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A Pick and Place Task with an KUKA Industrial Robot, Aided by an Arduino Board

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***Abstract*— Work with industrial robots is a very challenge task. Those kinds of robots, usually, have an architecture very difficult to interact with and their programming language is not quite friendly. In the Robotics Laboratory of the Taubaté's University, we have an industrial robot KUKA KR 6 R900 Sixx. In order to develop some research with focus in the robotics field and the applications of robotics in the industry we propose the development of these work, which has the idea to interact an industrial robot with a low-cost board (Arduino) to perform a pick and place task. To do so, we assembled an experimental setup, where a two-finger shape claw mounted on the end effector of the robot and controlled by an Arduino board, was used to pick an object and place it in a known position. The robot and the Arduino board are linked by the Kuka control unit, using digital ports in the PWM mode. After few tests and analyzing the results, we consider the performance of the system quite good.*
Keywords*— KUKA, industrial manipulator, Arduino, robotics, pick and place,

I. INTRODUCTION

The pick and place task are very common, considering industrial robots. In Saut, J. et all (2010), the authors propose a planning framework to deal with the problem of computing the motion of a robot with dual arm/hand, during an object pick-and-place task. They considered the situation where the start and goal configurations of the object constrain the robot to grasp the object with one hand, to give it to the other hand, before placing it in its final configuration.

In H. Işıl Bozma, M.E. Kalalıoğlu, (2012), the authors consider the problem of multirobot coordination in pick-and-place tasks on a conveyor band. The robot team was composed of identical robots with mutually exclusive, but neighboring workspaces. The products were fed in at one end of the band, move through each workspace sequentially until being picked up and were collected at the other end—if not picked up interim.

In Rengerve, A. et all (2011), the authors present a bio-inspired neural network used in a robot to learn arm gestures demonstrated through passive manipulation. The neural network allowed the robot to plan arm movements according to activated goals. The model was applied to learning a pick-and-place task. The robot learned how-to pick-up objects at a specific location and dropped them in two different boxes depending on their color. As the system is continuously learning, the behavior of the robot can always be adapted by the human interacting with it.

The idea of moving a robot in an environment, with sensors, can allow the manipulator to develop tasks in closed loop, avoiding obstacles and changing its path at any time. Connecting a camera to a Kuka robot, for example, enables the robot to observe the environment and react responsively. The low-level information captured by the camera, namely the pixels, can be transformed into a certain meaningful signal that constantly informs the robot's motion. In Sanfilippo, F. et all (2015) the authors discuss a Java open-source cross-platform communication interface, JOpenShowVar, to Kuka industrial robots. The novel interface developed, allows to read and write, using the controlled manipulator, variables and data structures. JOpenShowVar, which is compatible with all the Kuka industrial robots that use KUKA Robot Controller version 4 (KR C4) and KUKA Robot Controller version 2 (KR C2), runs as a client on a remote computer connected with the Kuka controller via TCP/IP. Even though only soft real-time applications can be implemented, JOpenShowVar opens up to a variety of possible applications, making the use of various input devices and sensors as well as the development of alternative control methods possible.

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In Safeea, M. and Neto, P. (2019), the authors present a tutorial of the KUKA Sunrise Toolbox (KST), a MATLAB toolbox that interfaces with KUKA Sunrise.OS. KST contains functionalities for networking, soft control in real time, point-to-point motion, parameter setters/getters, general purpose, and physical interaction. The toolbox includes approximately 100 functions and runs on a remote computer connected with the KUKA Sunrise controller via Transmission Control Protocol/Internet Protocol (TCP/IP). The potentialities of the KST are demonstrated, by the authors, in nine application examples.

In this work, we propose a very simple way to control a pick and place task, performed by an industrial Kuka robot KR 6 R900 Sixx, aided by a low-cost board, in an attempt of to simplify the communication between industrial robots and its environment allowing the simplification of robot's operations.

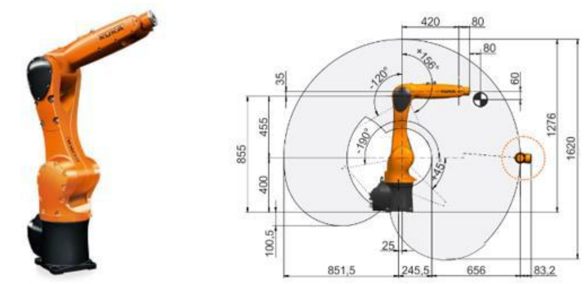
II. THE ROBOT KUKA KR 6 R900 SIXX

The robot KUKA KR6 R900 SIXX AGILUS (Fig.1(a)) is a small industrial robot that features high work speed, with high precision in the activities performed. Can be used handling, loading and unloading activities, and many others. At the Robotics Laboratory of the University of Taubaté, this robot is being used in postgraduate research activities focused on robotic control. Table 1 summarizes the robot information and figure 1 presents the robot model referred to in this article.

Table 1 – Robot information

Robot Specifications		Robot Motion Speed		Robot Motion Range	
Axes	6	J1	156 °/s (2.72 rad/s)	J1	±185°
Payload	6.00kg	J2	156 °/s (2.72 rad/s)	J2	+35° - 155°
H-Reach	1570.00mm	J3	156 °/s (2.72 rad/s)	J3	+154° - 130°
Robot. Mass	±0.050mm	J4	343 °/s (5.99 rad/s)	J4	±350°
Structure	Articulated	J5	362 °/s (6.32 rad/s)	J5	±130°
Mounting	Floor, inverted angle	J6	659 °/s (11.5 rad/s)	J6	±350°

The robot working envelope is shown in Figure 1 (b) and clarifies the reach of the robot, during its operations. The dimensions are in mm.

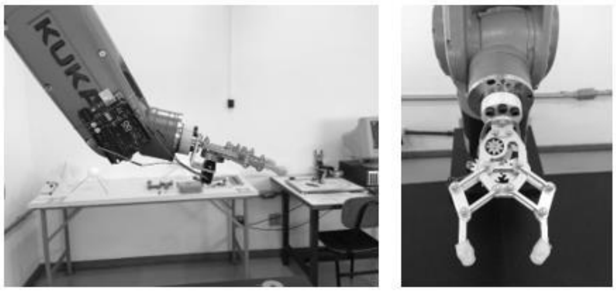


(a) KR6 R900 Sixx Agilus (b) Robot working envelope

Fig.1 - KUKA robot

III. THE EXPERIMENTAL SETUP

To perform the pick and place task, we attach at the robot end effector a two-finger shape claw (Figure 3) which is controlled by an Arduino UNO R3 board. The claw has a servomotor which is wiring to an Arduino's PWM port.



(a) Side view (b) Top view

Figure 3 - Claw attached at the robot end effector

The Arduino board is programed to open and close que claw, depending on a command received by the Arduino, sending by the robot, through its KR C4 controller device. The KR C4 controller has about sixteen digital available ports, which can be accessed via the KSS (Kuka System Software).

IV. DEVELOPMENT OF A SIMPLE COMMUNICATION PROTOCOL

The KSS (KUKA System Software) includes basic functions such as trajectory planning or input/output management. In addition, advanced features are already integrated in KSS. These features offer many possibilities in robot programming, including access to the controller KRC4 digital ports.

The Arduino board works with voltages from 0 to 5V, making it incompatible to use the direct signal from the robot's digital ports - which are from 0 to 24V with 0.5A of current. Thus, a conditioning and protection board was designed to receive the 24V signal from the robot and convert it to 5V, using an LM7805 IC, which is a tension regulator, that will be connected to one of the Arduino's digital input ports protected by a 4N35 opto-coupler (Fig. 4).

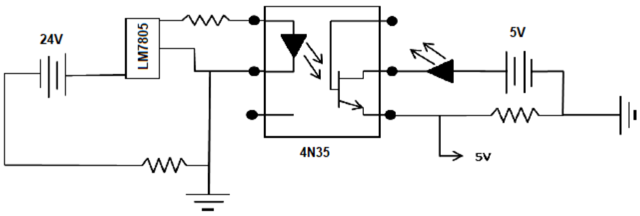


Fig.4 – Input signal conditioner

The figure 5, shows the scheme of the hardware used in this work. The robot, initially, moves to a known point in its work space, and stop in this point for a few seconds.

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After it stops, it sends a 24V signal to a digital port on the KR C4 controller. This port will be wired at the pin 1 of the voltage regulator, LM7805.

The voltage regulator, coupled to the opto-coupler 4N35, sends to the Arduino board, port 3, a 5V signal. When the Arduino board reads this signal, it will close the claw, acting in Arduino's PWM port 3. After that, the robot moves to another known position in its work space, stops for a few seconds, and sends a 0V signal to a digital port on the KR C4 controller. When the Arduino board reads this signal, it will open the claw, acting in Arduino's PWM port 3. Those steps will be repeatedly executed, putting the robot in a pick and place task.

Once the setup was assembled, we developed a simple program, off-line, which is shown in figure 6.

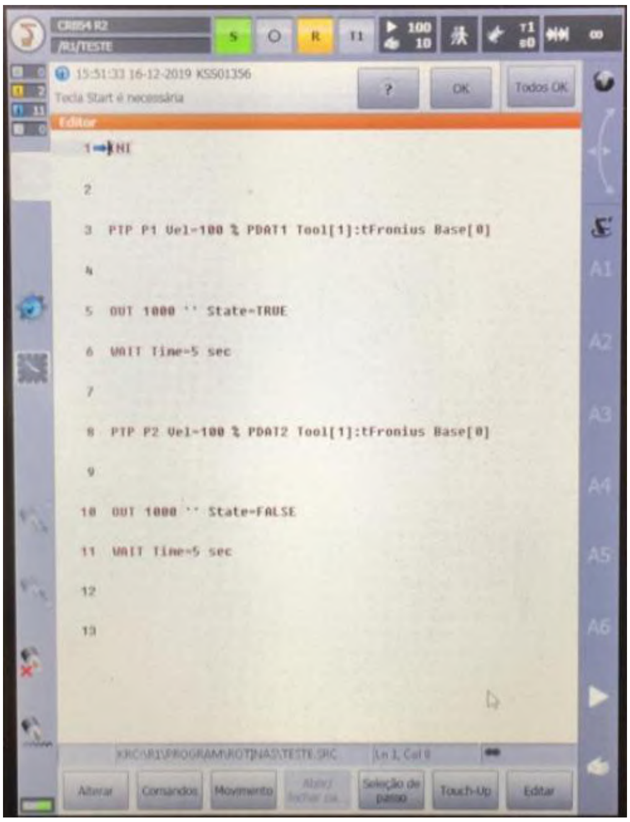

Fig.6 – Program developed to perform the pick and place task

V. CONCLUSIONS AND FURTHER WORK

The integration proposed in this work, worked very well. After the installation of the two-finger shape claw mounted, on the robot's end-effector, we performed the robot calibration to include the end-effector in the robot kinematics. After that the industrial robot was able to interact quite fine with its work space. The robot was able to execute several pick and place tasks and the communication protocol shown no problems in exchange signals with the Arduino Uno board.

With this improvement, we can program the robot to execute more complicated tasks, obeying a control strategy executed by the Arduino board.

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