Fraunhofer
PORTUGAL

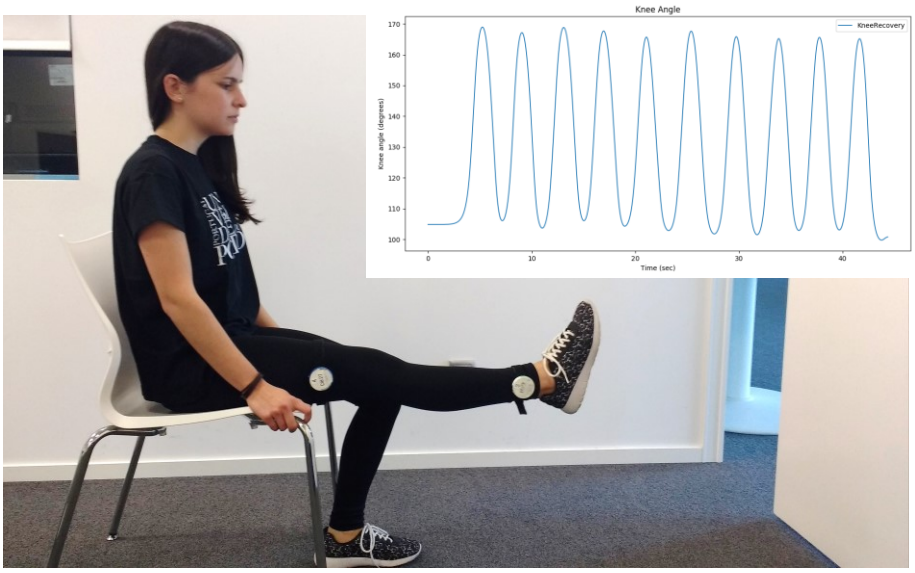

Fig1. Knee angle obtained by KneeRecovery System during the exercise Long Arc Knee Extension.

KNEERECOVERY

REHABILITATION EXERCISES FOR KNEE RECOVERY AT HOME

Osteoarthritis

Knee osteoarthritis (OA) is ranked as the 11th highest contributor to global disability, with sufferers commonly reporting pain, activity limitations and diminished health-related quality of life.

As a progressive disease, it gradually worsens with time being highly prevalent among obese and elderly people.

In advanced stages of knee OA, surgical intervention may be warranted due to a reduced effect of conservative treatment on symptoms. Total Knee Replacement (TKR) is a promising management strategy for end-stage OA, with typically large improvements in pain and self-reported function. Following discharge after a TRK, physical rehabilitation, comprising mainly physical therapy intervention, is widely advocated and provided as a standard of care.

Rehabilitation at home vs hospital

Recent years have witnessed an increasing demand for more efficient health care delivery which has resulted in an increase in home based rehabilitation. However, rehabilitation exercises performance at home can be jeopardized due essentially to the lack of a real-time feedback and adherence.

To address this problem, knee kinematics as the knee angle obtained during rehabilitation have to be quantified and the need of a system able to give this information emerges to allow a rehabilitation process at home.

Contact

Rua Alfredo Allen, 455
4200-135 Porto, Portugal

+351 220 430 300
info@fraunhofer.pt
www.fraunhofer.pt

KneeRecovery System

Intends to be used during knee rehabilitation process, by the patient him / herself, at home, after being subjected to a TKR. This system can let users perform the rehabilitation program at home and provide a real-time biofeedback during the rehabilitation process, informing the patient about achieved results.

Topics

- Osteoarthritis
- Rehabilitation at home vs hospital
- Inertial Sensors
- KneeRecovery System
- Results

Inertial Sensors

Inertial systems are normally a family of sensors represented by accelerometers, gyroscopes and magnetometers. The term "inertial" refers to the fact that this typology of sensors is able to measure their movement (or the movement of a rigid body to which the sensor is fixed) by exploiting the reluctance of a free mass to move (inertia) when contained in the sensor, while the latter is accelerated by an external force (accelerometer) or is rotated by a force couple system (gyroscope) or directed by the magnetic field (magnetometer).

Several successful examples exist in literature for the application of inertial sensor based systems in the measurements of knee angles, motoring the recovery of patients who underwent TKR.

KneeRecovery System

KneeRecovery system is a sequential algorithm that was thought to analyze the lower limb motion provided by the knee, using inertial sensors. This analysis consists in obtaining and analyzing the information about knee angles achieved during the execution of a set of knee rehabilitation exercises.

Two wearable sensors, the Pandlets developed by Fraunhofer Portugal AICOS are used to monitor movements and are placed on the lower limb: one on the middle lateral section of the thigh and the other one on the lateral lower section of the shank, aligned with each other. Sensors communicate wirelessly with a laptop via Bluetooth low energy. The system starts by estimating orientation, which involves a sensor fusion algorithm that was used to obtain the orientation of each lower limb segment (thigh and shank) relative to the Earth's reference frame, in the form of quaternions. Then, the limb vectors (thigh and shank) are determined through a change from sensor local reference frame to Earth's reference frame, which involves a rotation by quaternions. The knowledge of the two limb vectors allows the knee angle calculation.

Results

The KneeRecovery system was evaluated comparing its performance with two different methods: the camera motion tracking and the goniometer. The presence of an offset was verified for all the tests, which led to the need to implement a calibration method. After the calibration, a maximum mean absolute deviation of 4,02 degrees and 4,61 degrees was found for the camera and goniometer validation methods, respectively.

The results obtained suggest that KneeRecovery can be used to estimate knee angles, and can be a low-cost solution for the implementation of knee rehabilitation at home.

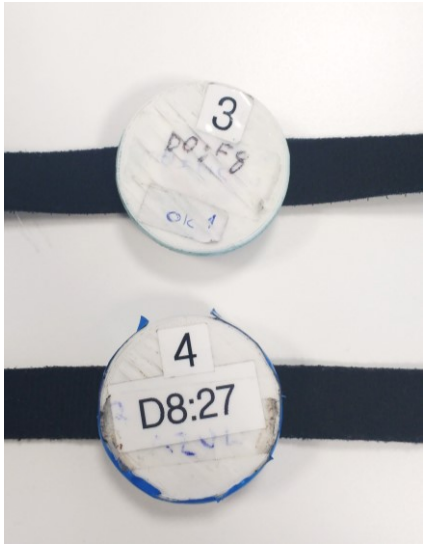

Fig2. **Pandlets used for KneeRecovery data acquisition.**