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FNSNF

Sensory System in SImOS

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Introduction

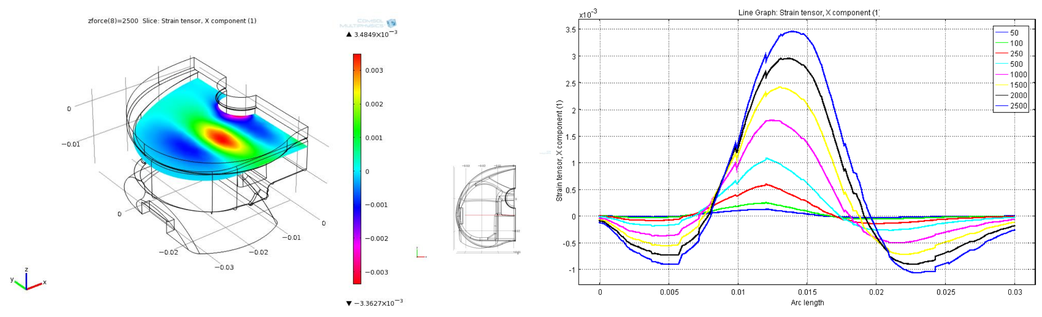
The typical parts of a human knee implant are a femoral component, a tibial component and an Ultra High Molecular Weight (UHMW) Polyethylene (PE) insert. Useful kinematic metrics for joint function evaluation are defined as joint orientation and displacement during daily activities and walking. In order to evaluate force balance of the implant, the amplitude of total force on the knee prosthesis and the amount of force in medial and lateral part of the prosthesis are considered. In order to avoid wireless connection problems, to fulfill energy harvesting constraints and to have minimal structural modifications on the implant, major part of our system was placed inside the polyethylene insert.

Considering the transparency of the human body to magnetic flux and the negligible effect of CrCo alloy-based prosthesis on magnetic flow, we chose anisotropic magneto resistance (AMR) sensors as low power consuming sensors to estimate joint kinematics. The measuring system consisted of a permanent magnet, and a number of AMR sensors.

In order to measure the total force applied to the prosthesis and the lateral-medial imbalance, strain gauges were designed, fabricated, and positioned inside the PE. The design and positioning of the strain gauges were based on finite element analysis of the F.I.R.S.T. prosthesis. A micromachining process was established to fabricate biocompatible sensors.

Force Sensors

Finite Element Simulations

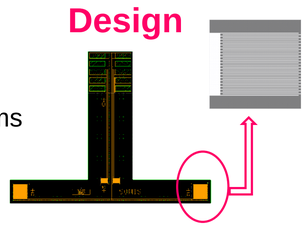


Specifications, Design Fabrication and Device

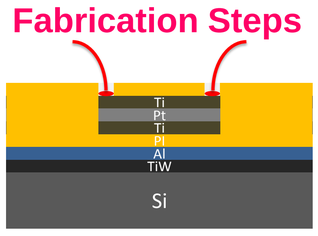
Specifications

Excitation: 1.5V
Impedance: 3.2kohms
Power: 0.7mW
Gauge factor: ~2

Design



Fabrication Steps

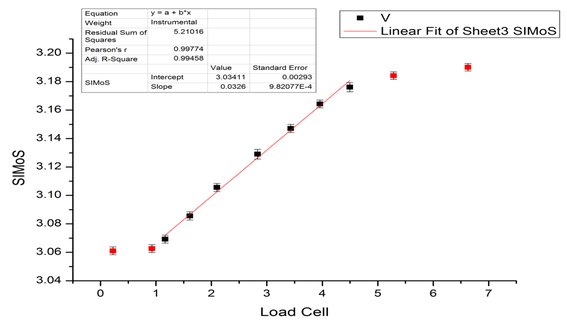


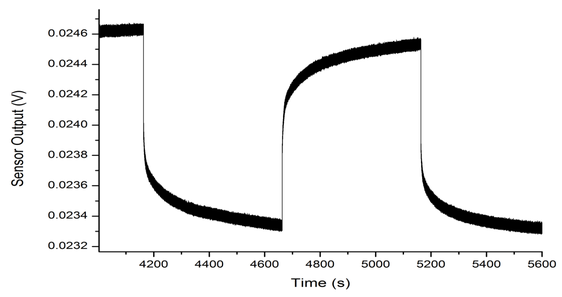
Device

Device Assembly for the UHMWPE Prototype

Robotic Knee Simulator

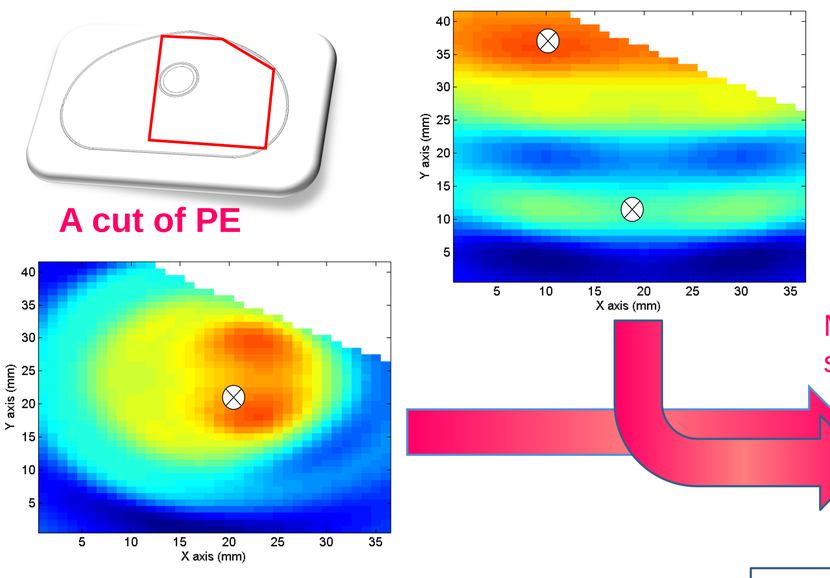
Calibration and Experiments





Kinematic Sensors

Sensitivity Regions Simulation (for different movements) Optimization (to find the best placement)

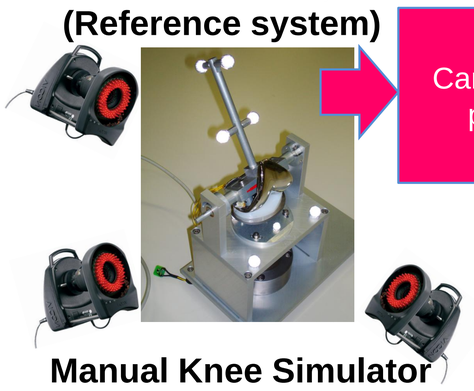


Magnetic Measurements

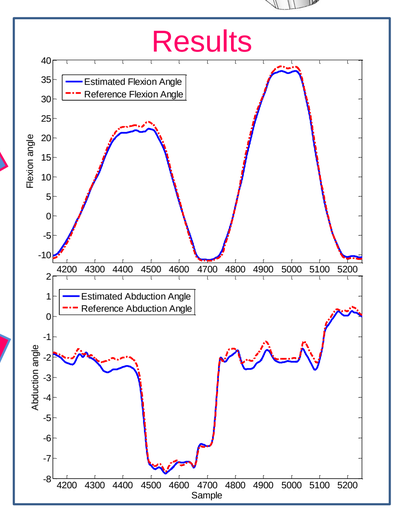
Processing and Estimation of angles

Infra red camera, Vicon (Reference system)

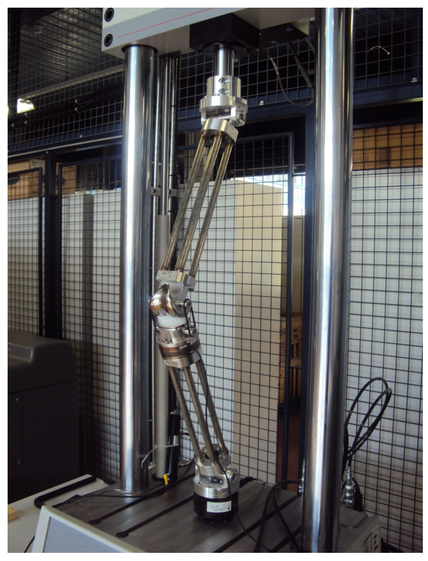
Camera records processing



Manual Knee Simulator



Robotic Knee Simulator



We designed and fabricated a more realistic simulator of the knee to perform the movements based on real data and also apply the actual force pattern in the knee.
This system will be used to validate the instrumented prosthesis measurement systems.

Conclusion and future works

Sensor system, including magnetic measurement system and strain gauges, was designed, configured and validated toward reference systems to provide needed information for functionality evaluation of the prosthetic knee.

The proposed instrumentation and electronics can be inserted into the polyethylene part without any change in the overall prosthesis design, representing a promising new system for monitoring medical implants with the help of new electronic systems.

It allows *in-vivo* monitoring and can provide information on the biomechanics of the knee - including force and kinematic - also to early detect problems due to knee imbalance and wearing. Furthermore, it can be used for improving patient's treatment during follow up.

In next step, the complete system including wireless telemetry will be assembled and tested on a knee simulator robot. This way, we can totally validate the kinematics and kinetics measurements, simultaneously. Besides, by mounting a cadaveric part on the simulator robot, we can study the relation between the external sensors and internal sensors. Also the force sensors must be optimized for *in-vivo* monitoring of the total force and the lateral-medial imbalance in a single device.