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A Low-Cost Data Acquisition System for On-Road Experimental Activity

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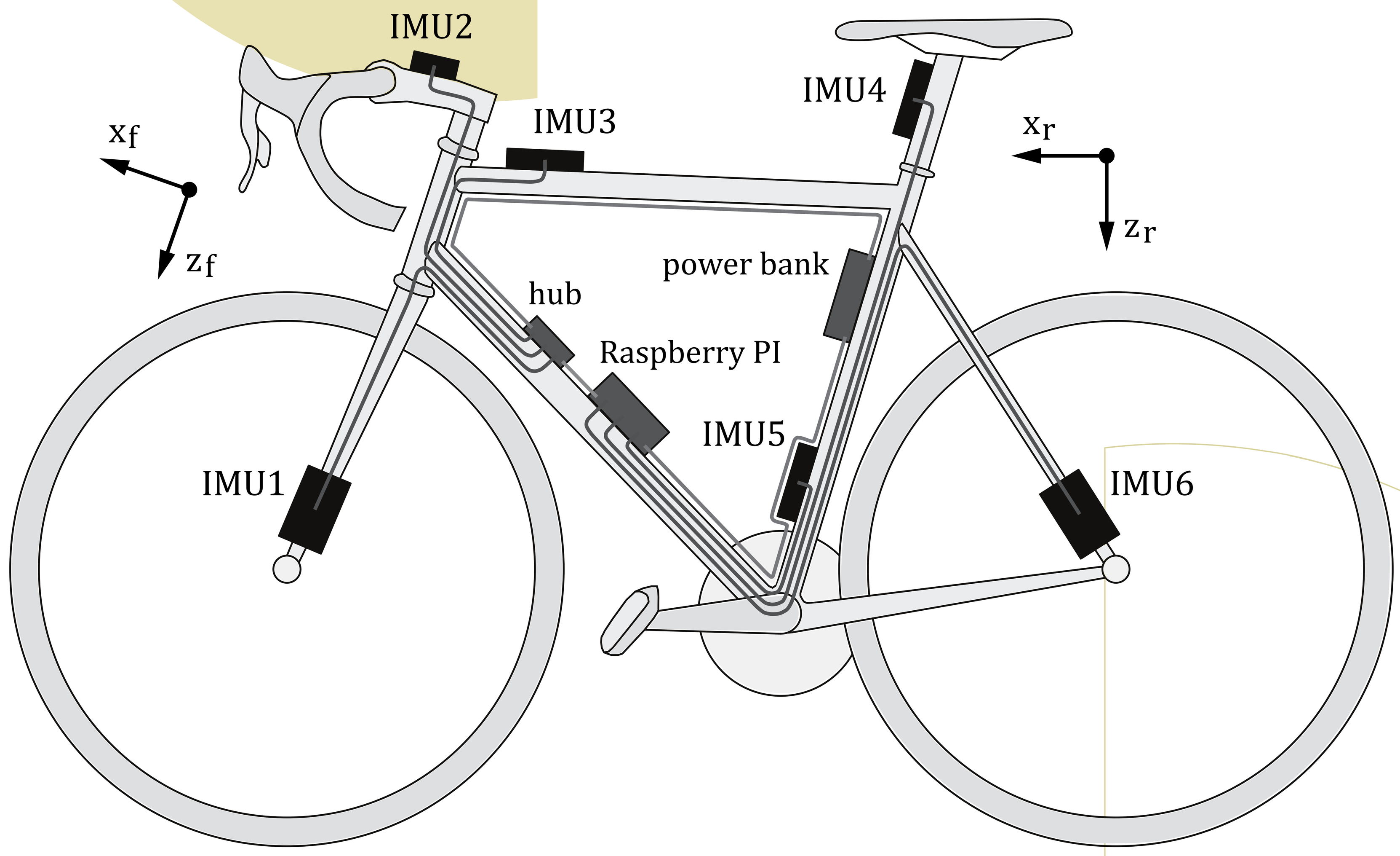
We present a low-cost Data Acquisition System (DAS) able of capturing bicycle or motorbike kinematics in on-road experiments.

Typical requirements of acquisition set-ups for the detailed kinematics description of different bike parts are light weight and small size of sensors to prevent measures contamination.

The widespread of small and low-cost sensors and devices for Cyber Physical Systems (CPS) allowed us to introduce multiple Inertial Measurement Units (IMU) in a standalone DAS.

In [1] the author presents an interesting approach based on wireless IMUs, however, in our experiments we experienced time reference drifts between different wireless sensors based on Bluetooth Low Energy or Zigbee networks and, especially in data logging mode (i.e. without a continuous data synchronization) a sample-wise synchronization can be easily lost.

In order to avoid this issue we adopted a wired link between the IMUs and the Central Unit (CU) obtaining an accurate synchronization and effective data logging in a light weight low cost and easy to reproduce system.



The adopted IMUs are based on the Arduino 101® equipped with an IntelTM Curie® that is provided with a Bosch™ BMI160 6-Axis sensor with 16bit Accelerometer and 16bit Gyroscope.

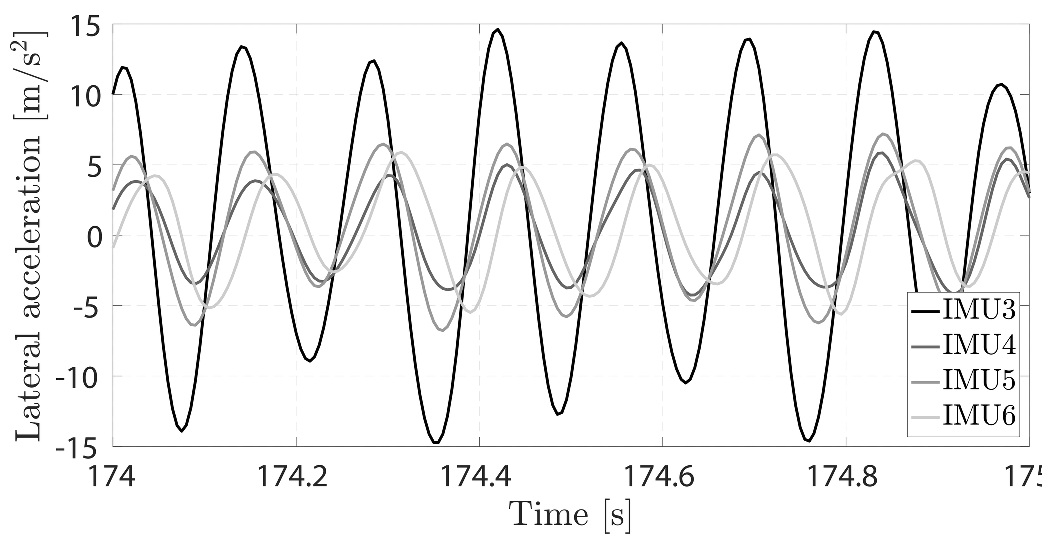
The measured accelerations can reach $\pm 16g$ and the gyroscope can read up to $\pm 2000°/s$.

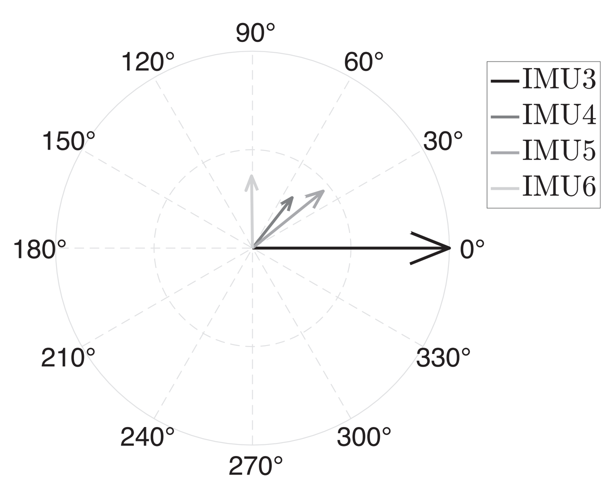
With the proposed set-up we can reach up to 1600samples/s.

In order to avoid any synchronization issue or data loss we developed an *ad-hoc* real time firmware for every IMU: through a wired connection from the GPIO of the Raspberry Pi a TTL signal is dispatched in parallel to all the IMUs that forthwith read IMU data.

Acquired data are then stored in a local buffer and sent to Rasberry Pi as soon as the USB Bus is available.

The specific real-time application on Raspberry Pi allows for a continuous storage of data streams from every IMU associated with the proper time-stamp of every sample.





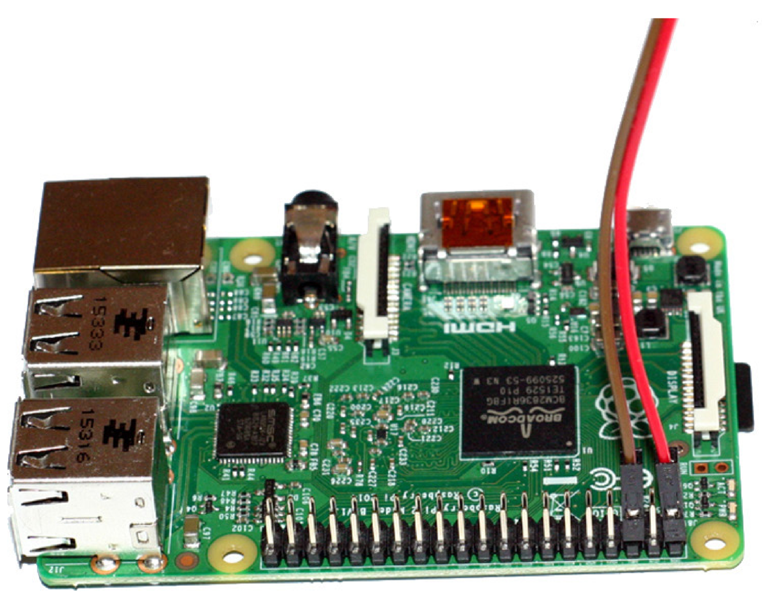
In the figure above accelerometer data are provided for 4 synchronous IMUs placed on the cental and rear frame of the bike during a shimmy episode acquired at the Bevera downhill in Lecco (Lombardy, Italy).

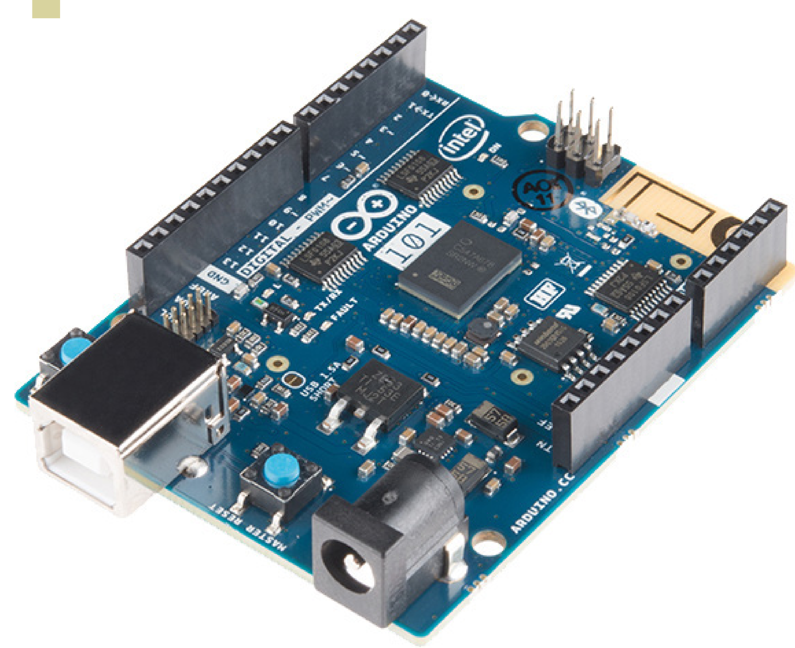
As can be seen in the phase plot there is a phase-delay between the two bike's portions underlying the non-rigid behaviour of the whole bicycle frame during shimmy episodes.

The presented setup was used to validate the model based simulationtions presented in [2].

Our setup consists of 6 IMUs connected through an externally powered USB Hub, to a Raspberry Pi 3 (model B+).

In our setup the possible number of IMUs is not limited and could be extended to the maximum allowed by the Linux OS.





[1] Cain S. M. "Measurement of bicycle and rider kinematics during real-world cycling using a wireless array of inertial sensors". In Proceedings, Bicycle and Motorcycle Dynamics,Symposium on the Dynamics and Control of Single Track Vehicles, (2016).

[2] Tomiati N., Colombo A., Magnani G. "A nonlinear model of bicycle shimmy. Vehicle System Dynamics". 2018; Available from: https://-doi.org/10.1080/00423114.2018.1465574