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Teleoperation of an Anthropomorphic Robotic Hand using a custom made data glove

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Abstract

Remote control of mechatronic systems is widely used not only in research, but also in the industry. Tele-operating a machine can enhance the safety of the operator and even the dexterity of the system, as well. However, remote control of robot manipulators and especially, in an intuitive way, for anthropomorphic robotic hands is not an easy task. Using also wireless control can sometimes be complex and harsh. In this work, we introduce the teleoperation of a total 16 degrees of freedom (d.o.f.) robotic hand. The system is based on a custom-made data glove that is equipped with 11 flex sensors in order to capture the motion of the thumb and the rest of the fingers of the operator's hand. In addition the robotic hand can be operated wirelessly by utilizing a wireless end-point communication. Furthermore, experiments were conducted to test the capability and applicability of the system. Ultimately, the data glove can track the movement of the operator and subsequently move the fingers of the robotic hand TALOS. The system can execute subtle gestures and also grab objects with different geometry.

Teleoperation of an Anthropomorphic Robotic Hand using a custom made data glove

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Introduction

Remote control of complex mechatronic systems, in an intuitive way, is not an easy task especially when we refer to robot manipulators and anthropomorphic robotic hands. In this poster we present a mechatronic system for the teleoperetion of a total 16 degrees of freedom (d.o.f) robotic hand. The system is based on a custom-made data glove that is equipped with 11 flex sensors in order to capture the human motion of the fingers and the thumb. Moreover, by using a wireless end-point communication the robotic hand can be operated wirelessly. Finally, experimental results are given in order to evaluate the practicability and effectiveness of the application system.

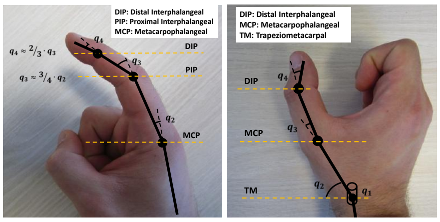
Objectives

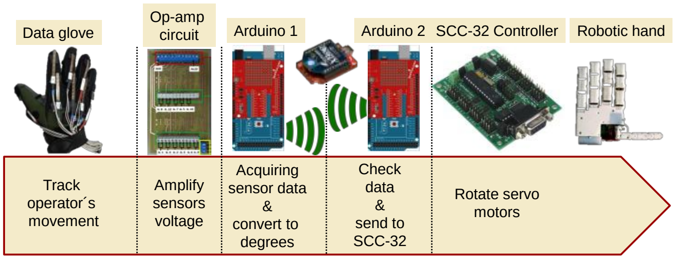
- To teleoperate the thumb and the fingers of the robotic hand TALOS [1] through a motion capture data glove.
- Use Wireless teleoperation.
- Almost real-time operation.
- Use 11 flex sensors in order to capture the motion of the thumb and the fingers.

The 16 DOF robot hand "Talos" | The developed data glove | Flex sensors

Methods – System's architecture

- The data glove can track the motion of 11 joints of the human hand and estimate the motion of another 5 joints by using human hand finger constraints described in [2]. The motion of the joints can be captured by using flex sensors
- Due to the enhanced dexterity of the thumb we use 4 flex sensor to track its motions.





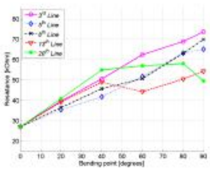
- Each flex-sensor is connected to an non-inverting amplifier in order to increase the voltage for A/D converter-measurements and subsequently have more distinct computation values.
- The system consists of two 8-bit microcontrollers (Arduino Mega 2560) with a corresponding wireless communication module (XBee shield).
- The RC servo motors of the robot hand are controlled by the SCC-32 servo controller.

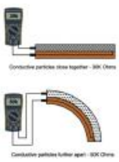
Calibration for the flex-sensors

Each sensor is calibrated by conducting experiments to determine the best possible position that the sensor will yield to linear and accurate data.

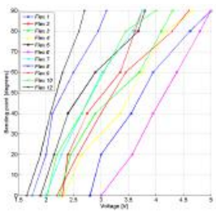
- The sensors were first laid on 3D-printed surfaces with an angle of 20, 40, 60, 80, 90 degs respectively. The radius of curvature for each 3D-printed surface is equal to the human finger radius of curvature (about 15mm).
- A linear relation relates the measured voltage with the flexion of each flex sensor.

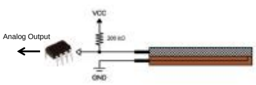
Calibration parts





The resistance changes when the sensors are bent





A voltage divider is used for calibrating the sensors

Experiments & Results

Teleoperation of the robotic hand

Below are shown the gestures and grabbing of objects with different geometry that were done by tele-operating the robotic hand by the data glove. It can be seen that the robot hand follows the motion of the globe exactly.

Acknowledgments

The contribution of the Laboratory of Electric and Electronic Construction at TEI of Crete is gratefully acknowledged for their construction of the PCB.

For further information, please contract Dr. J. Fasoulas (jfasoulas@staff.teicrete.gr)

Key References

1. "Design, Development and Control of the Robot Hand TALOS", submitted to AmiEs 2016 as a regular paper by John Fasoulas, Micheal Sfakiotakis, Ioannis Konstantoudakis and Nikolaos Kritsotakis.
2. S. Cobos, M. Fere, M. A. S. Uran & J. Ortego, "Constraints for Realistic Hand Manipulation" Proc. Presence, pp. 369-370, 2007.

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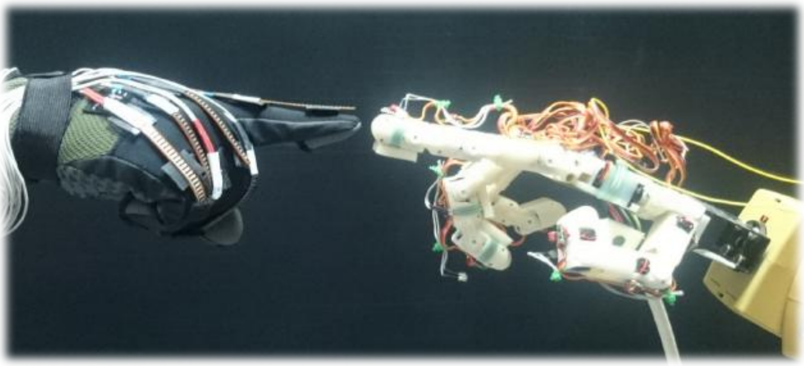
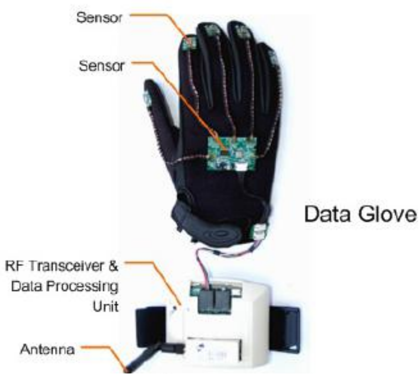


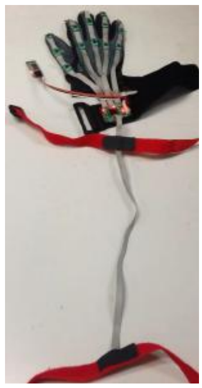
Related Work

CyberGlove II [1]

Talon robot data glove [2]



The YoBu data glove [3]



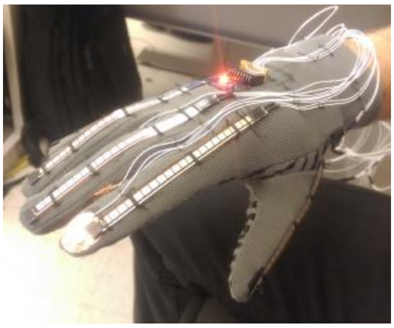
[1] http://www.cyberglovesystems.com/cyberglove-ii/

[2] Tran X. Nghia et al., (2009), “Wireless Data Glove for Gesture-Based Robotic Control”, Human-Computer Interaction, Berlin

[3] Fang B. et al., (2015), “A Robotic hand-arm teleoperation system using human arm/hand with a novel data glove”, IEEE Conference on Robotics and Biomimetics, China

Applications

Translation of sign language to sound or letters



Training through a virtual reality environment

Teleoperation of robotic systems

Figure 1 Credit: Monica Lin et al. “Sign Language Glove”

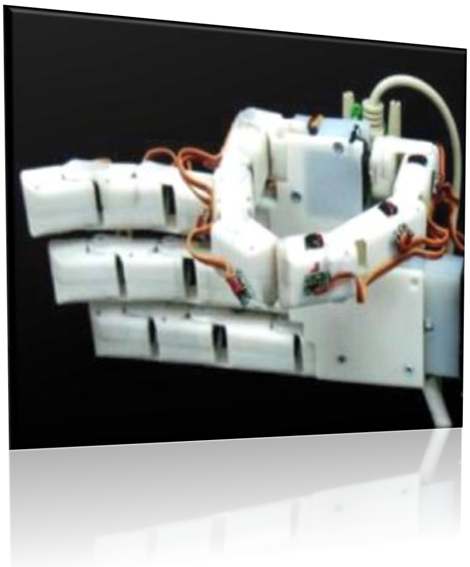
Figure 2 Credit: NASA

Figure 3 Credit: Tran X. Nghia et al., (2009), “Wireless Data Glove for Gesture-Based Robotic Control”

Objectives

- Teleoperate the thumb and the fingers of the robotic hand Talos through a motion capture glove.
- Wireless operation.
- Almost real-time operation.
- Use 11 flex sensors in order to capture the motion of the human fingers and the thumb.

Objectives



Robot hand TALOS' HAND

- ✓ Joints: 16 Degrees of Freedom (16 d.o.f)
- ✓ Construction material: thermoplastic type ABS (Acrylonitrile butadiene styrene)
- ✓ Weight: 620gr

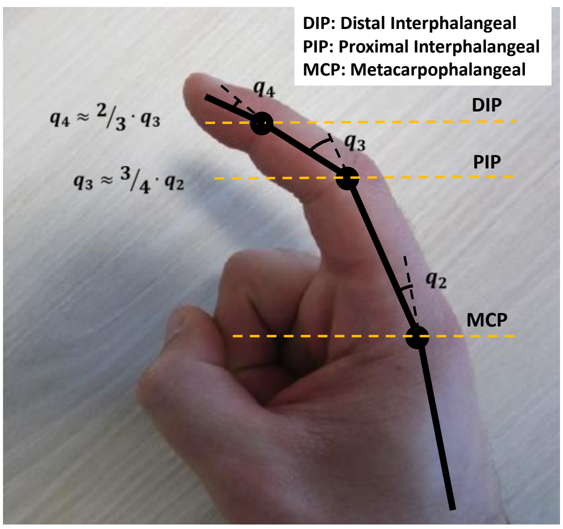
Capabilities

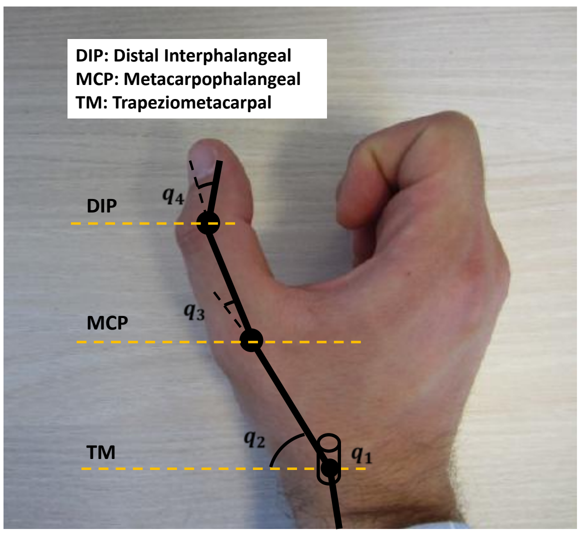



Hand gestures and object grasping

Fasoulas J. et al. (2016), "Design, Development and Control of the Robot Hand TALOS", AmiEs

Human finger constraints





Cobos et al., (2007), "Constraints for Realistic Hand Manipulation", PRESENCE, pp. 369 - 370

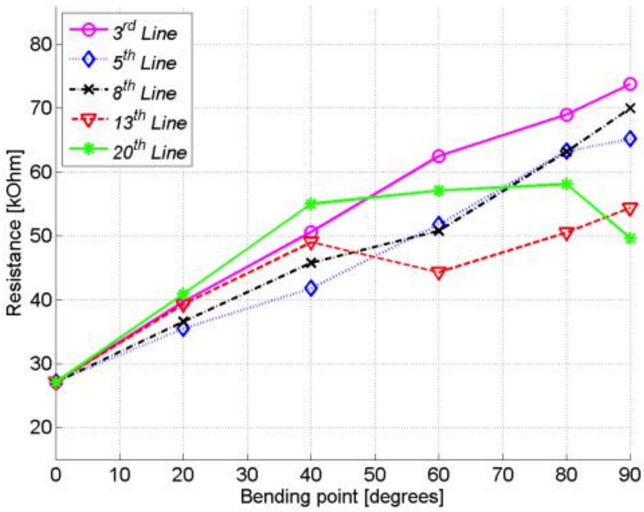
Custom made data glove

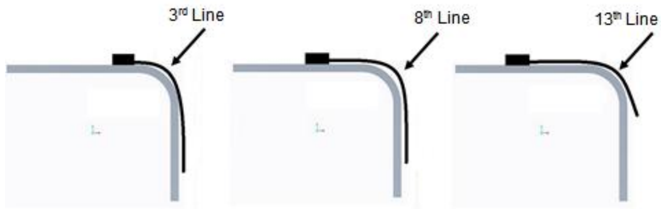
Data glove TALOS' GLOVE

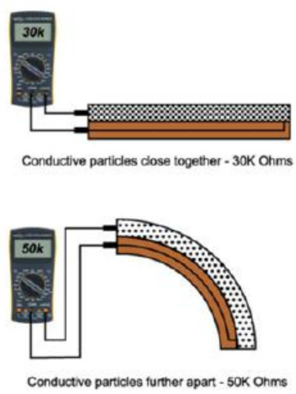
- ✓ Installed 11 flex sensors
- ✓ Wireless communication up to 30 meters
- ✓ Motion capture of 11 joints of the human fingers and estimate the movement of 5 more joints.

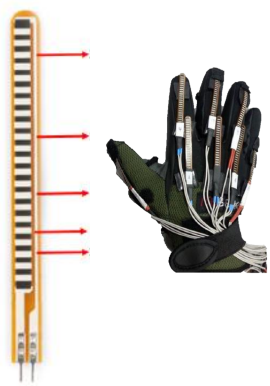
Figure credit: Spectra Symbol

Calibrating flex sensors

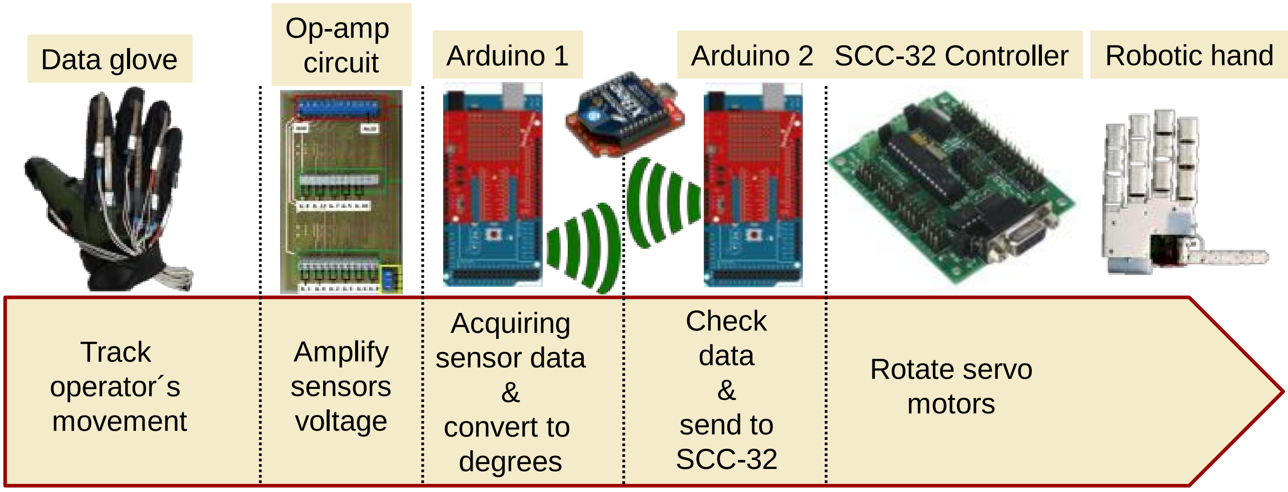




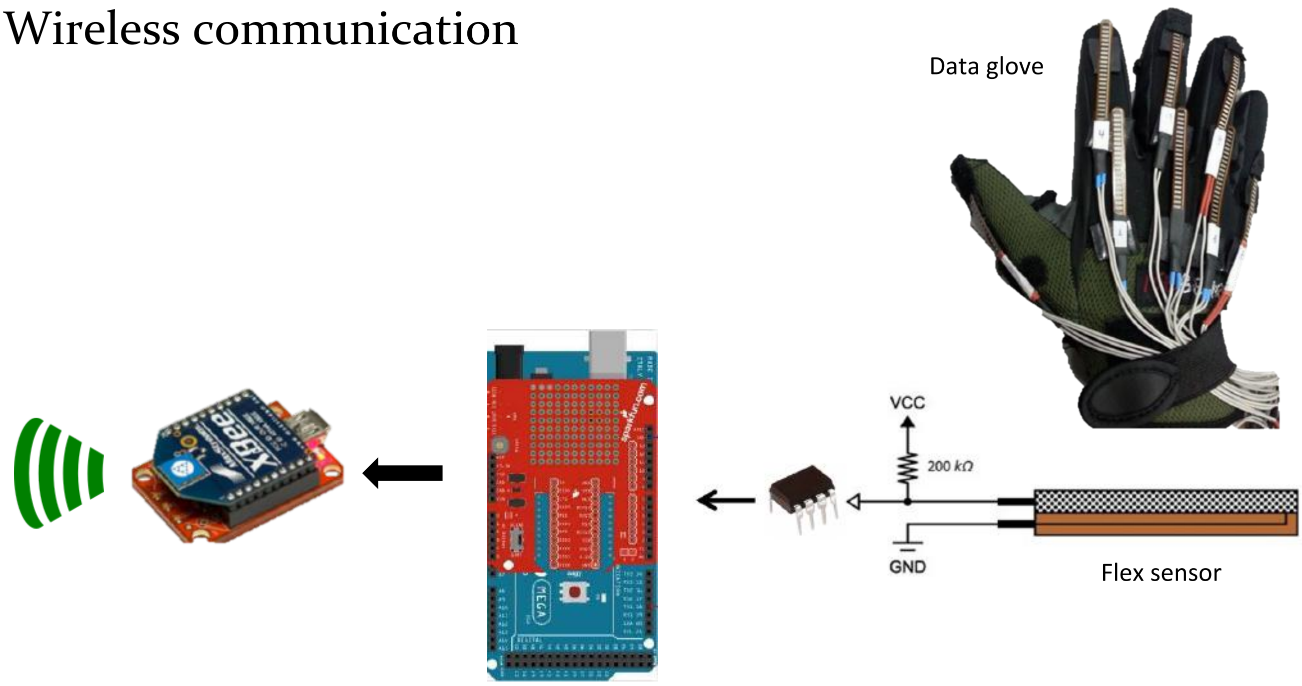




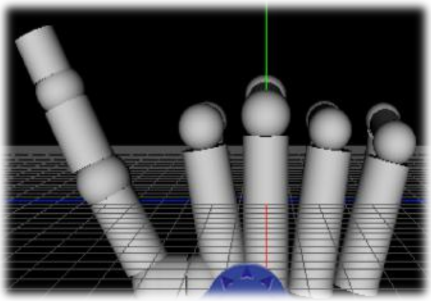
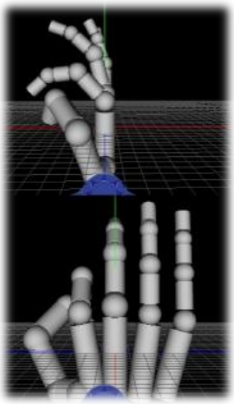
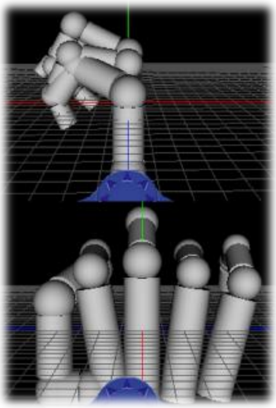
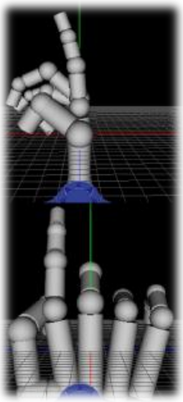
System Architecture



Wireless communication



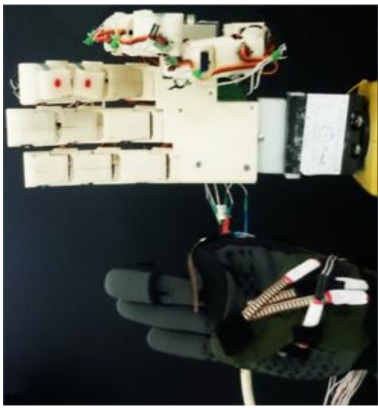
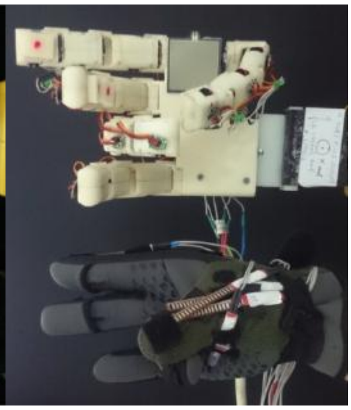
Testing the data glove in Simulation

Experiments & Results with the robotic hand TALOS

- Several hand gestures and thumb opposition

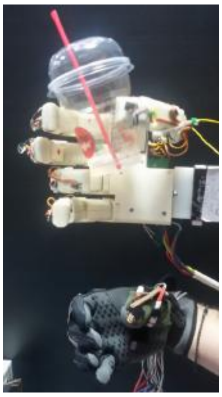


Experiments & Results with the robotic hand TALOS

- Grasping several objects

Precision Grasp: grasping a credit card



Power Grasps: Grasping a paper box and a plastic glass

Grasping a tool

Conclusion

- ✓ Sufficient accuracy and repeatability
- ✓ Decrease the number of sensors in use
- ✓ Wireless communication
- ✓ Simulation of the system to virtual reality environment

Future Goals

- ✓ Installation of force sensitive resistance (FRS) sensors to the end of the robotic hand fingers for feedback to the glove (haptic technology)
- ✓ Installation of gyroscopes and accelerometers to the data glove
- ✓ Recognition of the geometrical shape from grasp of objects

The End