POLITECNICO
MILANO 1863

Data analysis for mechanical system identification

Autocorrelation

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Measurements to investigate the dynamics of the tires

Dynamical analysis of a road vehicle tire:

- Measure of the acceleration on the tire
- Accelerometers inside the tire, close to the contact area

⇩

Extract information about the contact with the road surface

Measurements to investigate the dynamics of the tires

The tire is subjected to accelerations that depend on:

- Type of steer
- Type of asphalt
- Vehicle configuration (camber angle, angular speed, possible skidding slip, …)

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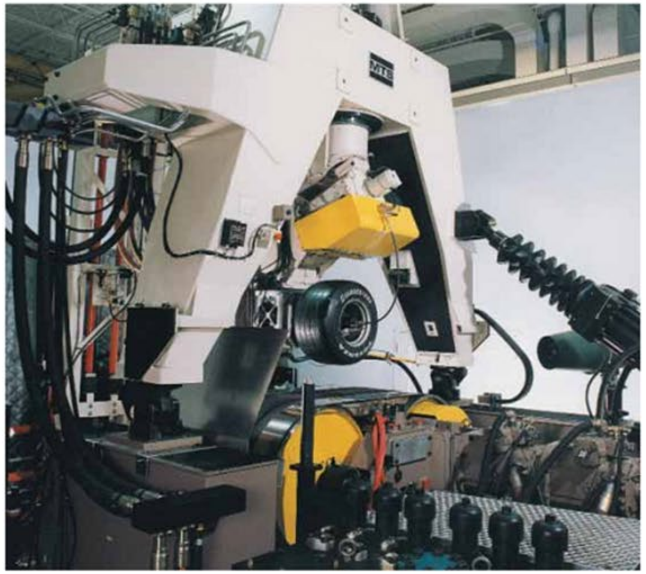
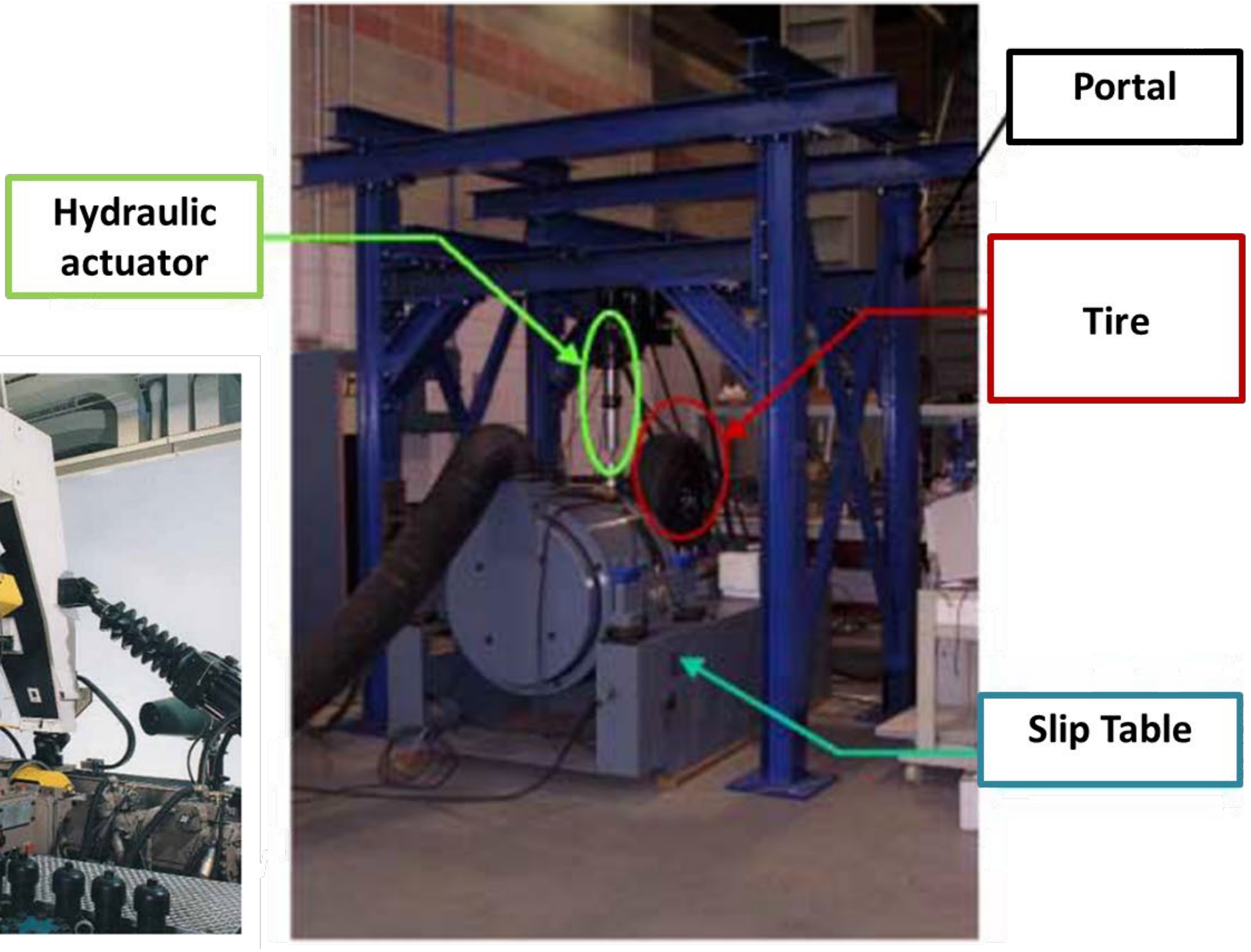
The measurement of these accelerations can give important information on the tire dynamics and therefore on the one of the vehicle

First step

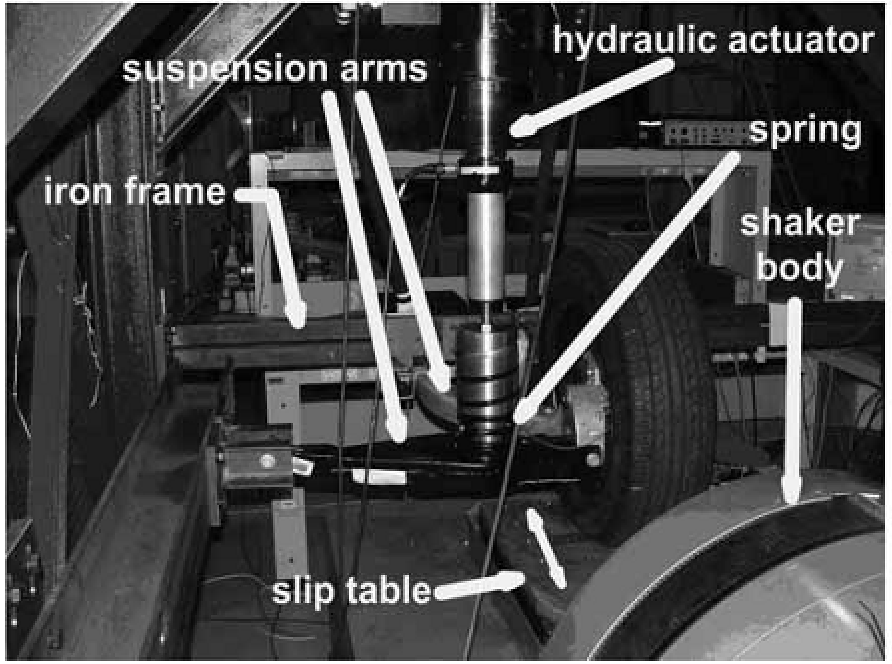
Study of the system dynamics

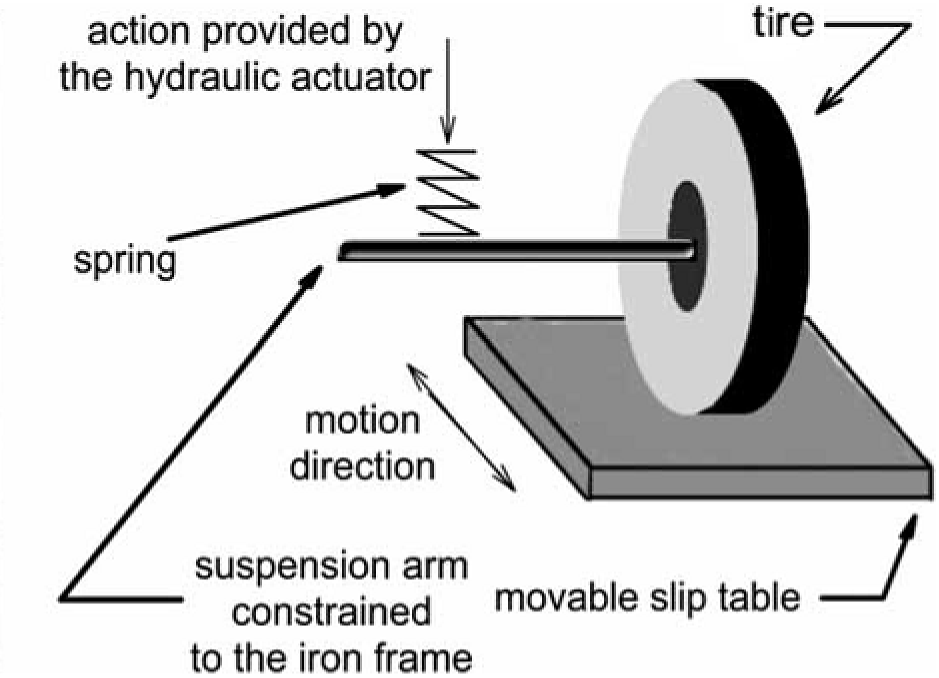




First step

Study of the system dynamics





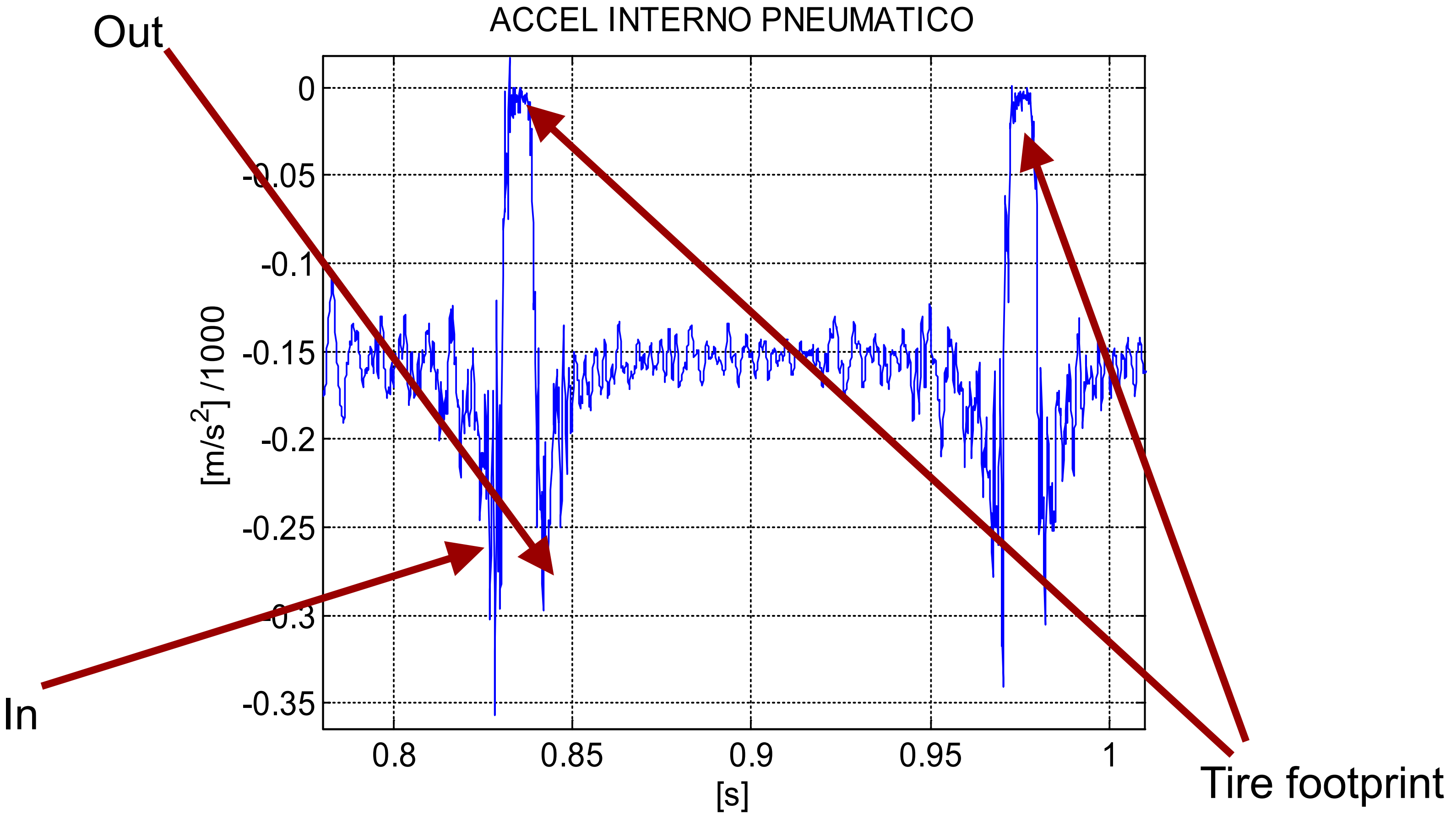
Acceleration measurements on a vehicle tire by means of MEMS sensors

Second step

Road tests

Acceleration measurements on a vehicle tire by means of MEMS sensors

Signal of the radial acceleration



Autocorrelation

Calculate the vehicle speed knowing that the tire diameter is 16 in (1 in = 0.0254 m)

This problem can be solved by deriving the rotation period by means of the autocorrelation.

$$R_{XX}(\tau) = \lim_{T\to\infty} \frac{1}{T} \int_0^T x(t) \cdot x(t+\tau) \cdot dt$$

$$\Downarrow$$

$$R_{XX}(k \cdot \Delta t) = \frac{1}{N \cdot \Delta t} \cdot \sum_{i=1}^{N} \left(x(i) \cdot x(i+k) \cdot \Delta t \right)$$

$$\tau = k \cdot \Delta t \qquad\qquad k = 0 : N-1$$

Autocorrelation

$$R_{XX}(k \cdot \Delta t) = \frac{1}{N \cdot \cancel{\Delta t}} \cdot \sum_{i=1}^{N} (x(i) \cdot x(i+k) \cdot \cancel{\Delta t})$$

$$R_{XX}(k \cdot \Delta t) = \frac{1}{N} \cdot \sum_{i=1}^{N} \big(x(i) \cdot x(i+k)\big)$$

- Can this formula be applied as it is? Or should I take into account that the recorded signal is not infinite?
- How should the autocorrelation formula be modified?

Laboratory: first part

1. Load the data and plot the time signal
2. Implement the autocorrelation function in order to find the revolution period of the tire.
3. Calculate the vehicle speed using the first two peaks of the autocorrelation (the tire diameter is known).
4. Find the distance between the first 10 peaks and see if the vehicle speed is constant.

USE THE FUNCTIONS diff and findpeaks

5. Compare the autocorrelation obtained at point 2 with the one obtained using the Matlab function
    - Use the Matlab function xcorr
    - Graphically compare the results

⇨ The autocorrelation function allowed to **estimate the period** of the signal

Laboratory: second part

An average process in the time domain allows to highlight the deterministic part of a signal.

Once understood which is the right method to calculate the autocorrelation function:

6. Find the period of the signal and split the time history in the single periods (use the estimate of the period on the first two peaks)
7. Average the signals (time averaging)
8. Compare graphically the result with the original signal