**Data analyzing method (MATLAB) passive rider identification -**

**Goal:**

* Determine the transfer function between the acceleration of the bicycle/platform and the resultant forces at the individual interfaces (seat post, handlebars and foot pegs).
* In frequency domain: 0 – 10 Hz.

**What kind of perturbation signal did I use?**

* Filtered white noise with reduced power at higher frequencies.
* The signals are sampled with 100 Hz. Thus, the lowest measured frequency is 0.01 Hz, and the highest is 50 Hz.

**Experimental procedure**

* Offset trial: measuring the force generated by the rider on the interfaces while the platform is not moving. Result: static force as a result of gravity, measurement offset/error of IMU and measurement offset/error of strain gauges.
* Trial 1: measuring the force generated by the rider on the interfaces as a result of the perturbation motion (60 sec).
* Trial 2: the same as trial 1.

**What kind of data did I obtain from the experiments:**

* The measurement offset of the IMU’s and strain gauges. Thus, what do they measure when there is no motion and no forces?
* Acceleration data of the platform measured by an IMU on the platform (2 trials)
* Forces, measured at all interfaces, generated by the rider as results of the perturbation motion (2 trials).

**How do I generate the input signal for passive rider identification**

1. I calculate the offset/error of the IMU, which is the mean of the offset trial when the platform is not moving.
2. I subtract the offset/error of the IMU from the data measured during trial 1 and 2.
3. I filtered both signals of both trials to remove noise. I used a low-cutoff filter with order 70 and a cutoff-frequency of 13/50 (normalised cutoff-frequency, since Nyquist frequency, is 50 Hz (sampling frequency = 100 Hz)). As a result of this, I keep maximum power in the frequency range of interest (0 – 10 Hz) and have almost zero or zero power at higher frequencies.
4. Since the start of the sampling of the IMU and the beginning of the perturbation signal do not start at the same time, I have to shift the IMU signal manually in the time domain. I do this by fitting the measured IMU signal to the known designed perturbation signal. To do this as accurate as possible, I build in a reference step signal before the start of the perturbation signal and after the end of the perturbation signal. I can use these reference step signals to fit the measured signals in the time domain since these step signals have clear and smooth peaks in the measured data.
5. After finding the most accurate fit for both trials, I extracted only the perturbation part (6000 samples) of the signal. Note, that only this part is relevant for the identification procedure.
6. Finally, I calculate over both trials the mean input signal. Thus, I go from 2 input signals to 1 input signal. This is the final input signal (= acceleration) I will use for system identification.

**How do I generate the output signal for passive rider identification?**

1. I calculate the offset/error of the strain gauges, which is the voltage generated by the strain gauges when the platform is not moving and when no person is sitting on the bicycle mock-up. Thus, no external forces are applied to the strain gauges.
2. I calculate the static force of the participant sitting on the bicycle while the platform is not moving.
3. I subtract the error of the strain gauges together with the static force from the measured data from trial 1 and 2. Result: I obtained the forces that are only a result of the perturbation motion.
4. Up until now, the data was measured in voltages. Thus, I convert voltages to newtons with given formulas corresponding to the strain gauges.
5. As already explained for the input signal, the start of sampling of the strain gauges and the start of the perturbation signal do not start at the same time. Ones again I have to fit in the time domain. I do this by fitting the reference step signals of both the offset trial and the perturbation trials (trial 1 and 2).
6. After finding the most accurate fit for both trials, I extracted only the perturbation part (6000 samples) of the signal. Note, that only this part is relevant for the identification procedure.
7. Finally, I calculate over both trials the mean output signal. Thus, I go from 2 output signals to 1 output signal. This is the final output signal (= force) I will use for system identification.

**Which identification procedure do I apply to obtain the transfer function?**

* Based on auto- and cross-spectral densities.
* The transfer function is estimated by the Welch method: Signal is divided into N segments with 50% overlap between segments. The individual segments are windowed after which the spectral density of each segment is calculated with discrete Fourier transformation. The individual segments are then averaged which reduces the variance of the individual power spectral density measurements. The final result is a bode plot.
* The linearity between the input signal (acceleration) and the measured output signal (forces) is analyzed by coherence.