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Wearable Low-Complexity 6DOF Magnetic Tracking System

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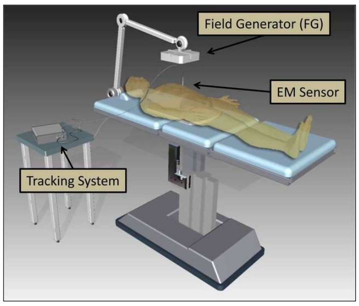
Research context and motivation

The accurate tracking of objects inside a determined space have been of great interest in different fields for while now. The necessity of immersive human-machine interaction have been manifested in the neuroscience research [1], medical instrumentation development [2], entertainment industry and sport engineering. Being able to comprehend and quantize how a human joints move, or an inanimate object is manipulated with a minimum required accuracy is the key to open the door to endless interactive applications. The application domains range from entertainment systems

System used to quantify the influence of movement intention [1].



Principle of intra-operative EM tracking [2].

Addressed research questions/problems

Magnetic tracking system can perform with millimeter level performance in an environment free of ferromagnetic materials, without the requirement of a line-of-sight. However, one weak point of current available magnetic tracking systems, is the lack of a wireless connectivity, since most systems have the tracked device wired to a central processing unit, which might limit the mobility of human joints when been worn, therefore limiting their use in immersive human machine interactive applications.

Polhemus Fastrak magnetic tracking system [3].

NDI Aurora magnetic tracking system [4].

The research focus on finding a solution to develop a magnetic tracking system that can maintain the 6DOF capability, high tracking accuracy and reliability, while adding a wireless communication between the tracked sensor or group of sensors and the user interface. This would allow an increased flexibility for its possible applications as well as an increased wearability in comparison to current solutions .

References

1. Ansuini, Caterina, et al. "The visible face of intention: why kinematics matters." *Frontiers in psychology 5* (2014): 815.
2. Franz, Alfred M., et al. "Electromagnetic tracking in medicine—a review of technology, validation, and applications." IEEE transactions on medical imaging 33.8 (2014): 1702-1725.
3. Polhemus, "Fastrak" https://polhemus.com/motiontracking/all-trackers/fastrak, 2019.
4. NDI, "Aurora" https://www.ndigital.com/medical/products/aurora/, 2019.

Submitted and published works

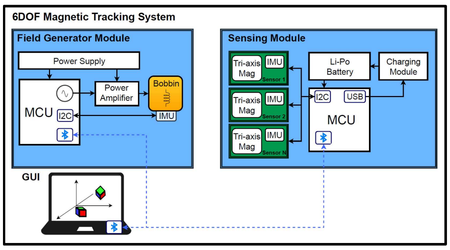
- David A. Fernandez G. ; Stefano Sapienza ; Bianca Sereni ; Paolo Motto Ros, "*Very low power event-based surface EMG acquisition system with off-the-shelf components*", IEEE BioCAS, Torino, 2017
- M. Grosso, D. Lena, S. Rinaudo, David A. Fernandez G., D. Demarchi , "*Training a classifier for activity recognition using body motion simulation*", IEEE BioCAS, Torino, 2017
- Author 1, A. , Author 2, A., and Author 3, C., "*On-Line Event-Driven Hand Gesture Recognition Based on Surface Electromyographic Signals*", IEEE ISCAS, Florence, 2018
- David A. Fernandez G., Enrico Macrelli, Danilo Demarchi and Marco Crepaldi, "*High-Accuracy Wireless 6DOF Magnetic Tracking System Based on FEM Modeling*", IEEE ICECS, Bordeaux, 2018
- David A. Fernandez G., Danilo Demarchi and Marco Crepaldi, "*A Wearable Low-Complexity 6DOF Magnetic Tracking System Based on Simulated Data Sets*", to be submitted to IEEE TCAS-I

Adopted methodologies

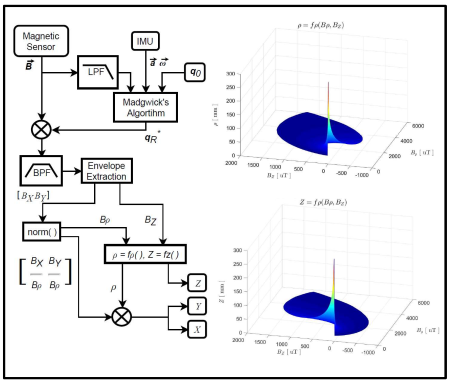
System level hardware architecture design projected as three different modules:

- Field Generator Module
- Sensing Module
- User device running the GUI

all interconnected wirelessly via Bluetooth 4.2 or Bluetooth 5



6DOF tracking system software projected around substituting commonly used regression methods to estimate the sensor position from its magnetic flux density readings by a LUT approach formed from FEM model calculations and calibrated with sensor measurements at known positions. This approach is adopted to lighten the needed system processing capacity while maintaining a minimum accuracy of the sensed magnetic field



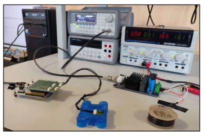
Novel contributions

6DOF magnetic tracking system PoC prototype developed with off-the-shelf components using the proposed modular hardware architecture.

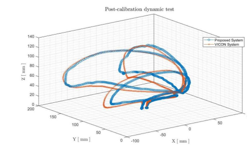
Main system characteristics:

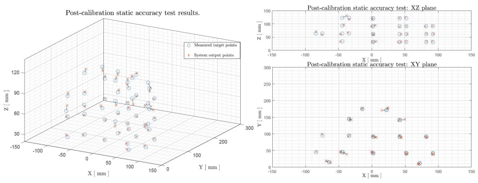
- Static RMSE: 4,3 mm
- Dynamic RMSE: 6,8 mm
- Orientation RMSE: 1,9°
- Update rate: 100 Hz
- Latency: 10 ms
- Current consumption*: 42 mA

*Sensor Module current comsumption



Developed PoC 6DOF magnetic tracking system





Future work

The future development steps to be taken will consist in:

- Enhancing the system accuracy by further developing an efficient calibration method as well as using different magnetic field sensors with higher resolution.
- Implementing wireless communication between the system modules.
- Developing algorithm for multi-sensor usage.
- Improving Field Generator and Sensing prototype modules up to commercial standards

List of attended classes

- 01SFTRV – Fondamenti probabilistici e visione nella robotica di servizio (12/06/2018, 4)
- 01SFURV – Programmazione scientifica avanzata in matlab (20/04/2018, 4)
- 01SHCRV – Unsupervised neural networks (09/04/2018, 6)
- 01QORRV – Writing Scientific Papers in English (21/03/2018, 3)
- 01QRQRV – Compressed sensing: theory and applications (23/09/2019, 4)
- 01RONKG – Python in the Lab (20/09/2019, 4)
- 01TEVRV – Deep learning (04/06/2019, 6)

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