

AIRCRAFT MODELING USING MATLAB/FLIGHT GEAR INTERFACE

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The aim of this article is to analyze the possibilities of connecting the dynamic simulation of aircraft movements in a virtual environment simulator Flight Gear interface with Matlab / Simulink, with a focus on technical and organizational problem solving, information transfer and display precision positioning and motion of any model aircraft.

Key words: simulation, connection, Flight Gear, Matlab

1 INTRODUCTION

The chapters of article is more familiar with the simulator Flight Gear, its numerous advantages and configuration problems on some aspects of normal operation. In the next section we deal linking the simulator interface Matlab / Simulink, this mean create the program algorithm, and the final model consisting of models longitudinal and lateral movement and other essential elements needed to link the simulator. The actual networking is time consuming, requires a detailed process models of aircraft movements and the associated countless adjustments to achieve proper function of the final model. The basic model can certainly combine multiple simulators, but we just chose Flight Gear, because it is freely available to everyone, and so this final model programmed directly on the simulator. This was possible thanks to the diversity of using Matlab / Simulink. Treatment process and the consolidation of individual models, as well as creating a script to run the simulation is described in detail in the core article.

2 THE OVERVIEW OF THE FLIGHT GEAR SIMULATOR

Flight Gear is "open-source" flight simulator. It is supported on many popular platforms (Windows, Mac, Linux, etc.). Source code for the entire project is available under GNU license and is developed through contributions there during their free time adds many talented people from all over the world. One of the many goals of this project is to minimize the shortcuts to create and make things right, trying to learn and develop skills, and efforts have the best simulator [1].

Functions of simulator [1]:

- Pervasiveness - if you comply with the terms of the GPL, you can freely download and copy any version of Flight Gear.
- Flight dynamics models - you can choose from three basic models of flight dynamics (JSBSim, YASim and UIUC)
- Extensive and accurate database of the world
- Precise and detailed model sky - simulator implements extremely accurate time of day in

which the model accurately placed the sun, moon, stars, planets for the specified time and date.

- A flexible and open system modeling aircraft - simulator has the ability to model a range of airplanes. Currently you can fly the 1903 Wright Flyer, strange flapping with "ornithopter", Boeing 747, Airbus A320, the various military jets and several ultralight aircraft models.
- Hardware modesty - simulator works with average hardware requirements and smoothing with an average frame rate, so it is not necessary several thousands of dollars of hardware to run it.
- Internal features - simulator allows users and aircraft designers access to a large number of internal state variables via numerous internal and external access mechanisms. These specific variables are arranged hierarchically in a so-called tree properties for convenient access.
- Network capabilities - Network capabilities reflect the number of network connections that allow the Flight Gear subsystems communicate with the simulator, such as. GPS receivers, external flight dynamics modules, external autopilot or control modules, as well as other software and mapping tools Atlas. Generally, the choice of input / output allows users to define the output log to a file, serial port or network client. According to [1].

Development of versions Flight Gear simulator over the years:

| Date | Version | Date | Version |
|--------------------|---------------|-------------------|-----------------------|
| October 22, 1999 | 0.7.1 (Vývoj) | March 26, 2004 | 0.9.4 |
| February 17, 2000 | 0.7.2 (Vývoj) | July 29, 2004 | 0.9.5 |
| May 18, 2000 | 0.7.3 (Vývoj) | October 12, 2004 | 0.9.6 |
| July 20, 2000 | 0.7.4 | January 18, 2005 | 0.9.8 |
| September 18, 2000 | 0.7.5 | November 17, 2005 | 0.9.9 |
| December 19, 2000 | 0.7.6 | April 5, 2006 | 0.9.10 |
| June 20, 2001 | 0.7.7 | May 2007 | 0.9.11 |
| July 13, 2001 | 0.7.8 | December 17, 2007 | 1.0.0 |
| February 16, 2002 | 0.7.9 | December 22, 2008 | 1.9.0 |
| April 20, 2002 | 0.7.10 | January 25, 2009 | 1.9.1 |
| September 7, 2002 | 0.8.0 | February 25, 2010 | 2.0.0 |
| December 3, 2002 | 0.9.0 | August 17, 2011 | 2.4.0 |
| December 5, 2002 | 0.9.1 | February 17, 2012 | 2.6.0 |
| June 4, 2003 | 0.9.2 | August 17, 2012 | 2.8.0 |
| October 24, 2003 | 0.9.3 | February 17, 2013 | 2.10 Najnovšia verzia |

Fig. 1 Development of versions Flight Gear, according to [2]

Hardware requirements:

Recommended hardware equipment for Flight Gear version 2.6.0:

- 3D graphics card with support for OpenGL 1.2 or better 2.0 and at least 512 megabytes of video RAM (Recommended 1GB RAM) with a reasonable sampling rate.
- At least 1 to 2 gigabytes of free memory RAM. Flight Gear uses 500 megabytes of RAM by default.
- CPU: Minimum dual core processor with approx. 2 GHz
- At least 1 gigabyte of hard disk space for installation, and up to 8GB of optional global scenery.
- The mouse with three buttons or two buttons and scroll wheel.
- Optional sound card, compatible with SoundBlaster best supporting EAX
- Optional joystick or pedal simulator from the list of supported devices.

Settings for slower graphics cards:

- Set up the hardware: Although the device can be adjusted more or less fixed, it is possible to make several improvements to produce a difference of 2 fps to 10 fps or more.
- Setting the simulator affecting graphic: Turning off unnecessary features, flying during the day and use a little busy airports.
- Settings changed during the flight: Disabling shaders and flying out of airports.
- Proper selection of aircraft: Some aircraft have lower demands on system resources than others. According to [3].

3 MATLAB / SIMULINK AND ITS LINKS WITH FLIGHT GEAR

Before you can work on the simulation of flight dynamics model, it is necessary to establish or acquire a set of model aircraft that will be compatible with the Flight Gear. You can choose from over a dozen 3D geometry file formats supported simulator Flight Gear. Currently, the most popular 3D file format geometry AC3D, which has the extension *. AC. AC3D is low costly geometry editor available at www.ac3d.org. Another popular 3D editor model airplanes is "Flight Sim Design Studio", distributed to www.abacuspub.com.

The algorithm of the program geometry of the vehicle:

This example shows how the training course depends on the definitions of animation elements, such as aircraft control surfaces and landing gear. To enable animations each element must be named number one in the geometry file. The resulting code forms part of HL20 to launch the model in working NASA HL - 20 demo version of the Flight Gear. Creating an algorithm is summarized in seven simple points.

1. The standard coordinates of the body model using Flight Gear geometry model system consists of the right hand.

X = positive direction towards the rear of the model

Y = a positive direction to the right of the model

Z = positive direction is upward, the wheels tend to have the lowest values of Z.

2. Finding two points that lie on the desired object and its registration as a trio XYZ, or they can be put into the calculation of Matlab:

A = [2.98, 1.89; 00:53]

B = [3:54; 2.75; 1:46]

3. Calculate the difference between the points:

pdiff = b - a

Pdiff = 0.5600 0.8600 0.9300

4. Hinge point is a point from the previous step, or center:

Mid = a + pdiff / 2

Mid = 3.2600 2.3200 0.9950

5. This point hitch place within the framework of animation through model-set.xml:

```
<center>
  <x-m> 3.26 </ x-m>
  <y-m> 2:32 </ s-m>
  <z-m> 1:00 </ from-m>
</ center>
```

6. The difference from step 3 used to define the relative motion vector in the axis of animation:

```
<axis>
  <x> 12:56 </ x>
  <y> 0.86 </ s>
  <z> 0.93 </ from>
</ axis>
```

7. These steps are used together to create a full animation of hinge point HL20 demo model:

```
<animation>
  <type> rotate </ type>
  <object-name> RightAileron </ object-name>
  <property> / surface-positions/right-aileron-pos-
norm </ property>
  <factor> 30 </ factor>
  <offset-deg> 0 </ offset-deg>
  <center>
    <x-m> 3.26 </ x-m>
    <y-m> 2:32 </ s-m>
    <z-m> 1:00 </ from-m>
  </ center>
  <axis>
    <x> 12:56 </ x>
    <y> 0.86 </ s>
    <z> 0.93 </ from>
  </ axis>
</ animation>
```

To start Simulink model aircraft while the animation Flight Gear with a set of data-model set.xml, you must configure the data files of the aircraft and modify Simulink model several new blocks.

The main steps for connecting simulator Flight Gear with the software Matlab / Simulink:

- Adjusting flight dynamics models in the network dataset airplane
- Getting the target IP address begins by identifying the IP address of the computer that is running Flight Gear

- Adding a link interface blocks, namely how to connect interface and location blocks in Simulink model-in
- Create Flight Gear computational scripts compatible with the software Simulink
- When you start Flight Gear guides you through the final steps to achieve cooperation and Simulink software simulator Flight Gear.
- Improve performance will help accelerate work model
- Start Flight Gear and Simulink software on different computers explains how we can create the exact link between the two programs, commands and what they respond, since it can synchronize. According to [4].

Setting communication interface:

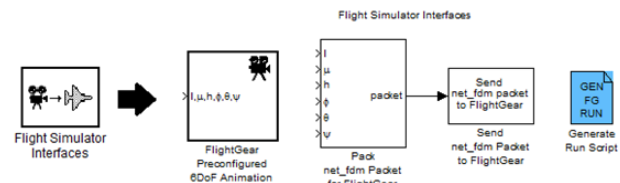


Fig. 2 Blocks for setting the interface

4 Longitudinal and lateral movement of aircraft

In this part of the article will be reviewed interconnection of two models of motion control plane interface in Matlab / Simulink. These are models of the longitudinal and lateral movement of the aircraft. The creation of models is used linearized equations for both models separately, whereas the two models posing in different variables. The equations are as follows draw diagrams for the interface Matlab / Simulink.

4.1 Longitudinal movement

Variables that affect the longitudinal motion (model inputs) are the size of deflection lever engine control (δP_{OM}) and the size of the deflection control lever elevator (δV). The outputs of this model are the speed (v), the angle of attack (α), altitude (H) and the longitudinal tilt (θ).

Angle of attack α is the angle between the aircraft and aircraft aerodynamic coordinate system. Longitudinal slope θ is the angle between the Earth and the aircraft carrier coordinate system.

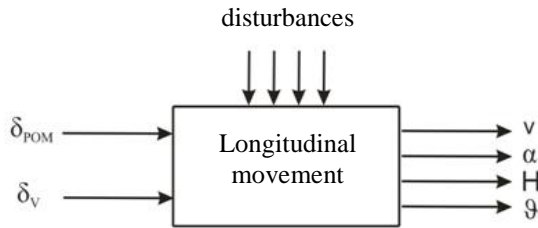


Fig. 3 Inputs and outputs of the longitudinal motion of the aircraft

In the design of the longitudinal motion of the aircraft model in MATLAB Simulink environment, we used linearized equations (1) - (4). According to [5].

Velocity equation:

$$(p + n_{11})v + n_{12}\alpha + n_{13}\vartheta + n_{14}H = n_p\delta_p \quad (1)$$

Equation angle of attack:

$$-n_{21}v - (p + n_{22})\alpha + (p + n_{23})\vartheta + n_{24}H = n_{p1}\delta_p + n_{\delta}\delta_v \quad (2)$$

Equation of trim:

$$n_{31}v + (n_0p + n_{32})\alpha + (p^2 + n_{33}p)\vartheta + n_{34}H = n_v\delta_v \quad (3)$$

Height equation:

$$n_{41}v + n_{42}\alpha + n_{43}\vartheta + p\dot{H} \quad (4)$$

According to [5].

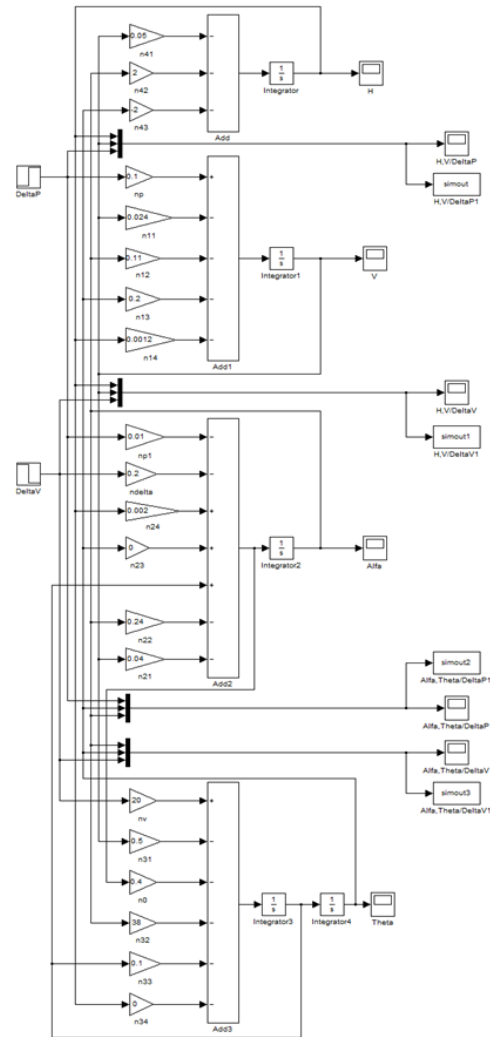


Fig. 4 Schematic diagram model of the longitudinal motion of the aircraft

4.2 Lateral movement

Movement in which the aircraft is operating forces in the plane XZ axis (GOST) is called lateral movement of the aircraft (Fig. 6).

Variables affecting the lateral movement (model inputs) are the size of deflection rudder control lever (δ_r) and the size of the deflection aileron control lever (δ_a). The outputs of this model are the speed (v), yaw angle (β), rate (ψ), cross slope (γ).

Yaw angle β is the angle between the aerodynamic and aircraft coordinate system. Rate ψ and γ are transverse tilt angle between the Earth and the aircraft carrier coordinate system.

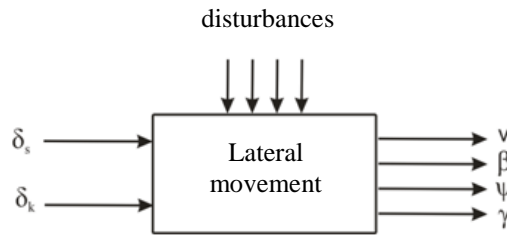


Fig. 5 Inputs and outputs lateral movement

When designing a model of lateral movement of aircraft in MATLAB Simulink environment, we used linearized equations (5) - (7). According to [5].

Equation yaw angle:

$$(p + n_{11})\beta + (n_{12}p + n_{14})\gamma + n_{13}p\psi = n_{1s}\delta_s \quad (5)$$

Cross-slope equation:

$$n_{21}\beta + (p + n_{22})p\gamma + n_{23}p\psi = -r \quad (6)$$

Rate equation:

$$n_{31}\beta + n_{32}p\gamma + (p + n_{33})p\psi = -n_{3k}\delta_k - n_{3s}\delta_s \quad (7)$$

According to [5].

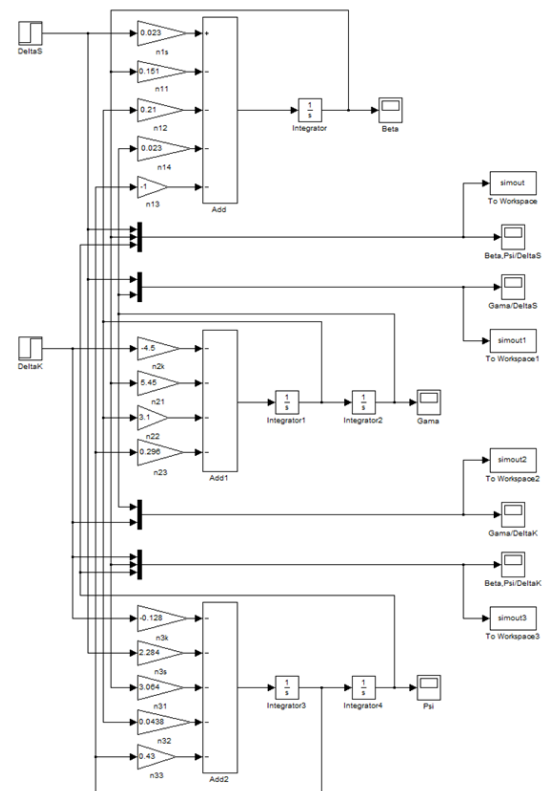


Fig. 6 Schematic diagram of model aircraft lateral movement

4.3 Ties to model the longitudinal and lateral movement

By linking these two models I created a model that is capable of displaying all aircraft movements in one simulation. Model response to the input quantities coming from the joystick, but it is possible to any of them and permanently set.

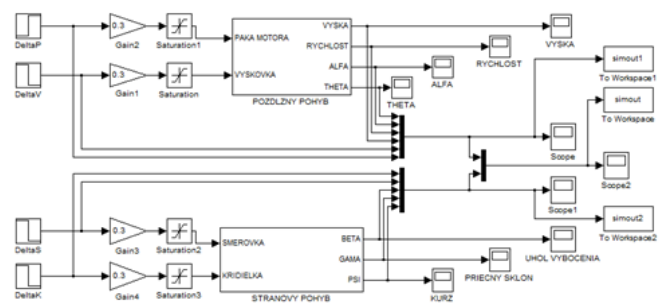


Fig. 7 Linked model of the longitudinal and lateral movement with fixed inputs

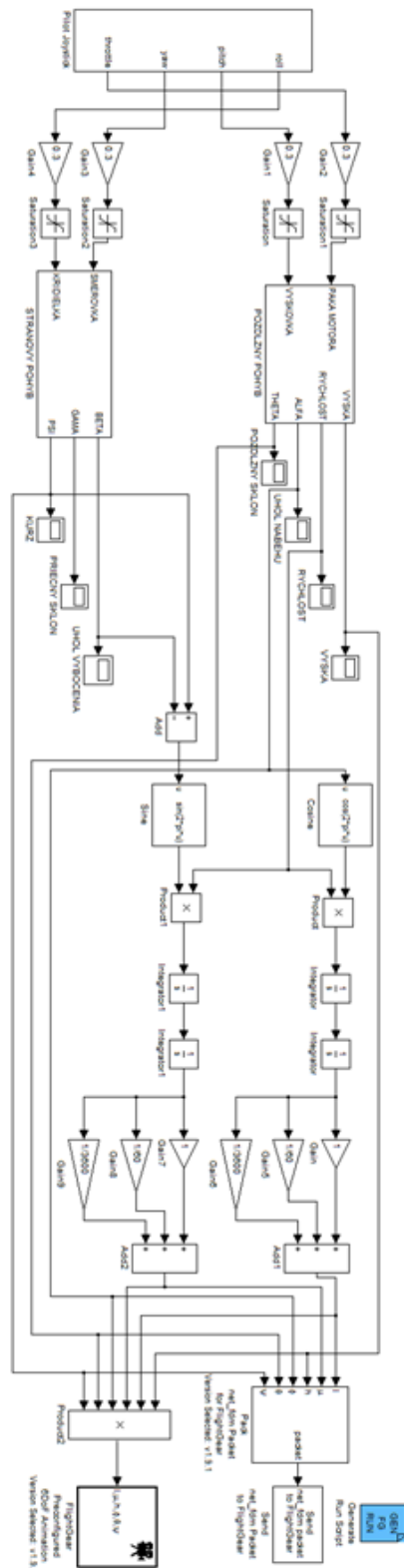


Fig. 8 Proposal terminal wiring diagram model with blocks to link the simulator

5 CONCLUSION

Simulator Flight Gear is due to the many features excellent tool for teaching in the field of avionics systems

on our faculty. Lets all real situations that could occur during the flight. The networking Matlab / Simulink with the simulator Flight Gear certainly has great potential in teaching, which will simply connecting computer sets can be simulated flight conditions change and thus help young people understand better avionics aircraft flight dynamics. Another very useful tool for teaching the insight into the cockpits of many aircraft and gain practical experience in observing changes in flight characteristics of the display and an alarm showing happens during flight. The article discussed models of the longitudinal and lateral movement of aircraft and outlined their schemes through Simulink. Furthermore, these models are linked and created the model with fixed inputs. Finally, the implementation of the proposal itself processed model results with the simulator.

ACKNOWLEDGEMENT

This work was funded by the European Regional Development Fund under the Research & Development Operational Programme project entitled "Construction of a research & development laboratory for airborne antenna equipment, ITMS: 26220220130."



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