REVIEW OF RECENT TRENDS IN RESEARCH USING KUKA ROBOTS

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ABSTRACT

KUKA is a German manufacturer of industrial robots and systems for factory automation. It has been owned by the Chinese company Midea Group since 2016. As of 2014, KUKA employed more than 13,000 workers. The KR16 with KRC2 has a 50 ms response time, and RSI has a 120 ms tracking delay. The proposed interface gives read and write access to variables on the controller during execution. It runs as a client on a remote computer connected with the Kuka controller via TCP/IP. Researchers have studied friction torque in a joint of the KUKA KR10 industrial robot. The largest impact on friction in the joint is caused by its axial load and velocity, as well as the temperature of the mechanism. Researchers have developed a method to estimate friction torque taking into account the temperature factor indirectly. We have done a detail literature review on recent research trends using industrial robots specifically KUKA Robots.

Keywords: *KUKA Robots, Welding Robots, Robotics, Automation, Controller*

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1. INTRODUCTION:

The company was founded in 1898 in Augsburg, Germany, by Johann Josef Keller and Jacob Knappich. KUKA is a German manufacturer of industrial robots and systems for factory automation. KUKA stands for "Keller und Knappich Augsburg" and they specialize in manufacturing industrial robots. It has been owned by the Chinese company Midea Group since 2016. The company is headquartered in Augsburg, Germany. As of December 2014, KUKA employed more than 13,000 workers. While previously emphasizing customers in the automotive industry, the company has since expanded to other industries. A KUKA robot fitted with a special protective suit and located in a climatic chamber imitates the motions of a human driver, thereby testing the durability of the seats. Robots come with a control panel (the KCP, or KUKA Control Panel), also known as a teach pendant, that has a display and axis control buttons for A1-A6, as well an integrated 6D mouse, with which the robot can be moved in manual(teaching) mode. The pendant also allows the user to view and modify existing programs, as well as create new ones. To manually control the axes, an enabling switch (also called a dead man's switch) on the back of the pendant must be pressed halfway in for motion to be possible. The connection to the controller is a proprietary video interface and CAN bus for the safety interlock system and button operation. The industrial robots are used in many application areas, such as material handling, loading, and unloading of machines, palletizing and depalletizing, spot and arc welding. They are used in some large companies, predominantly in the automotive industry, but also in other industries such as the aerospace industry.

2. LITERATURE REVIEW:

The KUKA KR6 robot can withstand some specific forces in incremental forming of some low plasticity alloys like Ti6Al4V. A dynamic model was created to verify that the mechanical structure of this low payload industrial robot of 36 Kg capacity can withstand these forces. [1] A camera is attached to its stand so that it is perpendicularly positioned with the workbench. Software for image processing (Halcon) and teach pendants were used to insert the location points for the path of the robot during welding process. The results show that the system can detect and locate the welding joint position where the localization errors found was less than 7 mm at the starting and ending point and 1mm at the others points. [2] JOpenShowVar is a Java open-source communication interface to Kuka robots. It allows for reading and writing variables and data structures of the controlled manipulators. The interface runs as a client on a remote computer connected with the Kuka controller via TCP/IP. [3] KUI is an open-source software interface for the integration of a Kuka robot with peripheral tools and sensors. In KUI, third-party tools can be added and controlled synchronously with Kuka light-weight robot (LWR) KUI can send the control commands via serial communication to the attached devices. [4] The

KR16 with KRC2 has a 50 ms response time, and RSI has a 120 ms tracking delay, with negligible delay caused by the ROS communication stack. The commercial interface is more reliable for feedback control tasks, but the proposed interface gives read and write access to variables on the controller during execution. [5]

The Kuka LWR robot (industrial version IIWA: Intelligent Industrial Work Assistant) gives the possibility for an industrial robot to investigate this problem using the joint torque sensors data, measured at the output of the drive chains. This work shows for the first time the strong result that motor torques calculated from motor currents can identify the links inertial parameters with the same accuracy than using joint torque sensor measurements. [6] A new paper heralds an optimization procedure that reduces up to 30% of energy consumption and up to 60% in peak power for the trajectories that have been tested on real industrial robots. The work was carried out by the EU project, AREUS, as an outcome of the European Union project. [7] The aim of this work was to implement and evaluate an SDC compliant connection between two collaborative robots. The KUKA LBR IIWA 7 R800 was adapted and the connectivity modelled and then tested with 42 transmittable properties. Latency measurements were conducted to evaluate the network stability, resulting in a median round trip time of 10.13 ms. [8] Researchers have studied friction torque in a joint of the KUKA KR10 industrial robot. The largest impact on friction in the joint is caused by its axial load and velocity, as well as the temperature of the mechanism. This study has set forth a method to estimate friction torque taking into account the temperature factor indirectly. [9]

Planning for serial 6 degree of freedom (DOF) machinery systems is demanding due to complex kinematic structure. A methodology to predetermine regions of feasible tool orientation (work window) is analytically and graphically presented. The KUKA KR robot family is used as a case study. [10] An approach is presented for the model identification of the so-called link dynamics used by the KUKA LWRIV robot. The robot is a lightweight manipulator with elastic joints that is very popular in robotics research. A complete and reliable dynamic model is not yet publicly available for this class of robot. [11] In this paper, we discuss the improvement of the inverse dynamics models of the KUKA LWR IV+ by a recently proposed approach called Independent Joint Learning (IJL). In IJL, the error between the torques from the real robot. and those from an inaccurate dynamics model is estimated using only joint-local information. [12]

Industrial robots have become multifunctional machines for a wide range of users, from small and medium enterprises to architectural and industrial design offices. The demands of these users differ significantly of how robots are used in the automotive industry. New technological advances are required to cover these needs. [13] The advent of the Internet has significantly changed the environment of the production and education. The relationships between suppliers, producers, consumers, which have so far been "personal" to become virtual. Local production and regional trade is becoming global. Through the internet it is possible to provide the operating instructions without physical presence. [14]

Welding is a process of joining two or more metals together by melting the adjacent surfaces. This paper focuses on the application of MIG Welding KUKA Robot in Industries. It will also elaborate on the components used for MIG welding operations, for example, KEMPPI (KempArc Pulse 450), KRC4 Controller, KR16 R2010 Robotic arm. [15] The KUKA Control Toolbox (KCT) is a collection of MATLAB functions developed at the University of Siena. The toolbox is compatible with all 6 DOF small and low-payload robots that use Eth. RSIXML. KCT includes more than 40 functions, spanning operations such as kinematics and trajectory generation. [16] In this paper, an offline programming approach for controlling a manipulator robot is presented using an open-source software tool called RoboDK. A solution based on artificial intelligence (AI) for controlling the robots is presented. This solution will allow robot manufacturers to master new markets in the industrial and service sectors. [17]

We present a lightweight implementation of a typical robotic DSL, the KUKA Robot Language (KRL), on top of our Robotics API. Although being a very flexible approach to programming industrial robots, KRL can be too complex for simple tasks. We introduce two different approaches of interpreting and executing KRL programs: tree-based and bytecode-based interpretation. [18] This paper focuses on developing a programmed code for pick and place three objects using KUKA robot. Point-to-point motion is used rather than linear and circular motion to achieve fastest cycle program. From the experimental result, this program has achieved 13.62s by using overwrite speed 50%. [19] This paper summarizes the singularity of robot positions and their uncertainty by analysing the KR5 industrial robot in the Robot Technological Laboratory in the University of Debrecen. The paper regards the definition of the ISO 8373:2012 standard as a base and deduces all ideas and relations from this standard. [20] It aims to improve dynamic identification procedure for robotic manipulators, such that obtained models are appropriate for trajectory planning and motion control. Significant part of the work is devoted to a case study in calibrating of a collaborative robot (co-bot) KUKA LWR4+. [21] The simulation trajectory simulation of KUKA arc welding robot system is realized by means of VC platform. It is used to realize the teaching of professional training of welding in middle school. It provides teaching resources for the combination of work and study and integration teaching, which enriches the content of course teaching. [22]

Trade sector is touching industry 4.0 and asks for a much-advanced automation process. In India, there is scarcity of Indian based robot manufacturers to satisfy the rising need. This paper gives an idea of the DENAVIT HARTENBERG method for forward and inverse kinematics of a 6 axis KUKA KR5 Arc robot. [23] The KUKA lightweight robot (LWR) provides unique features for robotic researchers. A new interface gives direct low-level real-time access to the KUKA robot controller. This paper describes the capabilities of the interface, the practical realization within the LWR control architecture. [24]

Virtual simulation can effectively provide the training environment for the robot. It can solve many problems in robot practice, such as complex equipment, high price and so on. Virtual simulation and communication of KUKA robot can increase more possibilities. This paper takes uniy3d virtual reality engine as the development platform. [25] An industrial redundant manipulator could be used to provide high force feedback for an orthopaedic surgeon while performing the reaming of the acetabula in a virtual environment. Real experiments have been performed to validate the virtual reality training framework. The results show that the system is intuitive and reliable from the user’s experience.[26] In this work, we have investigated the processes required for visual extracting and remote control of an industrial robot manipulator. First, we set up a Kinect in the robot proximity for the detection of objects (recognition of. shape, form, determination of position etc...) and finally we applied it to a practical example. [27]

Production management and workers who use "classic production" are coming a brake of development in favour of modern production systems bases on flexible NC machines, robots and computer-based control systems. Specially for this field is within the project “Leonardo DaVinci Programme prepared integrated set of vocational training based on eLearning technologies. [28] This paper introduces a methodology that aims to determine the best placement of the workpiece to be machined knowing the electrostatic model of the robot and the cutting forces exerted on the tool. The KUKA KR270-2 robot is used as an illustrative example throughout the paper. [29] An interface provides tools for robot path programming and visualizes it. Path visualization helps workers understand robot behaviour, it is important for safety human-robot interaction. We implemented our interface on Microsoft HoloLens and evaluated it on users. The paper presents an architecture of that system and the implementation for an industrial robot KUKA IIWA and mobile robot platform Plato. [30]

3. CONCLUSION:

- The research results show that the system can detect and locate the welding joint position where the localization errors found was less than 7 mm at the starting and ending point and 1mm at the others points.
- The Kuka LWR robot (industrial version IIWA: Intelligent Industrial Work Assistant) gives the possibility for an industrial robot to investigate this problem using the joint torque sensors data, measured at the output of the drive chains.
- Research works show for the first time the strong result that motor torques calculated from motor currents can identify the links inertial parameters with the same accuracy than using joint torque sensor measurements.
- New papers herald an optimization procedure that reduces up to 30% of energy consumption and up to 60% in peak power for the trajectories that have been tested on real industrial robots.
- Researchers have also studied friction torque in a joint of the KUKA KR10 industrial robot.

REFERENCES

[1] C. CRENGANIS Mihai, "A Dynamic Model for KUKA KR6 in SPIF Processes," Materials Science Forum, pp. 157-156, 2019.

[2] M. S. Z. S. &. Z. K. Hairol Nizam Mohd Shah, "An experiment of detection and localization in tooth saw shape for butt," The International Journal of Advanced Manufacturing Technology, 2018.

[3] L. I. H. H. Z. F. Sanfilippo, "JOpenShowVar: an Open-Source Cross-Platform, M. Fago, K. Y. Pettersen," Proceeding of the IEEE, pp. 1154-1159, 2014.

[4] M. R. K. Mahyar Abdeetedal, "An open-source integration platform for multiple peripheral modules," CIRP Journal of Manufacturing Science and Technology, pp. 1-10, 2019.

[5] I. E. F. S. J. T. G. M. H. Arbo, "Comparison of KVP and RSI for Controlling KUKA Robots Over ROS," IFAC PapersOnLine, pp. 9841-9846, 2020.

[6] M. G. J. Jubien, "Dynamic identification of the Kuka LWR robot using motor torques and joint torque," Proceedings of the 19th World Congress, pp. 8392-8396, 2014.

[7] O. W. K. B. B. L. F. Sarmad Riazi, "Energy and Peak Power Optimization of Time-Bounded Robot Trajectories," IEEE Transactions on Automation Science And Engineering, pp. 1-12.

[8] M. U. L. L. M. Johann Berger, "Evaluation of an IEEE 11073 SDC Connection of two KUKA Robots towards the Application of Focused Ultrasound in Radiation Therapy," Current Directions in Biomedical Engineering, pp. 149-152, 2019.

[9] B. S. N. V. V. K. V. Z. Maksim N. Nevmerzhitskiy, "Friction Model of Industrial Robot Joint with Temperature Correction by Example of KUKA KR10," Journal of Robotics, vol. Volume 2019, pp. 1-11, 2019.

[10] M. F. L. K. Ana M. Djuric, "Graphical Representation of the Significant 6R KUKA Robots Spaces," IEEE 11th International Symposium on Intelligent Systems and Informatics, pp. 221-226, 2013.

[11] F. F. D. L. Claudio Gaz, "Identifying the Dynamic Model Used by the KUKA LWR: A Reverse Engineering Approach," IEEE International Conference on Robotics & Automation (ICRA), pp. 1386-1392, 2014.

[12] P. M. J. S. Zeeshan Shareef, "Improving the Inverse Dynamics Model of the KUKA LWR IV+ using Independent Joint Learning," IFAC-PapersOnLine, pp. 507-512, 2016.

[13] S. S. Buchstab, "KUKA Robots On-Site," pp. 373-380, 2014.

[14] P. D. Dominika Palaščáková, "Measurement Precision KUKA Robots Move at a Defined Distance and Proposal for a Robotized Workplace to Support the Learning Process," MANUFACTURING TECHNOLOGY, vol. 16, no. 6, p. 42, 2016.

[15] S. K. Talele, "MIG WELDING USING 8-AXIS KUKA ROBOT," International Journal of Engineering Applied Sciences and Technology, vol. 4, no. 10, pp. 101-105, 2020.

[16] S. S. F. M. D. P. Francesco Chinello, "The KUKA Control Toolbox : motion control of KUKA robot manipulators with MATLAB," IEEE ROBOTICS AND AUTOMATION MAGAZINE, pp. 1-10, 2010.

[17] R. M. Y. B. M. G. K. Anouar MABROUK, "Offline programming with intelligent vision system of KUKA robot," International Journal of Control, Energy and Electrical Engineering (CEEE), vol. 8, pp. 1-7, 2019.

[18] H. W. R. Henrik M¨uhe, "On reverse-engineering the KUKA Robot Language," pp. 1-6, 2010.

[19] P. S. S. B. P. Nurul Azimah binti Ahmad Arzaai, "PICK AND PLACE THREE VARIOUS RINGS USING KUKA ROBOT," GREEN TECHNOLOGY & ENGINEERING SEMINAR, pp. 1-8, 2019.

[20] G. Husi, "Position Singularities and Ambiguities of the KUKA KR5 Robot," INTERNATIONAL JOURNAL of ENGINEERING TECHNOLOGIES, vol. 1, no. 1, pp. 44-55, 2015.

[21] "Refining Dynamics Identification for Co-Bots: Case Study on KUKA LWR4+," IFAC PapersOnLine, pp. 14626-14626, 2017.

[22] M. Hu, "Research on Kinematic Trajectory Simulation System of KUKA Arc Welding Robot System," IOP Conf. Series: Materials Science and Engineering, pp. 1-9, 2017.

[23] M. S. M. S. Aparna Jha, "Simulation and kinematic analysis of KUKA KR5 Arc robot," IOP Conf. Series: Materials Science and Engineering, pp. 1-7, 2021.

[24] S. R. B. Günter Schreiber, "The Fast Research Interface for the KUKA Lightweight Robot," pp. 15-21.

[25] Z. Y. Y. W. Bin Shen, "Virtual simulation of communication between KUKA robot and PLC," Journal of Physics: Conference Series, pp. 1-6, 2020.

[26] L. P. M. L. P. K. D. P. T. C. S. G. G. D. G. L. S. Knopp, "Using the KUKA LBR iiwa Robot as Haptic Device for Virtual Reality Training of Hip Replacement Surgery," Third IEEE International Conference on Robotic Computing (IRC), pp. 449-450, 2019.

[27] S. B. H. K. K. H. M. Hassine BELHADJ, "KUKA Robot control based Kinect image analysis," International Conference on Individual and Collective Behaviors in Robotics, pp. 21-26, 2013.

[28] S. J. V. M. Hajduk Mikuláš, "Robotic cell with robot Kuka for spot welding," 6th International Symposium on Applied Machine Intelligence and Informatics, pp. 115-116, 2008.

[29] C. D. S. G. B. F. Stephane Caro, "Workpiece Placement Optimization for Machining Operations with a KUKA KR270-2 Robot," IEEE International Conference on Robotics and Automation (ICRA), pp. 2921-2926, 2013.

[30] R. Y. K. M. Ostanin, "Interactive Robots Control Using Mixed Reality," IFAC PapersOnLine, pp. 695-700, 2019.