IMU based goniometry monitoring on Patients, quo Vadis?

Integrated sensor technologies are widely used in various self-monitoring devices for leisure and professional sports activities. Vital signals and general gait information are transferred into fitness and risk levels. Additional information of the musculoskeletal system coming from inertial measurement units (IMU) can provide important information for a better holistic interpretation.

This thesis explores the reliability (precision, accuracy and reproducibility) of a wireless IMU based motion tracking systems, commonly used in todays' film-industry to capture motion for animated movies in a pilot trial. Is this system reliable enough for dynamic angulation measurements on patients under medical aspects?
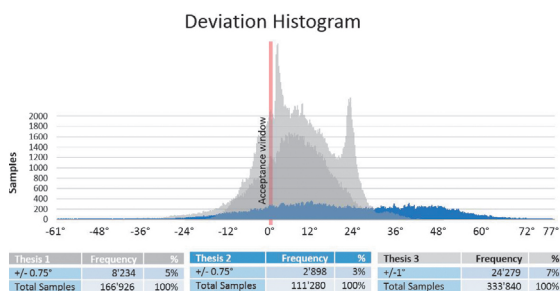
Goniometric data were simultaneously acquired from an industrial robot arm and from the right elbow of 5 subjects, with an IMU based system from Noitom and an optical system from Vicon. The synced data sets were benchmarked to determine the reliability of the Noitom System.

5% of the 166'926 collected data samples of the **5 minutes robot trials** are within the acceptance window of +/− 0.75°. 3% of the 111'280 collected data samples of the **5 minutes human trial**s are within the acceptance window of +/− 0.75°. 7% of the 333'840 collected data samples of the **1 hour robot trials** are within the acceptance window of +/− 1°.
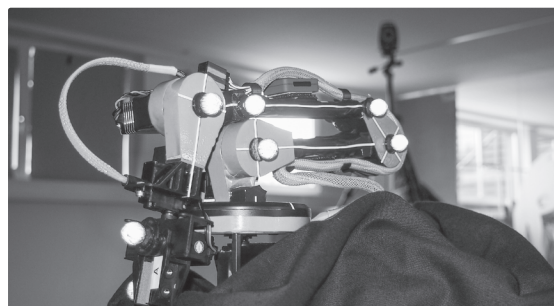
The Noitom system didn't fulfill the acceptance criteria on all trials. However, the main cause on the detected deviation could be linked to a reproducible recurrent error pattern based on multiple axis motion interference. Nevertheless, this lack of accuracy it is still acceptable to monitor motion patterns and detect characteristic changes as caused by fatigue or by other systematic status changes.

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Deviation Histogram

Thesis 1	Frequency	%	Thesis 2	Frequency	%	Thesis 3	Frequency	%
+/- 0.75°	8'234	5%	+/- 0.75°	2'898	3%	+/-1°	24'279	7%
Total Samples	166'926	100%	Total Samples	111'280	100%	Total Samples	333'840	100%

Deviation Histogram on the three thesis

Franconia Robotix with mounted Vicon IR-reflector-markers and Noitom IMU sensor node.