

UNIVERSITY OF BIRMINGHAM

COLLEGE OF ENGINEERING AND PHYSICAL SCIENCES

SCHOOL OF COMPUTER SCIENCE

Building a Falcon 9 Rocket Model

Undergraduate project

in various fields including Computer Science, Electronics,
Robotics, Mechanical and Aerospace Engineering

PERFORMED BY COMPUTER SCIENCE BSc STUDENTS

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Contents

1	Basic information	3
1.1	The goal of the project	3
1.2	Development Plan	3
2	The Learning Process	5
2.1	Getting to know the 3-Axis Accelerometer and Gyroscope	5
2.2	Getting to know basic Rocketry by building a model rocket	6
2.3	Building a 2D stabilising device	7
2.4	Radio Control	8
2.5	Introducing a gimbal system and using a propeller for propulsion	9
3	Realizing the Falcon 9 Rocket Model	10

1 Basic information

1.1 The goal of the project

The final goal is to build a functional SpaceX Falcon 9 rocket model.

The model is planned to use Thrust Vectoring Control (TVC), the current principle of choice is a motorised gimbal that stabilises the rocket by moving the rocket engine/nozzle and therefore adjust the angle of the engine thrust. The TVC will be controlled over a programmed Arduino micro-controller that reads sensor data from multiple sensors and returns appropriate behaviour instructions to the gimbal system. While current plans don't go as far as landing the rocket, we consider different approaches how we could achieve this for an extended future project (e.g. by being able to throttle the engine or reigniting the propulsion system used).

1.2 Development Plan

Obviously this is a very ambitious project and many small steps must be taken before we can take on the actual challenge of building the Falcon 9 model rocket. Below is the concept by which we plan to progress. The sub-projects will increase in complexity and difficulty and are supposed to slowly teach us all necessary aspects to take on the rocket design for the Falcon 9 model rocket.

Project 1: Getting to know the 3-Axis Accelerometer and Gyroscope

To gain a better understanding of the usage of the accelerometer and gyroscope (precisely the [GY-521 3 Axis Gyroscope + Accelerometer Module MPU-6050](#)) we plan to do some basic testing of its functionalities using the Arduino Uno as the receiving and processing board.

Project 2: Getting to know basic Rocketry by building a model rocket

To get a better view on the practical side of things, we then plan to build a basic rocket and use an [industry-standard certified Estes rocket motor](#) to launch it. We hope to understand practical issues we could encounter and important concepts we need to research further to enable our rocket to fly as stable as possible while remaining as close to an actual practical rocket design as possible (reduced use of fins inducing atmospheric drag).

Project 3: Building a 2D stabilising device

Using the knowledge from Project 1 we plan to build a device that is able to stabilise itself and compensate for exterior forces acting on it using the accelerometer and gyroscope data. After this project we are as prepared as we can be to develop a stabilising system in a 3D operating vehicle.

Project 4: Radio Control

Before moving on to Project 5 we could introduce the concept of radio control which would enable us to control the rocket remotely. Prior to launching a self-stabilising rocket, a connection system between the rocket and Ground Control should be established in order to guarantee safety and enable controlled remote takeoff and landing.

Project 5: Introducing a gimbal system and using a propeller for propulsion

In a way, we take a step back and turn our rocket into something close to a monocopter. We exchange the hard-to-control rocket motor with an electric motor with propellers. This way we will be able to introduce the gimbaling system without having to worry about the complex rocket engine thrust and we will be able to throttle the rotor to easier test the gimbaling system with less damages and potential safety issues. The gimbaling system will bring all the challenges the final project version will encounter using rocket engines but is safer and easier to handle.

Final Project: Realizing the Falcon 9 Rocket Model

The final step will be to re-introduce the rocket engine and optimise the gimbal system to successfully stabilise the rocket during flight. If we reach this point, further project ideas on re-ignitable rocket engines or thrust-control to enable a takeoff and landing procedure could follow.

2 The Learning Process

2.1 Getting to know the 3-Axis Accelerometer and Gyroscope

2.2 Getting to know basic Rocketry by building a model rocket

2.3 Building a 2D stabilising device

2.4 Radio Control

2.5 Introducing a gimbal system and using a propeller for propulsion

3 Realizing the Falcon 9 Rocket Model