Project specification: Launching into orbit

Staffan Al-Kadhimi (stafak@kth.se)

Background

The first artificial satellite was launched by the Soviet Union in 1957 [1]. 62 years later, I now plan on building an interactive simulation reminiscent of the game *Kerbal Space Program*, where you can launch a rocket from the surface of a planet and fly into orbit in real time yourself.

Simulating a rocket launch is not entirely simple. There may only be four main forces that you have to deal with (thrust, weight, lift, and drag), but as in many cases accurate simulations will need to perform many computations to calculate them, and within the atmosphere a large part of this involves aerodynamics [2]. As I want to create a real time interactive simulation, I will primarily focus on finding a good balance between realism, performance, and ease of use.

I'm not aiming for a specific grade, so I'll just take what I can get with a normal amount of effort.

Objective

The end result should:

- be an interactive semi-realistic simulation of a step rocket launching from the Earth or a planet with similar characteristics
- allow getting the payload (which would preferably be the entire final stage, for simplicity's sake) into orbit
- simulate thrust, weight, lift and drag forces on the rocket
- simulate the propellant usage in the rocket
- allow the user to steer the rocket in some way (possibly by gimbaled thrust and/or reaction wheels), as well as control the engine throttle and staging
- display information that is meaningful to the user on the screen
- closely follow the rocket in a fitting environment (for example, there should not be a sky background at high altitudes)

Implementation

The simulation will be implemented using the Unity game engine. Unity has a rigid body system that will be used to apply the relevant forces on the rocket.

The blog where I'll be documenting the process may be accessed at `https://letsflyinto.space`.

Challenges

I've identified these points as the primary challenges and possible sources of problems:

- Lift and drag simulation – aerodynamics are complex and require a lot of computations. I will probably need to find a good way to approximate these forces.
- Unity's coordinate system being based on single-precision floats, which makes large-scale simulations much harder to create than if it had been based on doubles. Possible solutions include not having a full-scale simulation and keeping the rocket near the origin.
- Validation – realistically, it would take almost 90 minutes for a satellite at an altitude as low as 160 kilometers to perform one revolution around the Earth, which makes thorough testing very time consuming. It should be possible to speed up the simulation, although this would come at the cost of accuracy.

References

[1] NASA. Sputnik and The Dawn of the Space Age [Internet]; 2007 [cited 2019-03-01]. Available from: `https://history.nasa.gov/sputnik/`.

[2] NAROM. Aerodynamics and forces acting on the rocket [Internet]; [cited 2019-03-01]. Available from: `https://www.narom.no/undervisningsressurser/sarepta/rocket-theory/rocket-dynamics/4-1aerodynamics-and-forces-acting-on-the-rocket/`.