



Title: Interactive assistant tool for the evaluation of kinematic patterns and EMG signals in patients with a forearm injury

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Introduction



Subjective feelings feedbacks are commonly employed by a patient during forearm rehabilitation therapy without real-time data, leading to suboptimal recovery results in some patients



Consequences

- Deficient recovery process.
- Long Time recovery process.
- High Cost recovery process.

The literature evidence on devices and interfaces for motion recognition shows a trend in medical applications related to physical rehabilitation



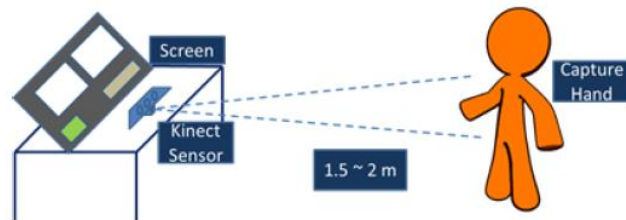
Related-Work

Guneysu et al. (2018)



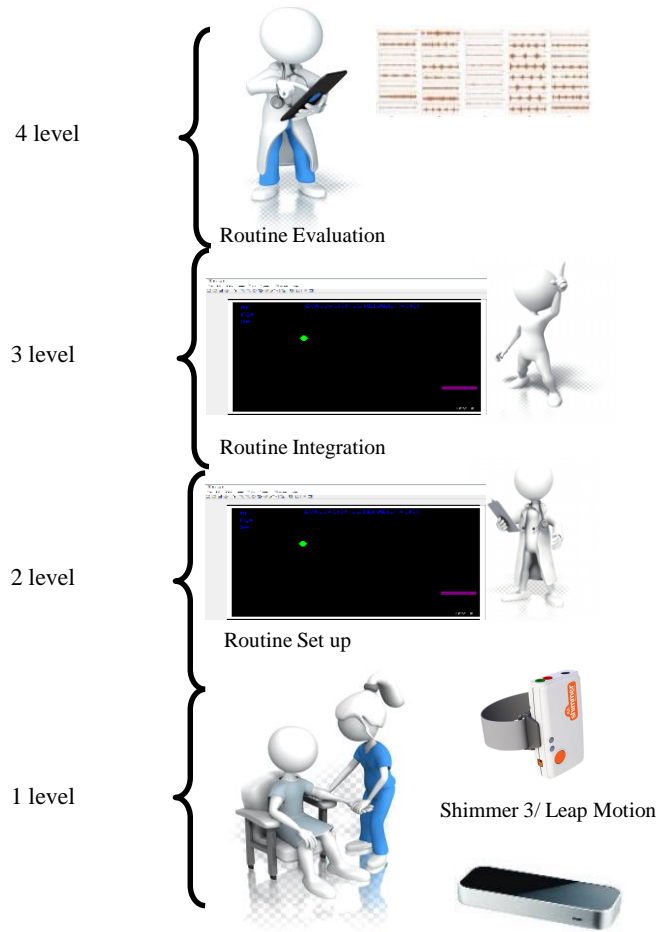
Opportunity Area

Samad et al. (2017)



The literature review exposes some areas of opportunity that have not been explored at all, such as sensor fusion in interactive interfaces as a quantitative evaluation tool of the patients on the recovery process from a forearm injury.

Methodology



The present work shows an alternative sensor fusion tool of two capture sources (kinematic and EMG) that are contained through an interaction guide interface to evaluate the forearm movements

based on a multi-level operation design, using non-invasive real-time signal acquisition methods.

Signal Acquisition

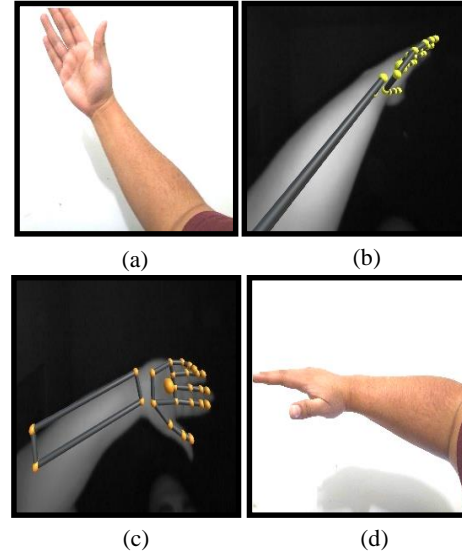
Leap Motion

Ultraleap's optical hand tracking module captures the movements of your hands



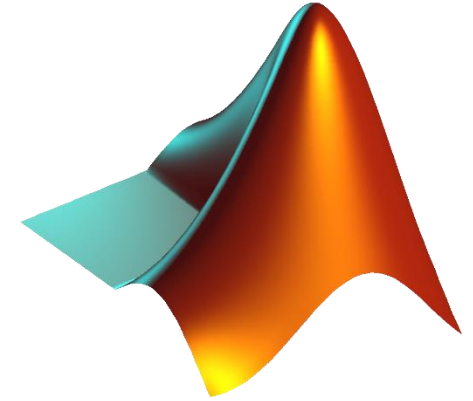
Ultraleap Co.

Features
IR Filters lens
IR Cameras
Touch Free control



Three infrared LEDs which emit light with wavelength of 850 nanometers (outside the visible spectrum) and two cameras that capture the reflected light in this spectrum

sequence of pairs of grayscale stereo images



APIs for JavaScript, Unity,
C#, C++, Java, Python,

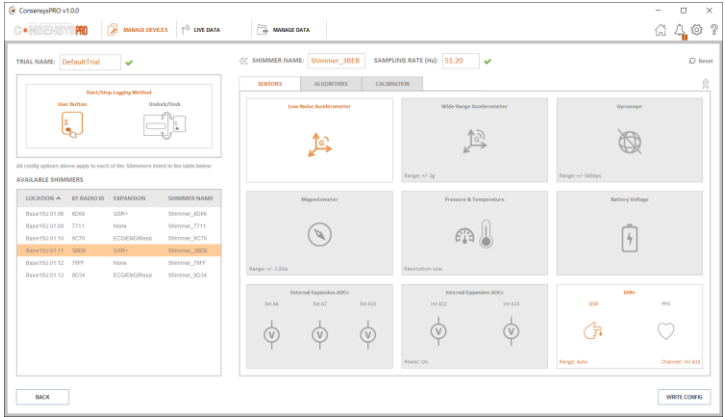
Shimmer 3 EMG



Unit provides a configurable digital front-end, optimized for the measurement of physiological signals for EMG.

Features
 Wireless Solution
 2 Channels
 Non-invasive

Muscle	Movement Types	Electrode position
Arm biceps	Internal Rotation	
Arm biceps	Flexion - Extension	
Brachioradial	Supination	
Extensor extensor of carpal of the radius	Wrist flexion/extension	



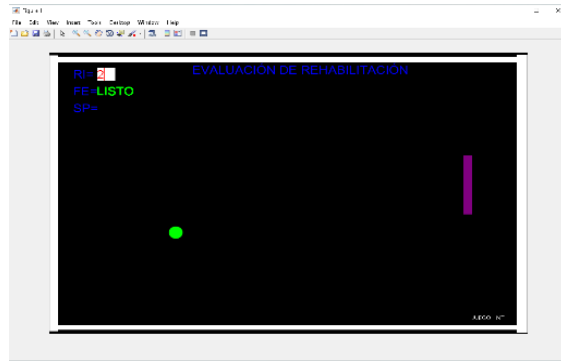
Software Interface

Settings Screen

The screenshot shows a software window titled "REHABAPP" with a dark background. The main title "Rehabilitation App" is centered at the top. The interface is organized into two columns. The left column contains a "Name" label above a white text input field, a "Years" label above another white text input field, a "Start" button, and a "Stop" button. The right column contains four dropdown menus: "Forearm" (set to "Right"), "Internal Rotation" (set to "1"), "Flexion-Extension" (set to "1"), and "Supination Palm" (set to "1").

Field	Value
Name	[Empty]
Years	[Empty]
Forearm	Right
Internal Rotation	1
Flexion-Extension	1
Supination Palm	1

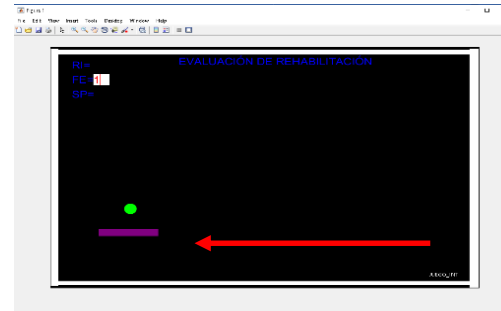
Game Screen



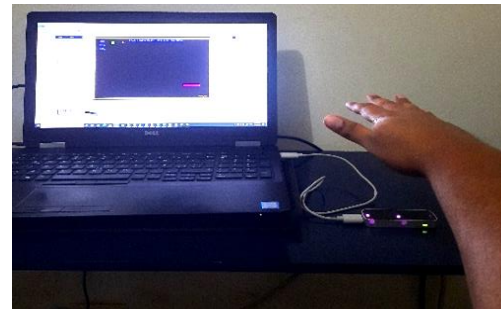
(a)



(b)



(a)



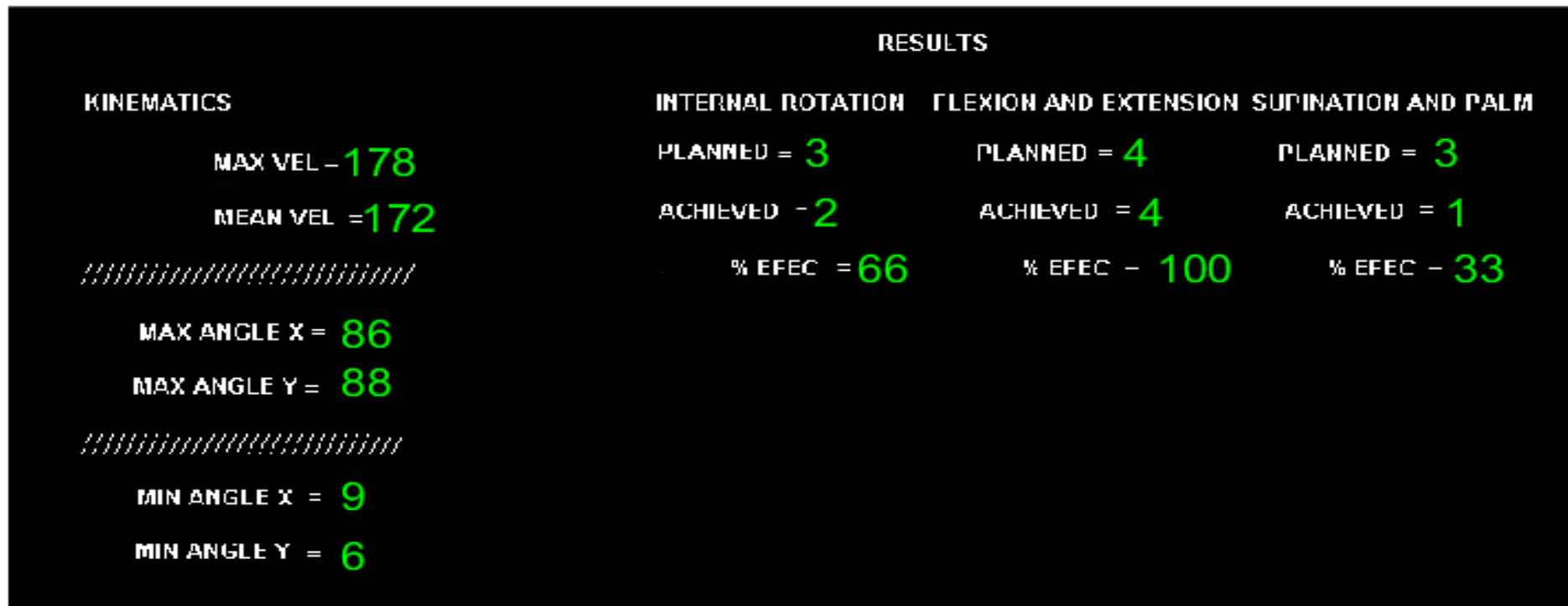
(b)



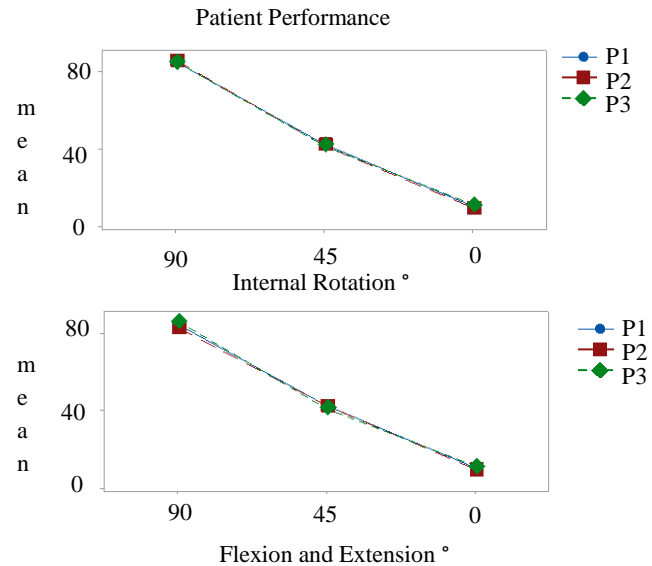
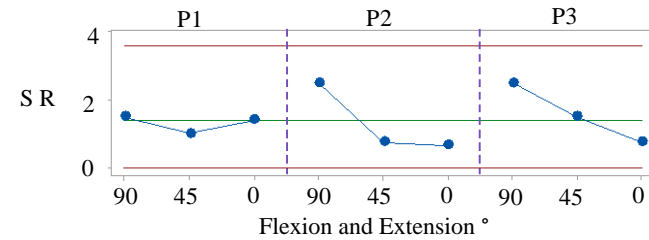
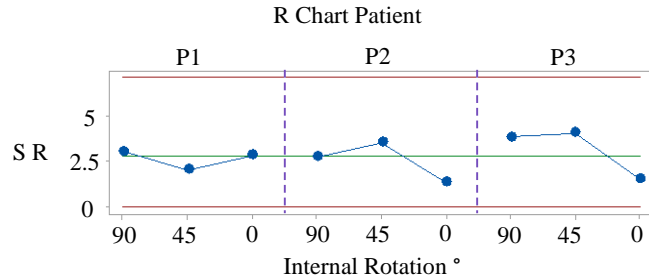
(c)



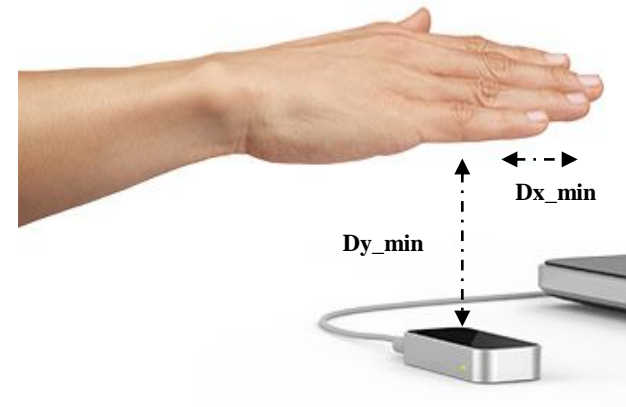
Results Screen



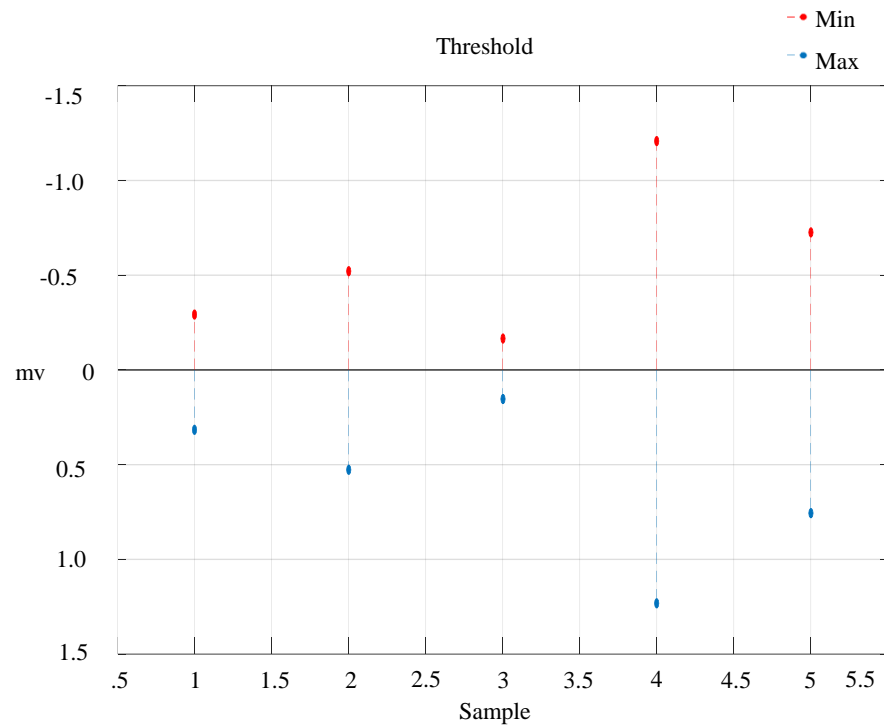
Results



- 1.- Repeatability of the flexion-extension and internal rotation movements is about 3% and 4%, respectively
- 2.- The maximum limit operating speed is 190 mm/s.
- 3.- The minimum flexion-extension and internal rotation range that the device and interface detect are 9 to 88 degrees maximum
- 4.- Operating ranges at a minimum distance of $Dx_{min} = 100$ mm, and $Dy_{min} = 180$ mm above the LM



EMG RESULTS



There is a difference in the threshold voltage magnitude between patient movements in the results. Each movement is classified by the EMG signals values in the routine.

Final Results

Patient	Max Vel	% IR	% FE	% REMG
1	172 mm/s	92	100	90
2	178 mm/s	95	100	92
3	189 mm/s	98	100	95
4	170 mm/s	95	90	92
5	180 mm/s	100	100	95

Conclusion

In conclusion, the improvements presented by the interactive tool to monitor the recovery process are:

- Clinical diagnosis support by quantitative evaluation reports in the forearm recovery process.
- The patient develops exercises therapy through the programming routines proposed by professionals in an entertainment environment.
- Sensor fusion of multiple variables (kinematics and EMG) defines the forearm movements to monitor the recovery progress.



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