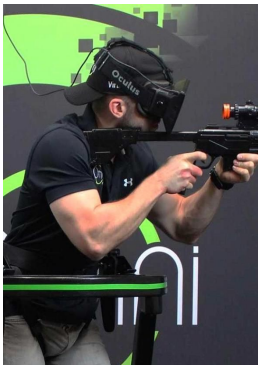
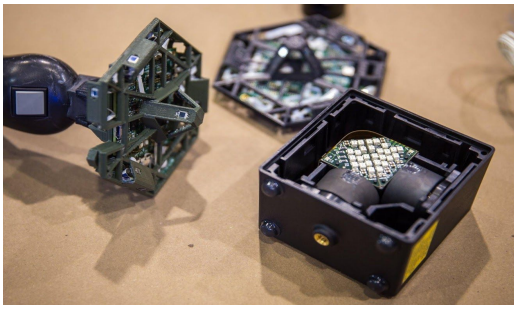
EECS Master's internship

Sensor Fusion of IMU & 3d Positioning data for Virtual/Augmented/Mixed Reality

Abstract

Context: Virtual reality is emerging as one of the main directions in human-machine interaction. Achieving an immersive environment requires tracking the user's movements in space at all times. One must know eyes positions to calculate stereoscopic image to perfectly create an illusion of reality.
In this internship, we will focus on following objects such as hands or tools, to allow real time interaction. Several sensor systems exist on the market to perform this monitoring, with variable performance but prices are often exorbitant. We thus developed our own system, the Hive Tracker, a miniature 3d positioning device, usable with the HTC Vive, but not only.





Goal: Your challenge will be to improve this system to increase accuracy and make it more dynamic. We use the laser-based lighthouse system by HTC, and our sensor modules uses an active approach by calculating its position according to the optical signals it receives. A proof of concept was validated, you will improve our latest iteration by optimizing different algorithms (Kalman, gradient descent, etc). Basically, the refresh rate of the optical positioning system is limited to 30Hz, but the IMU can provide data at up to ~500Hz rate and it can be used to accelerate the position estimation, that's the mission. A technical presentation by the inventor of the system is available online (seek to 5m17s for details about this sensor fusion challenge): hackaday.com/2016/12/21/alan-yates-why-valves-lighthouse-cant-work

Organization

Profile: Autonomous and motivated EECS master's student, with a strong focus on math and/or signal processing. C/C++ will be necessary and some experience with git would be appreciated.

Duration: 6 months (with potential international collaborations at the end)

Place: ISIR, UPMC, Paris

Stipend: legal french amount

References:

- "Estimation of IMU and MARG orientation using a gradient descent algorithm" by Sebastian O. H. Madgwick (ieeexplorer / sci-hub / github / x-io)
- "Optimal State Estimation" by Dan Simon (amazon / libgen)
- "Probabilistic Robotics" by Sebastian Thrun (amazon / libgen)

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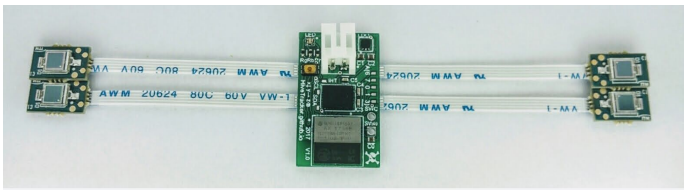

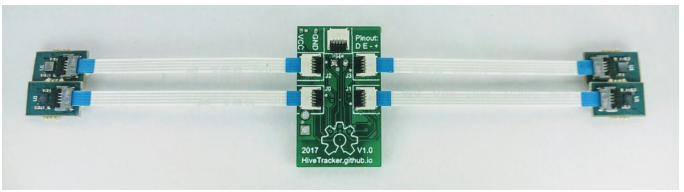

Mission details

- State of the art about 3d tracking and sensor fusion
    - Search in ACM, IEEE, industry, open source...
    - Start a report in a shared document (wiki, etherpad…)
    - Time planning for the project duration (Gantt diagram, PSSC...)
- Software
    - Simulations
        - Create/reuse GUI to visualize the an object in 3D
        - Generate sensors data (perfect at 1st, then with noise)
            - Magnetometer: slow & noisy
            - Gyroscope: drifting if integrated for orientation
            - Accelerometer: drifting if integrated for positioning
            - 3d positioning: with random interruptions
    - C/C++ fusion experimentation / implementation
        - Investigate possible Madgwick algorithm adaptations
        - Investigate Kalman filter to adapt it
        - Evaluate performances
        - Calibrate coefficients using optical MoCap as reference
- Hardware
    - Implementation with the HiveTracker (using nRF52 in Arduino)
    - 3d modelisation of an enclosure (for adapted photosensors disposition)
- Validation
    - Test jig design and algorithms performances comparisons
    - User study with various applications (games, etc.)
- To deliver
    - Documented GitHub repository
    - Presentations: state of the art, results
    - Report in ACM article format