

KUKA youBot Integration with LabVIEW for Industrial Application

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Abstract

In this paper, we are going to explore how we have successfully implemented the interaction of KUKA youBot with LabVIEW using NI hardware C-RIO 9025, ether CAT cable and VGA cable. KUKA has recently launched a major research and development effort towards designing a mobile manipulation platform. We have been able to control the movement of all the five axis of youBot and gripper control. With the help of VGA cable we were able to establish connection between the youBot and PC to align youBot in its “open arm position”. Real time motion of youBot is achieved using C-RIO that is real-time embedded controller.

Keywords: *NI LabVIEW, C-RIO, KUKA youBot, VGACable*

1. Introduction

LabVIEW (short for Laboratory Virtual Instrument Engineering Workbench) is a system-design platform and development environment for a visual programming language from National Instruments. The graphical language is named "G" (not to be confused with G-code). In 1986 it was emerged from Apple Macintosh, LabVIEW is commonly used for acquiring data using DAQ-Card, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various versions of UNIX, Linux, and Mac OS X. The latest version of LabVIEW is LabVIEW 2015, released in August 2015. LabVIEW is that diminished form of language which can be easily coded and evaluated for results [1]. In this project we have used LabVIEW software as an interface to integrate Youbot. **KUKA** is a German manufacturer of industrial robots and solutions for factory automation. Johann Josef Keller and Jacob Knappich established the firm in 1898 in Germany. At first, the company focused on house and street lights, but soon expanded to other products (welding equipment and solutions; big containers), to become the market leader in communal vehicles in Europe by 1966 [2, 5]. The KUKA youBot system is an open, expandable, modular robot system that has been specially developed for research purposes with an emphasis on robotics. The KUKA youBot system may only be used by laboratory and research purpose for the performance of special experiments and research tasks. Nowadays some of the universities/ colleges have this robot in its campus so that faculty/students can do research on it. Creation of the control software for the KUKA youBot system is part of the research project and is the responsibility of the user/system integrator. KUKA youBot is 5 axis omnidirectional mobile platform [3].

1.1 KUKA youBot Omni Wheel

The Omni Wheel consists of convex, non-driven rollers, which are mounted between 2 rims at an angle of approximately 45° . The rollers are arranged in such a way that they replicate a circle. The wheels do not have a steering mechanism. Translational and rotational velocity and the center of rotation of the vehicle are essentially determined by the direction of rotation of the wheels relative to one another.

1.2. NI C-RIO 9025

NI C-RIO is an embedded controller provided by National Instruments that can be used as deterministic control, data logging, and analysis. It runs on Real time operating system (RTOS). C-RIO has clock frequency of 800 Mhz processor, 4gb nonvolatile storage. With an inbuilt feature of dual Ethernet ports one can establish a connection between youBot and C-RIO via using VGA cable or LAN port [4]. .

2. Implementation And Working

Using LabVIEW KUKA youBot APIs, we have switched the simulated model into real model. The inbuilt LabVIEW KUKA youBot APIs were designed to follow the graphical system design approach, using this ability we were able to switch from the simulated youBot VI version to the real model. There are three major components of the KUKA youBot VIs and we will discuss each of the components in this section.

1. **Initialization VIs** to initialize simulated or physical KUKA youBot
2. **Arm VIs** to configure KUKA youBot manipulator
3. **Platform VIs** to configure KUKA youBot platform

2.1. KUKA youBot Initialization APIs

In this particular VI 2 loops are running in parallel (Gripper control loop and Arm & platform control loop) *i.e* data is processed at the same time in each loop. In gripper control loop open gripper control is used to switch the opening and closing of gripper. We are using local variable for “Running state” in order to give instruction to Gripper loop when to execute. And in arm and platform control loop we are basically dealing with the control of axis and velocity of youBot. We have used build array function to merge values of X, Y and angular velocity. Also formula node is used to convert value of degree to radians.

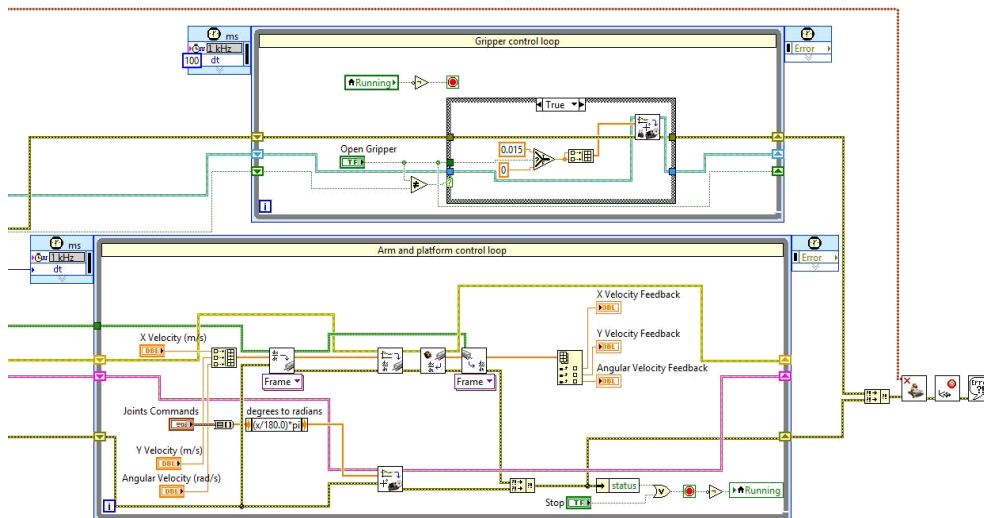


Figure 1. KUKA youBot Initialization API

The initialization VIs contains two instances: KUKA youBot and Simulated KUKA youBot. The design utilizes the hardware abstraction layer that will be discussed in the following section to allow the user to maintain the same codebase and architecture for both environments. This is a very powerful technology to enable rapid prototyping for robotics design. The part of Initialization initializes the KUKA youBot in open gripper position and is calibrated before heading to running state.

2.2 Simulation and Hardware Abstraction

Simulation is considered as one of the fastest way where developer can test algorithms and codes without use of hardware. We have used LabVIEW software as a tool to simulate KUKA youBot API and check the working of each axis and gripper. C-RIO is connected via ether Net cable and VGA cable to youBot. Before actually running the application youBot is set to its “open arm position”. Open arm position is that position in which all axis of youBot is stretched in such a position that its entire axes are in vertical position. All the connections are properly checked and it is made sure that both the host address and IP address are configured. KUKA youBot is considered as Slave while C-RIO acts as Master end. We have also altered .xml file in order to reinitialize the axis and coordinate system. Data is abstracted from .xml file and with the help of initialize youBot API we are able to call the fill path and the data in file is synchronized with the youBot. Once we run VI the Calibration led turns on green in front panel and when the calibration part gets over the led against Running turns on green. This means we can now control the movements of joints and axis using control’s provided on front panel. We can also control the speed of bot in both directions x and y along with angular velocity.

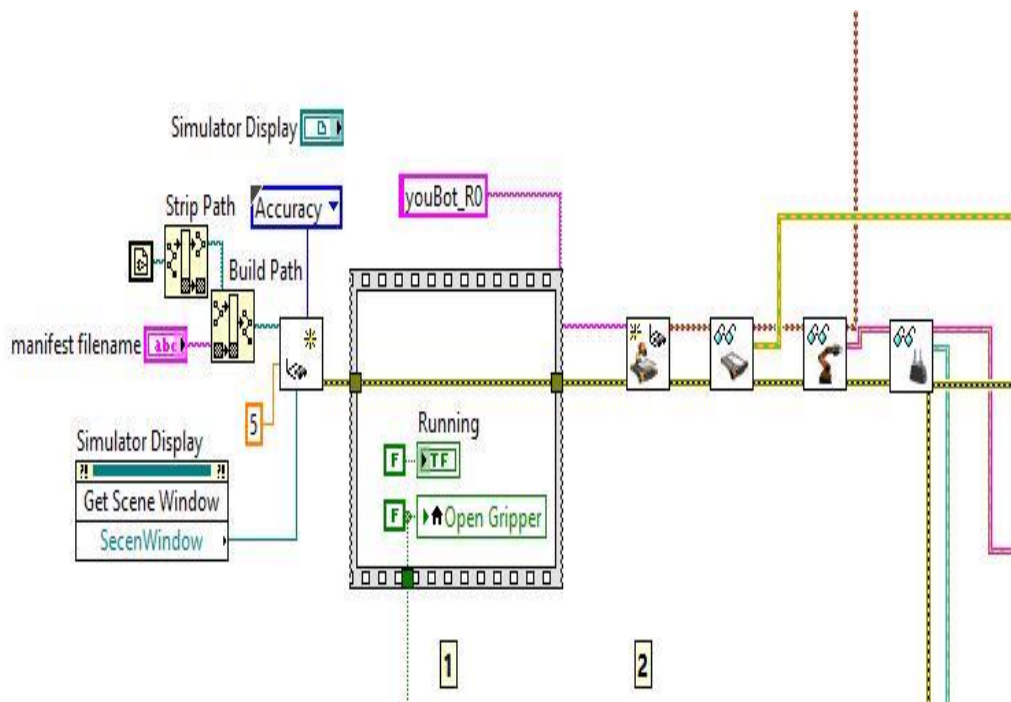


Figure 2. Presenting How the VI is Initialized and File Path is Given to API using Build Path and Strip Path Function

3. Kuka Simulation Panel

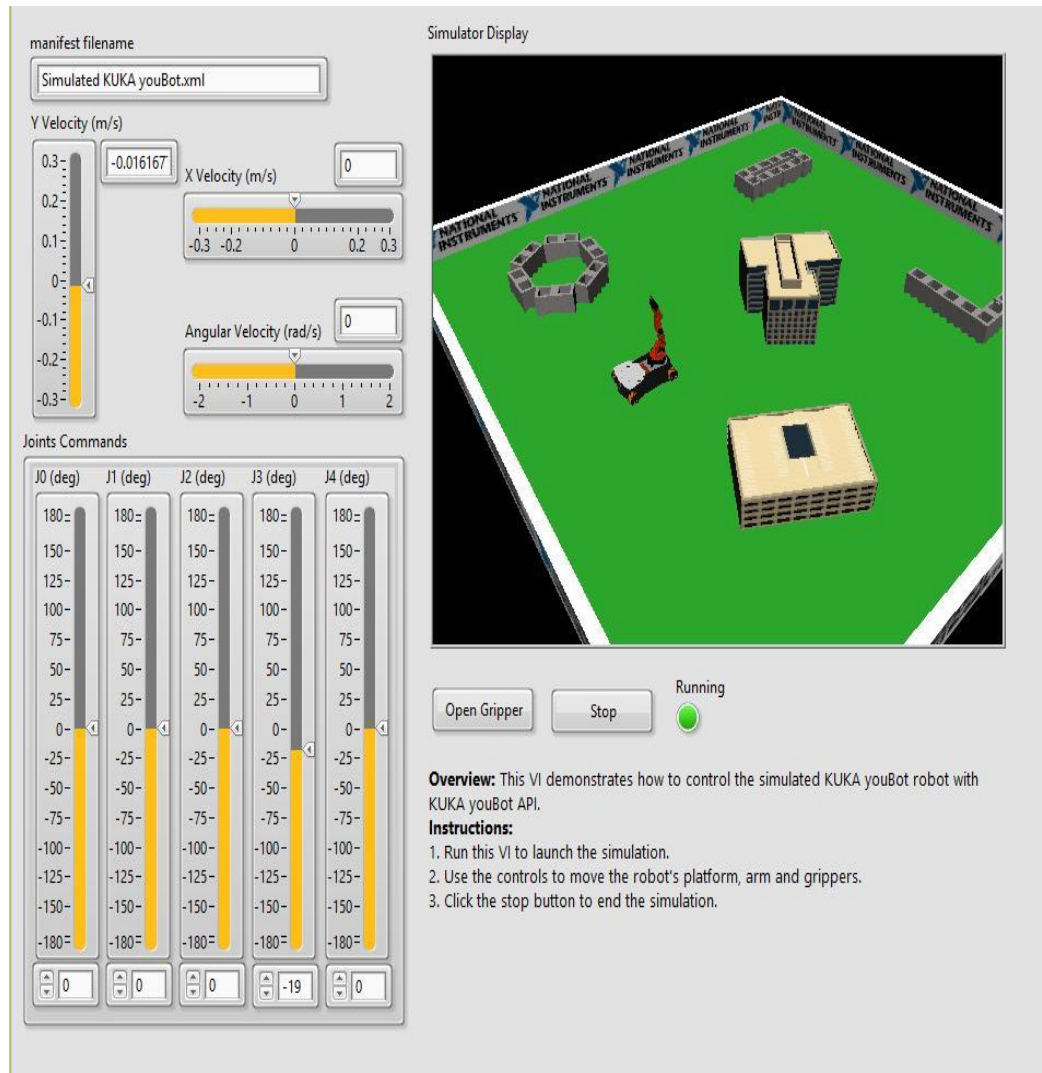


Figure 3. LabVIEW Front Panel of Simulated KUKA youBot front Panel

In this very example simulated VI of KUKA youBot is developed in order to check all the axis and its joints. There is option for open gripper on front panel which is used in order to control opening and closing of the gripper.

4. Conclusion

KUKA youBot serves as an affordable mobile manipulator platform that can be used in both research and education in various ways. The modularity of the KUKA youBot, by adding additional kinematic arm, gripper, and sensors introduces additional challenges to mobile manipulation research. At the same time, LabVIEW Robotics KUKA youBot APIs provides real physical simulation and interfaces for KUKA youBot to further promote innovation and accelerate advanced robotics development. The hardware abstraction layer in LabVIEW can bridge the gap between simulation and real system and improve efficiency. As we move forward, incorporating advanced computing technology such as field programmable gate array (FPGA) is a natural progression. This would enable much faster I/O response times and motor control loops at 40MHz with

exceptional computing power. At the same time, sophisticated software architecture with different types of computing targets (FPGA, Real Time, and Windows) can cross communicate all using the same code base with deterministic processes.

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