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INTEGRATION OF VISION SYSTEM AND ROBOTIC ARM UNDER ROS

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Abstract: *The paper presents the conception of integrating a three-dimensional image sensor device with the robotic arm manipulator via Robot Operating System. Using a 3D camera, the position of user's arm is retrieved. Selected angles are replicated into desired robotic joints. The authors focused their attention on ability of implementing this using online available libraries.*

Keywords: Robot teleoperation, Kinova, Robotic arm, Kinect, Human tracking.

1. Introduction

Although artificial intelligence starts being used for decision-making in many areas in our lives, human intelligence is still necessary to make decision and manipulate the robot in unstructured changing environments.

Usually teleoperation require complicated knowledge of various modes of control. Task can be performed using joysticks and dials. According to (Du et al., 2016), recently lot of research have been conducted in the area of the robot teleoperation using human hand gesture. New developed methods were able to tracks motion of user's hand-arm using inertial sensors placed in gloves and exoskeleton systems. Processed user motion after translation becomes robot's motion.

However, this equipment may cause difficulty in natural human-limb motion. Scientists found the solution for that in contactless technology based on vision and markers tracking. Markerless, contactless approach came in with the next step of development.

According to (Marić et al., 2016), a complete replication of human arm movement with robotic arms is impossible because of the complexity of shoulder and finger joints. Even the most advanced robotic arms cannot match human ability, and as a consequence impossibility of direct mapping of human arm joint positions to a robotic arm. The alternative could be a dynamic transform of the measured angles to acceptable ranges as explained in section 3.2 (Implementation of control).

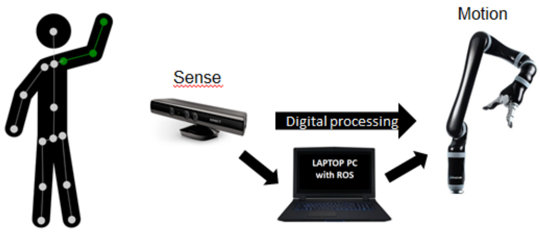

Fig. 1: Conceptual drawing.

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In this paper, the aim of the authors is to present an integration of Image sensor with the robotic arm in ROS environment using existing libraries. The result of this project is a simple robot teleoperation based on joint angle copying. Robotic arm will respond to a human hand motion, replicating simplified selected human joints described in Fig. 1. The rest of this paper is organized as follows: the next section is dedicated for hardware implementation of the system. Section 3 contains a short introduction to ROS and software implementation.

2. Hardware Integration

For this project both devices, Kinect and Kinova arm, communicate by USB interface. Producer provides required drivers for both devices. Personal computer is responsible for handling those devices.

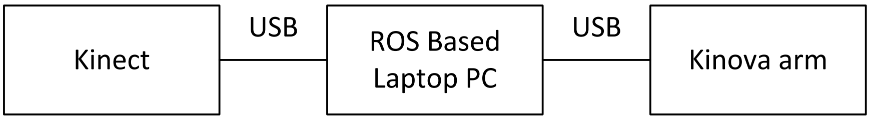

Fig. 2: Block diagram.

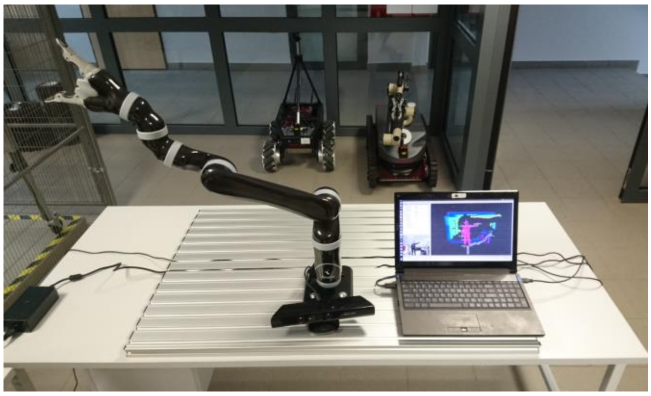

Fig. 3: Workbench.

2.1. Kinova arm

The Kinova arm is a light-weight robot composed of six inter-linked segments, the last of which is a two-fingered hand. The arm has a weight of 5 kg and can reach approximately 70 cm in all directions. It can be mounted on any mobile platform or to a fixed station. The arm can be controlled by user through the controller or though the computer. The objects can be grasped or released with the hand of this device. The arm lifts objects up to 750 g in the long-range and 1250 g in the mid-range. (Kinova, User Manual)

Below, parameters for kinematics of the Kinova arm are presented.

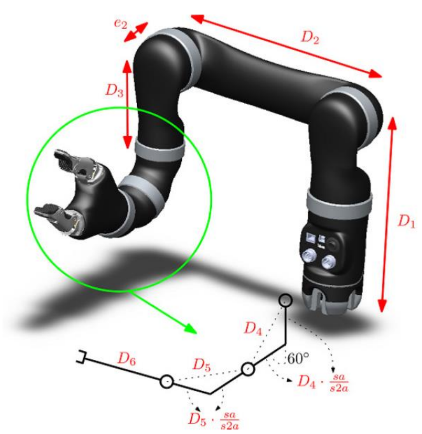

Fig. 4: DH Parameters of the Kinova arm.

Tab. 1: Classic DH Parameters of the Kinova arm.

DH Parameters				
i	alpha(i-1)	a(i-1)	di	teta1
1	pi/2	0	D1	q1
2	pi	D2	0	q2
3	pi/2	0	-e2	q3
4	2*aa	0	-d4b	q4
5	2*aa	0	-d5b	q5
6	pi	0	-d6b	q6

Current position of the arm is obtained by absolute encoders implemented in each servo which also has torque, current, acceleration and temperature sensors for better monitoring.

The Kinova arm comes with libraries called Kinova API (www.github.com/Kinovarobotics/kinova-ros) which allows the arm to be controlled via user's own application in two different control modes. The first one is joint mode. It provides direct access to each joint of the robot arm. Desired angular position or angular speed can be set in each joint. The another one, Cartesian mode, gives ability to control position and orientation of the robot's hand.

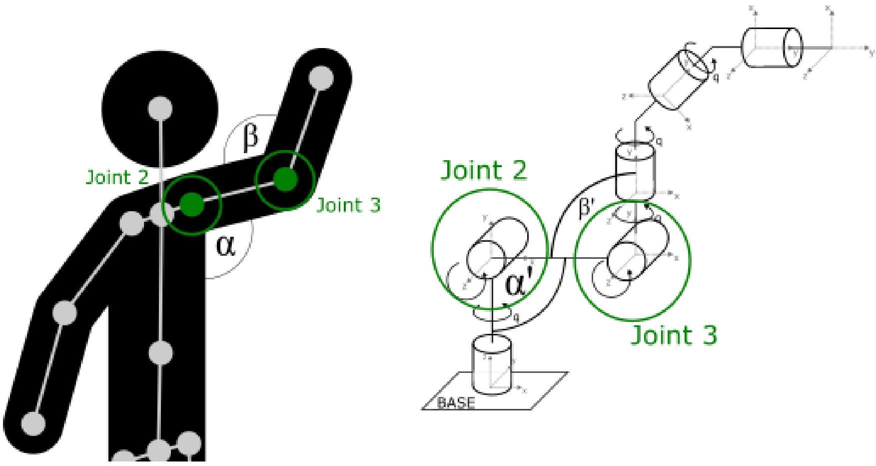

Fig. 5: Simplified conception of joints control.

2.2. Kinect

In this project, Kinect is used for sensing the environment. This is a complex input device which contains several sensors like RGB camera, depth sensor and microphone array (Keen et al., 2011). RGB camera can provide image in VGA resolution (640 x 480 pixels) with 30 Hz frame rate. Depth sensor uses IR camera and IR structured-light laser projector to get the infrared image which is transformed into point cloud by the built-in algorithm. We can derive the exact position in space of everything in the room it occupies.

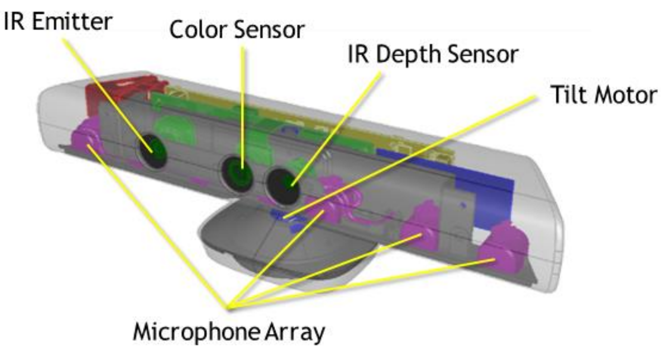

Fig. 6: Parts of the Kinect sensor. Source: MSDN Microsoft.

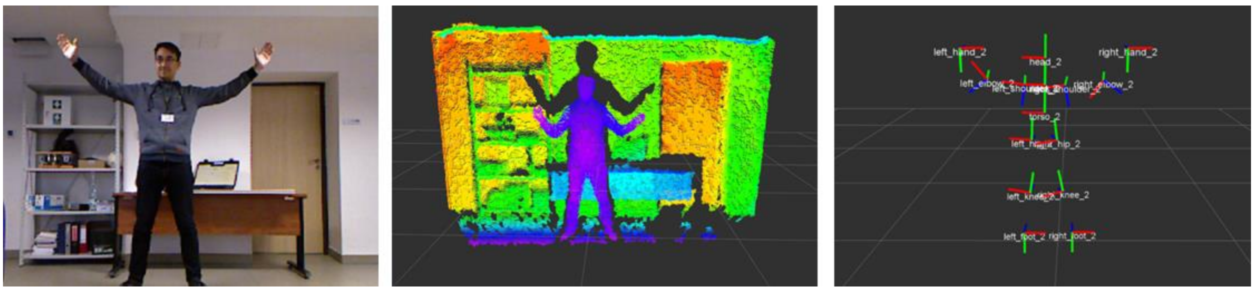

Fig. 7: Kinect data input (from left): a) RGB Image; b) Pointcloud image; c) Joints positions.

3. ROS

ROS is a Linux-based, open source, meta-operating system which allows user to low-level device control, passing messages between processes, and package management. The distributed nature of ROS gives rise to specific concepts that allow many independent computational processes to interact with each other, and together create the overall behavior of a robotic system. The communication structure of ROS is designed around the concept of nodes, messages, topics, services, and parameters. In ROS system, the main organizational component is the package. It consists of executable programs called nodes, libraries, data-sets, and configurational files. Inside the system, nodes process data and communicate witch each other. The communicated data are called messages. The nodes exchange data over the topics, which is a simple string. More information is available in (Quigley et al., 2015)

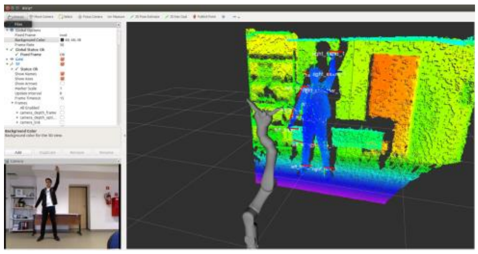

Fig. 8: RVIZ application.

3.1. OpenNI Kinect Package

For human detection and tracking OpenNI Kinect package (www.wiki.ros.org/openni_kinect) has been used. The package allows to interact with digital devices. This is ready solution, with minimal time spent on configuration, user can focus on further integration with other devices, such as manipulators. After detection of a human, for human tracking, quick initialization is needed. Initialization procedure looks like 'surrender sign' shown in Fig. 7. After successful initialization, tracking script provides axes coordinate (transforms) of each part of users body (Fig. 7c).

3.2. Implementation of control

The program computes the angles between the right shoulder, right elbow, and right hand transforms then the manipulator's joint 2 and 3 will be controlled to move so that the calculated angles are reached (Fig. 5). Because of limitations on the robotic joints and for safety reasons, the arm's joints are required to move only in specified ranges which are prescribed in the program.

4. Conclusions

This paper presents a method of creating a link between an image sensor and a robotic arm using robot operating system and public available libraries. A simple robot teleoperation system has been designed. User can control the robotic joints using his right hand. Future works will be conducted to implement under ROS complete Cartesian control to check the possibilities of markerless contactless methods of robot teleoperation.

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