

## Robotics 2 (SS 2022)

### Exercise Sheet 4

Presentation during exercises in calendar week 26

#### Exercise 4.1 – Optimization of a rocket car

**This exercise can only be compiled and run on the CIP Pool!!!**

In the following we will investigate the rocket car given in

`/RocketCar_Template/doc/setup_rocket_car.pdf`

as a (min energy) optimal control problem:

$$\min_{T, x(t), u(t)} \int_0^T u^2(\tau) d\tau \quad (1a)$$

subject to: (1b)

$$\dot{x}(t) = \begin{bmatrix} \dot{q} \\ u \end{bmatrix} \quad (1c)$$

$$r(0) = \begin{bmatrix} q(0) \\ \dot{q}(0) \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \quad (1d)$$

$$r(T) = \begin{bmatrix} q(T) \\ \dot{q}(T) \end{bmatrix} = \begin{bmatrix} L \\ 0 \end{bmatrix} \quad (1e)$$

$$\underline{t} \leq t \leq \bar{t} \quad (1f)$$

$$\underline{u} \leq u \leq \bar{u} \quad (1g)$$

$$\underline{x} \leq x \leq \bar{x} \quad (1h)$$

**a** Familiarize yourself with the code template given in

`/RocketCar_Template/`

and fill in the gaps.

**b** Now, the car has an engine problem - maximal acceleration goes down to  $0.8 \frac{m}{s^2}$  - what happens to the solution? make a second trial with maximal acceleration at  $0.5 \frac{m}{s^2}$

**c** Reformulate problem **a** such that it is solved for minimum lap-time (use the `mfcn` function). Use  $\underline{t} = 0.0s$  and  $\bar{t} = 40s$  for time box constraints (1f) (`h_min`, `h_max`). What does happen?

**d** Now the engine goes to serious overheat and the maximal acceleration goes down to  $0.5 \frac{m}{s^2}$ . What happens now?

#### Notes:

- In order to run muscod with one of your `DatFileName.dat` files, go to your build folder - `/SRC/`, `/DAT/` as well as your libraries (`.so` files) should be there - and execute

```
muscod DatFileName
```

- If you want to maintain multiple source files, compile multiple libraries by adding additional lines

```
ADD_LIBRARY ( LibName SRC/SrcName.cc)
```

to your `CMakeLists.txt`. After that you have to run `cmake` again (from inside your build folder).

- Dont forget to link your `.dat` file to a library by modifying the following lines inside the `.dat` file:

```
libmodel
```

```
libLibName ← your library will have the lib prefix once compiled!
```