Module name: Dynamic online trajectories generation for industrial robot with 3D camera

- **Main functionalities**:

A solution for providing depth based real-time information of workspace for generating dynamic trajectories for robot. This module will provide a flexible and adaptive way to generate robot trajectories for safe human-robot collaboration based on information from 3D-camera(s).

Technical specifications:

The overall description of hardware and connections of this module is shown in figure 3. Workspace is monitored by Orbbec 3D Astra Pro 3D Camera at frame rate of 30 frames per second. Robot is Kuka KR6 R900 SIXX with KR C V8.3 software, EthernetKRL option is mandatory for this module to work. ROS nodes utilize TCPROS transport layer to publish and subscribe messages. Nodes that generate messages publish to relevant topic. In this case, camera publishes 3D depth model of workspace and kuka_experimental node subscribes to it.

Kuka_experimental package is used to provide low-level communication between robot controller and depth-based safe collaboration system. Kinetic_astra_package is used to receive data from Orbbec Astra 3D-camera and transmit this data to depth-based safe collaboration system. Depth-based safe collaboration system monitors environment and re-creates trajectories dynamically if safety violations or changes in working environment are detected.

3D-camera is connected by USB3 to PC and robot is connected to same PC with Ethernet cable. PC is running ROS Kinetic Kame over Ubuntu 16.04 and performs calculations of trajectories. To compile this module OpenCV, PCL and standard C++ libraries are needed. It is possible to use Kinect V2 instead of Orbbec Astra by changing Kinetic_astra_package with IAI_Kinect2.

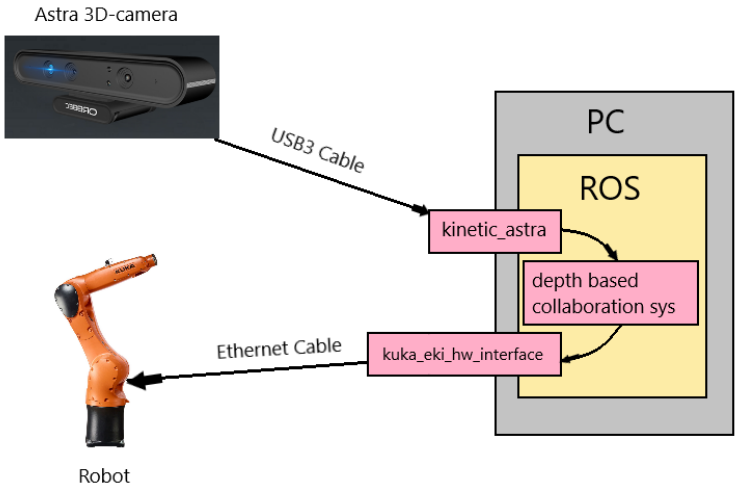

Fig 3. Module connections and components

- **Preliminary software configurations:**
  Before this module can be used 1) Robot and sensor must be calibrated, 2) Wired connections between PC, robot and camera must be established, 3) Ubuntu and ROS with appropriate packages must be installed on PC.

- **Inputs and outputs**
  Data is transferred via ROS interface as publish / subscribe semantics. Input here is depth and camera information from ROS module kinetic_astra. This camera topic is subscribed by depth based collaboration system to receive depth image and and camera information. Also joint_state message is needed for positioning robot in depth image. Outputs of this module are trajectories for robot. For outputting these kuka_eki_hw_interface is utilized. Relation of inputs and outputs of ROS nodes can be seen on Fig 4.

Fig 4. ROS nodes

- **Interface specification:**

The end-user does not interface with this module. Module communicates with robot controller by creating trajectories for robot based on depth information from 3D-camera.

- **Formats and standards used**:

ISO 10218, ISO TS 15066, ISO 10303-STEP, ROS

Availability:

This module is currently under development. First version is available at the beginning of year 2020.

- **Application scenarios:**

This module has applications with integrators and companies who are building applications where robot trajectories are generated dynamically using information from 3D cameras.

- **Offered for internal / external use**

This module as a concept will be available for internal and external use.