autopilot, for example a controller that maintains a given altitude, a given speed, or both?

   Of course, you are not allowed to assign to speed or altitude directly, the autopilot should work through the controls only.