

This is a Matlab-based software package of six-degree-of-freedom F-16 fighter aircraft model. Please read this file carefully before install and use this package. Any further comments are welcomed by the author.

## **Installation**

For installation, click the link 'download software ( F-16 fighter aircraft model) ' on the web page and save the zip file to appropriate folder on your disk. Unzip the file to the same folder. Open Matlab and add the folder to the paths of workspace or change the current directory to this file folder. The software will be ready for use in Matlab.

## **Manuscript**

The manuscript file *Model.pdf* gives illustration of the coordinate system and the description of states and control variables used in the nonlinear aircraft model. The equations of motion for full nonlinear model are also organized inside the package, which can be found in the same file.

## **How does this software package work?**

The software package can mainly accomplish three tasks:

1. To get the trim flight data for different flights;
2. To derive the linearized model of the aircraft around trim flight data;
3. To simulate the nonlinear dynamic response using the full nonlinear aircraft model.

For your first time, just type in Matlab command window 'runF16' and you will see on the screen

```
>> runF16
```

You will be asked to choose the task you want to accomplish and input appropriate flight parameters. The results will be shown promptly on the screen.

If you want to obtain the information of specific task above, please refer to the following sections and you will get the detailed instruction for using those functions.

## 1. To get the trim flight data for different flights

This software can help you compute the trim data for straight & level flight with specified velocity, altitude and center of gravity position. The function to get the trim data is [find\\_trim.m](#) which is ready to run in Matlab. The trim data is derived by optimizing the cost function associated with different flights using simplex search.

Function Inputs	
velocity	- true velocity, ft/sec
altitude	- altitude, ft
xcg	- c.g. position in fraction of mean aerodynamic chord

  

Function Outputs	
state_trim	- trim data for the state vector
control_trim	- trim data for the control vector

Note: Acceptable values for flight parameters are

	Min Value	Max Value
velocity	350	1000
altitude	0	40000
xcg	0.2	0.5

For more information of the state and control vectors, please type in the Matlab command window

```
help find_trim
```

## 2. To derive the linearized model of the aircraft

With help of the software users can easily get the linearized model for F-16 fighter aircraft around the trim data of state and control vectors. The linearization is accomplished by numerical approximation of corresponding function derivatives. The Jacobian matrices are obtained to describe the real aircraft into a linear time-invariant model

$$\begin{aligned} \dot{x} &= A * x + B * u \\ y &= C * x + D * u \end{aligned}$$

The function to compute the Jacobian matrices is [jacobian\\_f16.m](#). It is ready to run in Matlab.

### Function Inputs

velocity - true velocity, ft/sec  
altitude - altitude, ft  
xcg - c.g. position in fraction of mean aerodynamic chord

### Function Outputs

A, B, C, D - Jacobian matrices with appropriate dimensions

Note: Acceptable values for flight parameters are

	Min Value	Max Value
velocity	350	1000
altitude	0	40000
xcg	0.2	0.5

Detailed information for linear states and controls, i.e., x and u, is available if type in Matlab

help jacobian\_f16

### 3. To simulate nonlinear responses from nonlinear model

A main contribution of this software package is to enable users simulate the dynamic response of F-16 aircraft with designed control laws.

#### 3.1 Simulate F-16 aircraft using simulink model

To simulate the F-16 aircraft, users need to choose the flight conditions and get the trim flight data as shown above. The control variables are left as inputs to the block of F-16 aircraft model. The software package can do the simulation via simulink model *simF16.mdl* and the trajectories of the dynamic responses can be observed in multiple figure windows.

#### 3.2 One-time-step computation

To help users get familiar with the how to simulate the aircraft dynamics, the software package provides a function to help users implement one-time-step computation. Given control variables the function *f16\_dynam.m* can perform the one-time-step computation to get the output values and the time derivatives of state variables. It is easy to implement this function using S-function in simulink or integrate the output and state values directly to calculate the trajectories of the dynamic responses of F-16 aircraft.

#### Example

If you input following commands in Matlab command window

```
time = 0
x =[500 0.5 -0.2 -1 1 -1 0.5 -0.6 0.7 1000 900 10000 90]'
control =[ 0.9 20 -15 -20]'
xcg = 0.4
[x_dot,an,alat,qbar,amach,q,alpha] =f16_dynam(time,x,control,xcg )
```

You will see on the screen\* that

```
x_dot =
-77.4774
-0.8850
0.8250
```

```
0.6973
-0.9132
0.2344
6.0325
-0.1155
1.1167
342.4439
-266.7707
248.1241
-58.6900
```

```
an =
```

```
5.5549
```

```
alat =
```

```
0.4906
```

```
qbar =
```

```
219.7837
```

```
amach =
```

```
0.4644
```

```
q =
```

```
-0.6000
```

```
alpha =
```

```
28.6479
```

```
>>
```

---

```
* For physical significations & units of variables, please type
```

```
help f16_dynam
```