Satellite Attitude Animation and Simulation (SAAS)

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Abstract

This is a documentation for the Satellite Attitude Animation and Simulation (SAAS) program written in MATLAB. This documentation covers the overall structure of the program, including the input file format, different simulation mode, and the algorithm behind the simulation, etc.

Note that this is still an ongoing project with updates to be expected in the future. The source code is managed by git, permission will be required to gain access to the code, either to download or fork.(TODO)

NOTE: Some of the concepts here require extensive literature reading, serve this either as a starting point or collection of knowledge, as I'll do my best to include materials that are helpful during my studies.

***Index Terms* — Satellite Attitude, quaternion, propagation**

I OVERALL STRUCTURE

Satellite Attitude Animation and Simulation (*SAAS*) is a tool for preliminary deisgns of satellite on-orbit attitude, with the capability to transform numerical results into visualisation with the corresponding imported CAD model. The following sections provide detail explanations and procedures to execute SAAS.

I-A Code Structure

```
SAAS
+- /src
    +-  SAAS.m
    +-  READ_INPUT.m
    +-  /MAIN
    |   +- init.m
    |   +- ATT_sim.m
    |   +- ATT_file_prop.m
    +- /component
    |   +- create_comp.m
+- /input
    +- INPUT_SIM.txt
    +- INPUT_PROP.txt
+- /model
    +- model_setup.m
+- /output
```

Table I: Code Structure

Before diving right into the instructions, it is essential to grasp an overview of the code structure as shown below in Table. I. The code is mainly executed by a single command file called *SAAS.m* (file path: /SAAS/src), while the inputs to the program is dictated by the user input in the *INPUT.txt* files. Specific format and entrices have to be followed in order for the program to initialise the simulation correctly.

The *init.m* (file path: /SAAS/src/MAIN) function initialises the simulation and distributes variable data and model parameter depending on the mode selected, which currently contains two, ***Simulation*** or ***Propagation*** mode. The Simulation mode allows the user to import either single or profiles of quaternion that characterises the rotation, or in more general terms, attitude on-orbit. Users can also select the *DESIGN* mode, to design a profile of quaternion control law that maximises the solar energy input based on a preselected sun beta angle. The Propagation mode allows input of large trending data from actual satellite data to visualise the attitude during service, some complementary files might also be needed for this mode. Details for each mode will be expanded and further discussed in the later sections.

I-B Inputs

To improve user experience and ease the load for constant variable changes in different functions, I have created an generalised input file that can handle this. The two modes each required separate *INPUT.txt* files, to better distinguish and avoid variable overload problem.

I-B1 INPUT SIM.txt

dfsd

```
TITLE INPUT_SIM.txt

MODE  simulation
MODEL
        NAME     FS9
        CG      [2.7717896e+00  1.8211494e+01  8.9988957e+02]
        FILE    'model/fs9_SADA.stl'
END
ENV
        BETA_ANGLE 15
END
COMPONENT
        STR1    [474.918, 479.593, 931.902]
                [473.641, 478.316, 934.298]
        STR2    [-486.347, 537.236, 332.014]
                [-443.741, 494.732, 411.878]
        USER    [-0.388, -0.198,-0.01]
                [0, 0, 0]
END
OPTION
        STR_VIEW    0
END
VALUE
        DESIGN          1
        FRAME           'ECI'
        QUAT_DESIGN     [0, -240, 50]
        QUAT_SINGLE     []
        QUAT_PROF       'QUAT_PROFILE.txt'
END
```

Table II: Simulation Input Data

```
>> SAAS

|-MODE:          simulation
|-MODEL:
|-       NAME:   FS9
|-       CG:     [2.7717896 18.211494 899.88957]
|-       FILE:   model/fs9_SADA.stl
|-       CAD:
|-               vert:   [52958x3 double]
|-               faces:  [110808x3 double]


|-ENV:
|-       BETA_ANGLE:     0.261799387799149

|-COMPONENT:
|-       STR1:   [474.918 479.593 931.902;473.641 478.316 934.298]
|-       STR2:   [-486.347 537.236 332.014;-443.741 494.732 411.878]
|-       USER:   [-0.388 -0.198 -0.01;0 0 0]

|-OPTION:
|-       STR_VIEW:       0

|-VALUE:
|-       DESIGN_opt:     1
|-       FRAME:          ECI
|-       QUAT_DESIGN:    [0 -240 50]
|-       QUAT_SINGLE:    []
|-       QUAT_PROF:      []

Orbit SA energy percentage:     48.34%

Rotation Simulation Completed!
```

Table III: Terminal Simulation Data Display

I-B2 INPUT PROP.txt

```
TITLE INPUT_PROP.txt

MODE  propagation
MODEL
        NAME          FS9
        CG           [2.7717896e+00  1.8211494e+01  8.9988957e+02]
        CAD FILE     'model/fs9_SADA.stl'
END
ENV
        BETA_ANGLE 15
END
COMPONENT
        STR1     [474.918, 479.593, 931.902]
                 [473.641, 478.316, 934.298]
        STR2     [-486.347, 537.236, 332.014]
                 [-443.741, 494.732, 411.878]
        USER     [-0.388, -0.198,-0.01]
                 [0, 0, 0]
END
OPTION
        STR_VIEW    0
END
TREND
        QUAT          'fs7t_SE_SAAS_Q_2024050090000_2024051090000_A.txt'
        ECI           'fs7t_SE_SAAS_ECI_2024050090000_2024051090000_A.txt'
        LLA           'fs7t_SE_SAAS_LATLON_2024050090000_2024051090000_A.txt'
        ECLIPSE       'fs7t_SE_SAAS_Eclipse_2024050090000_2024051090000_A.txt'
        SUN           'fs7t_SE_SAAS_SUN_2024050090000_2024051090000_A.txt'
END
```

Table IV: Propagation Input Data

```
>> SAAS

|-MODE:          propagation
|-MODEL:
|-        NAME:  FS9
|-        CG:    [2.7717896 18.211494 899.88957]
|-        FILE:  model/fs9_SADA.stl
|-        CAD:
|-               vert:   [52958x3 double]
|-               faces:  [110808x3 double]


|-ENV:
|-        BETA_ANGLE:     0.261799387799149

|-COMPONENT:
|-        STR1:  [474.918 479.593 931.902;473.641 478.316 934.298]
|-        STR2:  [-486.347 537.236 332.014;-443.741 494.732 411.878]
|-        USER:  [-0.388 -0.198 -0.01;0 0 0]

|-OPTION:
|-        STR_VIEW:       0

|-TREND:
|-        QUAT:  [89x4 double]
|-        ECI:   [1350x4 double]
|-        LLA:   [1350x2 double]
|-        ECLI:  [1350x1 double]
|-        SUN:   [1350x3 double]
|-        DATE:  [1350x1 datetime]


Trending File Propagation Completed!
```

Table V: Terminal Simulation Data Display