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Visual Teleoperation of an Anthropomorphic Robotic Hand

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Abstract

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 case, teleoperation is often performed through expensive motion tracking systems along with uncomfortable data gloves in order to capture the configuration of the palm and the motion of the fingers. For this reason we propose a teleoperation system that is solely based on optical data for controlling the motion of a robot hand with 22 degrees of freedom (d.o.f.). The proposed system does not require the user to wear any motion capture glove or other exoskeleton devices. The main task for the system is to imitate user's hand configurations for grasping objects or doing human gestures. The system consists of the following subsystems: a) the 16 d.o.f. robotic hand "TALOS" that is developed by the Control Systems & Robotics Lab at the Technological Educational Institute of Crete b) the RV-2A six d.o.f. robot manipulator by Mitsubishi and c) the "3D Hand Tracking" software that is based on the RGB-D Kinect sensor and developed by the Computational Vision & Robotics Laboratory of the Institute of Computer Science /FORTH. The robot hand is used as a gripper at the end effector of the RV-2A robot manipulator. Finally we present experimental results that demonstrate the effectiveness of the proposed telemanipulation system.

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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 case, tele-operation is often performed through expensive motion tracking systems along with uncomfortable data gloves, in order to capture the configuration of the palm and the motion of the fingers.

In this poster we present a teleoperation system of a 22 degrees of freedom (d.o.f.) robotic hand. The task is to imitate the user's palm configuration and the movements of the fingers while performing gestures or grasping objects. Experimental results are given in order to evaluate the practicability and effectiveness of the application system.

Objectives

The aim of this work, is to teleoperate a robotic hand through visual data. The system consists of the following subsystems:

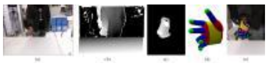
a) the 16 d.o.f robotic hand "Talos" [1], developed by the Control Systems & Robotics Lab at the Technological Educational Institute of Crete .

b) the six d.o.f robot manipulator RV-2A by Mitsubishi

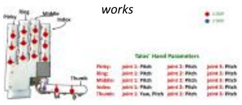
c) the "3D Hand Tracking" algorithm based on a RGB-D sensor (Kinect) which has been developed in the Computational Vision & Robotics Laboratory of the Institute of Computer Science /FORTH [2],[3]

The final goal for the system is to imitate user's hand configurations for grasping objects or preforming human gestures, in near real time.

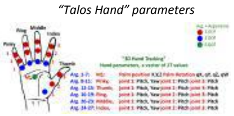
System's architecture



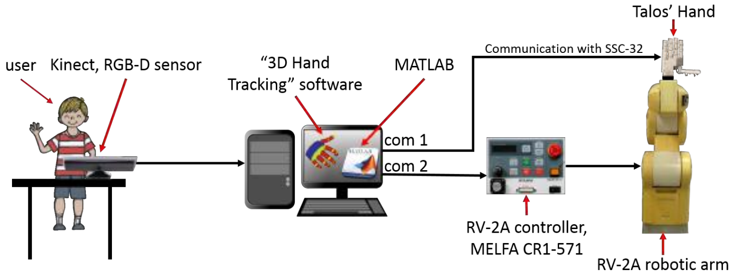
How the "3D Hand Tracking" software works



"Talos Hand" parameters

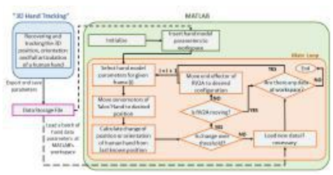


"3D Hand Tracking" parameters



System's architecture

Flow chart of the algorithm in MATLAB that synchronizes the three different subsystems

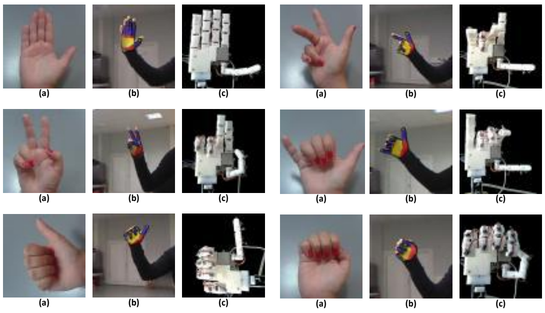


flow chart, algorithm of teleoperation

Experimental Results

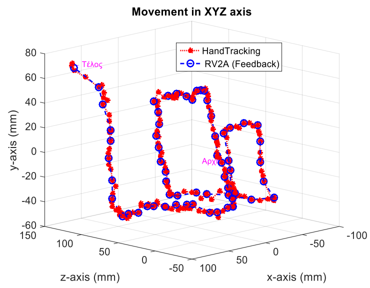
Teleoperation of the robotic fingers

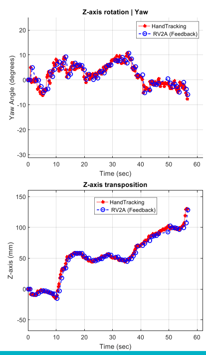
The user's hand (a), the predicted pose of the "3D Hand Tracking" system (b) and the final configuration of the robotic hand (c) are demonstrated respectively in the following figures for a number of common gestures.



Teleoperation of the robotic palm (end effector of RV-2A)

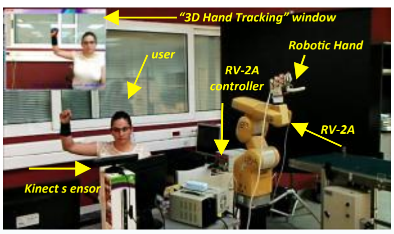
On the following diagrams we can see the path of the human hand, as recognized from the "3D Hand Tracking" software and the trajectory of the RV-2A end effector.

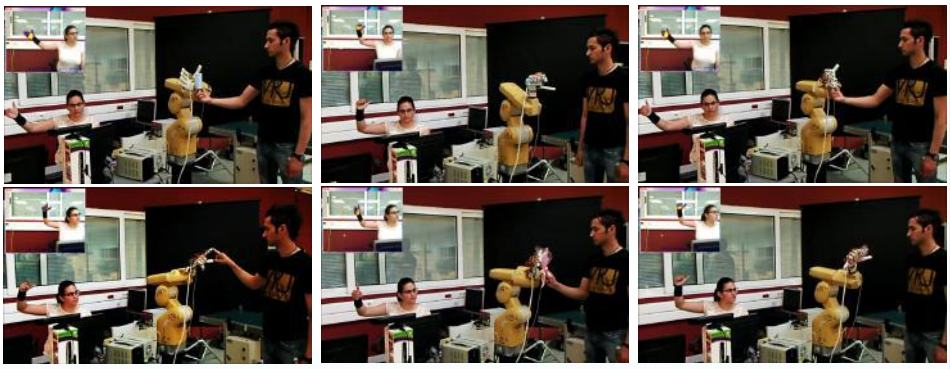




Teleoperation for grasping objects

The following images highlight the experiments of the teleoperation of the robotic system. The goal of the experiments is to grasp a box and a tulle with different configurations.





Acknowledgments

The contribution of Ammar Qammaz and Iason Oikonomidis, members of CVRL/FORTH, Dimitris Petropoulos student of Mechanical Engineering department at TEI of Crete and Spiridonas Kalantzis student in Msc: "Advanced Manufacturing Systems, Automation and Robotics" at TEI of Crete is gratefully acknowledged.

Key references

1. John Fasoulas, Michael Sfakiotakis, Ioannis Konstantoudakis and Nikolaos Kritsotakis, "Design, Development and Control of the Anthropomorphic Robotic Hand TALOS", *International Symposium on Ambient Intelligent and Embedded Systems 22-24 September 2016, Heraklion, Crete, Greece.*
2. "3D Hand Tracking, Official Page", [online] http://cvrlcode.ics.forth.gr/handtracking/?page_id=7
3. Oikonomidis, I., Kyriazis, N., & Argyros, A. A.. "Efficient model-based 3D tracking of hand articulations using Kinect". In BMVC (Vol. 1, No. 2, p. 3) (2011, August).

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Technological Educational Institute of Crete

Introduction - Overview

The aim of this work, is to teleoperate a robotic hand through visual data. The system consists of the following subsystems:

a) The 16 DoFs robotic hand "Talos", developed at the Control Systems & Robotics Lab at the Technological Educational Institute of Crete.

b) The six DoFs robot manipulator RV-2A by Mitsubishi.

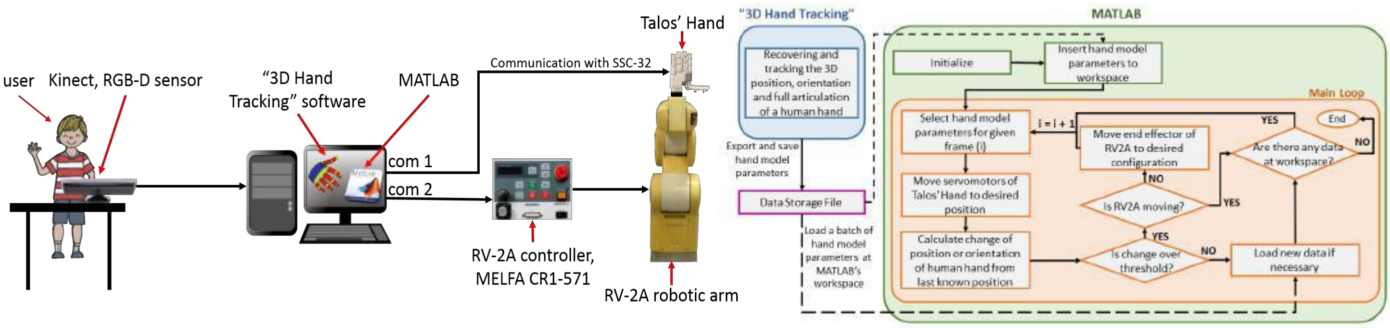
c) The "3D Hand Tracking" application based on a RGB-D sensor (e.g. Kinect), developed at the Computational Vision & Robotics Laboratory of the Institute of Computer Science /FORTH.

The final goal for the system is to imitate user's hand configurations for grasping objects or preforming human gestures, in near real time.

Methodology

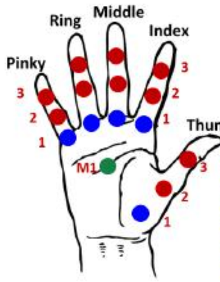
A 22 DoF visual teleoperated system.

- The user's palm trajectory replicated from the RV-2A end effector (6 DoFs)
- The configuration of the user's fingers replicated from the "Talos" hand (16 DoFs)



"3D Hand Tracking" & Talos' Hand

The parameters extracted from the application "3D Hand Tracking".

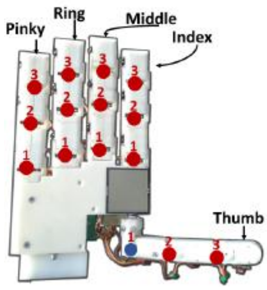


Arg. = Arguments
- 1 DOF
- 2 DOF
- 6 DOF

"3D Hand Tracking"
Hand parameters, a vector of 27 values

Arg. 1-7:	M1:	Palm position X,Y,Z Palm Rotation qX, qY, qZ, qW		
Arg. 8-11:	Pinky,	joint 1: Pitch, Yaw	joint 2: Pitch	joint 3: Pitch
Arg. 12-15:	Thumb,	joint 1: Pitch, Yaw	joint 2: Pitch	joint 3: Pitch
Arg. 16-19:	Ring,	joint 1: Pitch, Yaw	joint 2: Pitch	joint 3: Pitch
Arg. 20-23:	Middle,	joint 1: Pitch, Yaw	joint 2: Pitch	joint 3: Pitch
Arg. 24-27:	Index,	joint 1: Pitch, Yaw	joint 2: Pitch	joint 3: Pitch

The parameters that the controller of "Talos" hand accepts as input.

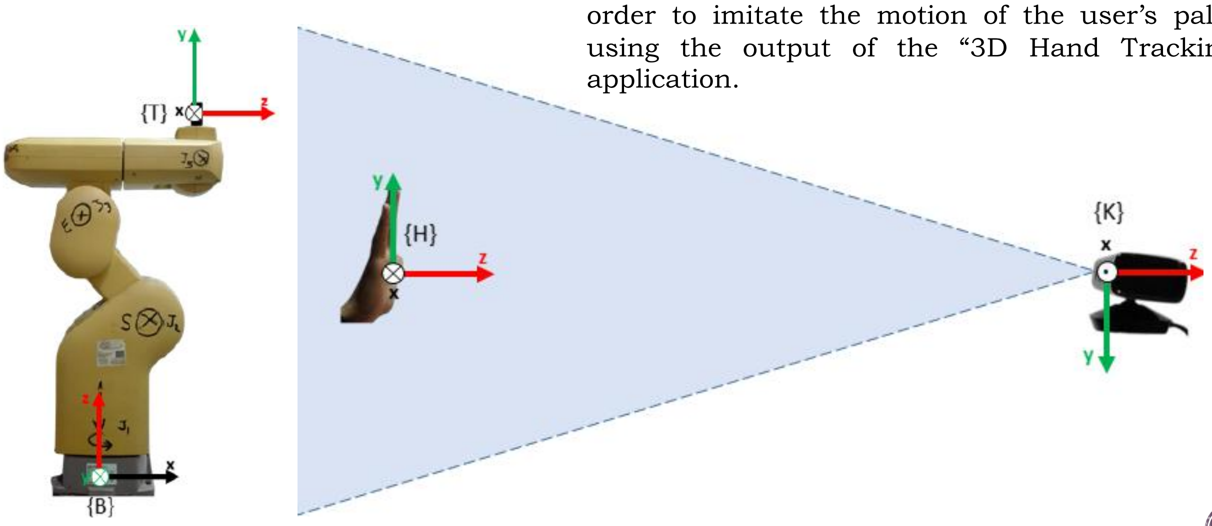


Talos' Hand Parameters

Pinky:	joint 1: Pitch	joint 2: Pitch	joint 3: Pitch
Ring:	joint 1: Pitch	joint 2: Pitch	joint 3: Pitch
Middle:	joint 1: Pitch	joint 2: Pitch	joint 3: Pitch
Index:	joint 1: Pitch	joint 2: Pitch	joint 3: Pitch
Thumb:	joint 1: Yaw, Pitch	joint 2: Pitch	joint 3: Pitch

“3D Hand Tracking” & RV-2A

The RV-2A end effector has to be controlled in order to imitate the motion of the user’s palm, using the output of the “3D Hand Tracking” application.



Teleoperation of the robotic fingers

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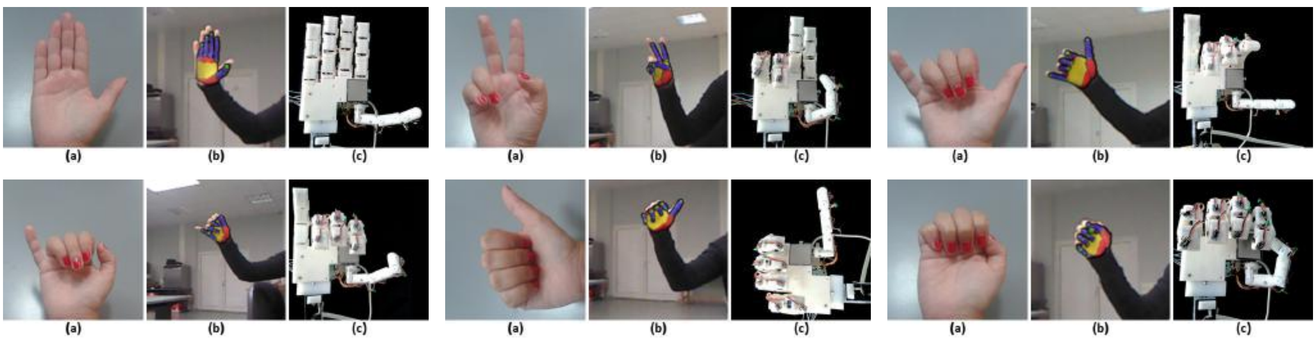
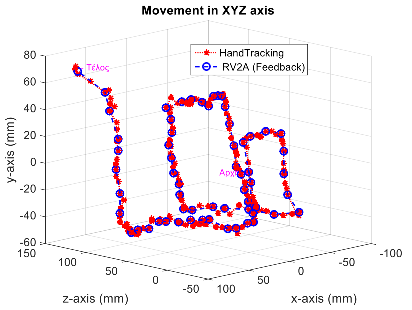
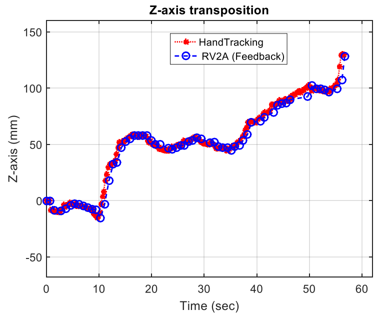


Teleoperation of the robotic palm (end effector of RV-2A)

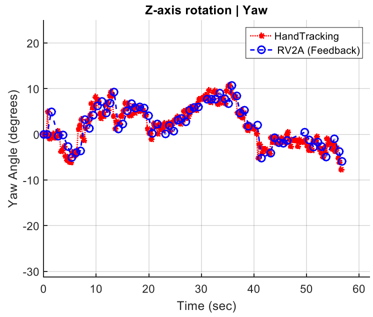
The following diagrams show the path of the human hand, as recognized from the "3D Hand Tracking" software (red) and the trajectory of the RV-2A end effector (blue).



Movement in 3D

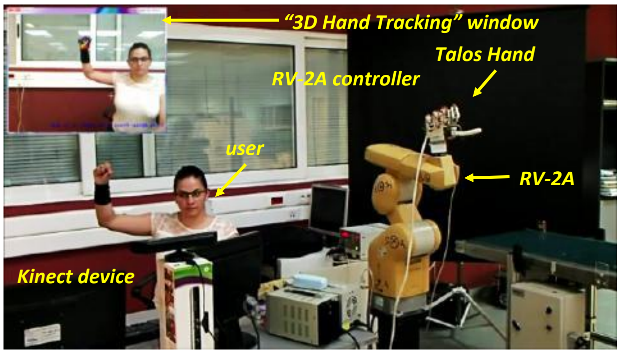


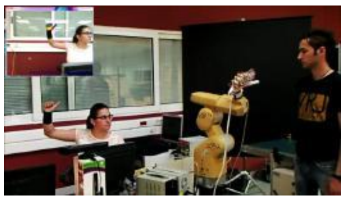
Translation in Z axis versus time



Rotation in Z axis versus time

Experimental results





Thank you

- The thesis “Visual teleoperation of an anthropomorphic hand” was submitted in partial fulfillment of the requirements for the Degree of MSc: “Advanced Manufacturing Systems, Automation and Robotics”.

- The contribution of Ammar Qammaz and Iason Oikonomidis, members of CVRL/FORTH, Dimitris Petropoulos student of Mechanical Engineering department at TEI of Crete and Spiridonas Kalantzis student in Msc: “Advanced Manufacturing Systems, Automation and Robotics” at TEI of Crete is gratefully acknowledged.