

# Depth sensors-based upper limb motion capture system for functional neurorehabilitation

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## 1. INTRODUCTION

Versatile and accurate motion capture systems, with the required properties to be integrated within both clinical and domiciliary environments, would represent a significant advance in following the progress of the patients as well as in allowing the incorporation of new data exploitation and analysis methods to enhance the functional neurorehabilitation therapeutic processes. Besides, these systems would permit the later development of new applications focused on the automatization of the therapeutic tasks in order to increase the therapist/patient ratio, thus decreasing the costs [1]. However, current motion capture systems are not still ready to work within uncontrolled environments.

## 2. METHODS

The authors propose a depth sensors-based motion capture system able to track the kinematic parameters of the patients' upper limbs while carrying out functional rehabilitation exercises. This system will allow a future analysis of the patients' performance by detecting those clinical response indicators needed to identify the changes related with good and bad prognosis to be either maximized or inhibited.

Figure 1 shows the block diagram corresponding to the proposed platform. The following modules can be identified:

- A communication module to make the depth sensor receive commands
- A monitoring module to process the information captured by the depth sensor and calculate the kinematic variables related to the upper limb motion. In this work, an 8 Degrees of Freedom (DoFs) kinematic model has been considered (scapular elevation/depression -eleB-, shoulder flexion/extension -fexS-, abduction/adduction -abdS- and rotation -rotS-, elbow flexion/extension -fexE- and pronation/supination -pronoE-, wrist flexion/extension -fexW- and grasping -graspH-).
- A Graphic User Interface (GUI) both to configure the device and to visualize the results

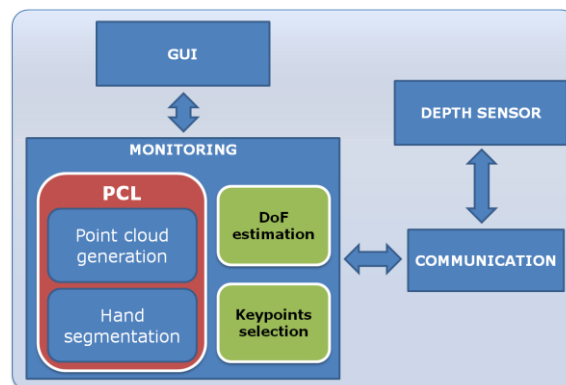


Figure 1. Motion capture system architecture

In this work, *Microsoft Kinect* has been used as depth sensor in such a way that the information provided by this sensor is directly used to calculate all the DoF but the wrist flexion/extension and grasping due to its lack of consistency in detecting hands when the subjects manipulate objects. For this reason, the hand detection has been enhanced by using the Point Cloud Library (PCL) [3] and the MIT's *Hand Detector* [4] algorithms, that use the information provided by *Microsoft Kinect* to generate one point cloud per hand and thus obtain their position by calculating the corresponding centroids. The remaining DoFs are extracted from the Euler angles related to each upper limb segment following [2].

### 3. RESULTS

A preliminary validation of a 4 DoF (fexS, abdS, rotS and fexE) motion capture system prototype has been carried out to check the viability of the proposed solution. In this way, a qualitative analysis of a series of analytic movements has been performed. Figure 2 shows the kinematic data calculated by the system when a subject performs the following sequential actions:

1. Rest
2. 90° shoulder flexion
3. 90° elbow flexion
4. Full elbow extension
5. 90° shoulder horizontal abduction
6. Rest



Figure 2. Analytic motion tracked

As it can be observed in Figure 2, all the DoFs have the expected morphology: fexS value is close to the 90° during most of the time; fexE value is close to 0° when the elbow is supposed to be fully extended and is close to 90° when it should be; in the last part of the plot, as expected, abdS takes a value close to 90°; finally both fexS and abdS return to the resting position.

### 4. CONCLUSIONS

The proposed prototype is considered as a proof concept for a future development of an upper limb motion tracking system. Given the aforementioned qualitative results, next steps to take will be to expand the system to calculate the remaining DoFs (eleB, rotS, pronoE and graspH) and perform a systematic validation by co-registration using the BTS SMART-D tracking system [5] as a gold standard.

## REFERENCES

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