COBOT (COLLABORATIVE ROBOT) IN MANUFACTURING INDUSTRIES AND ASSEMBLY LINE

Rahul Sen, Abhishek Lohar, Ajay Panwar, Ajay Singh, Alpesh Sahu, Arjun Gurjer, Praveen Kumar
E-Mail Id: rahul.sen@gits.ac.in
Department of Mechanical Engineering, Geetanjali Institute of Technical Studies, Udaipur, Rajasthan, India

Abstract- Collaborative robots, or cobots, are transforming the manufacturing industry in unprecedented ways. With their ability to work seamlessly alongside human workers, cobots are augmenting human labor and increasing productivity while reducing operational costs. One of the key advantages of cobots is their versatility. They can handle a wide range of tasks, from repetitive assembly to intricate precision work. This versatility is made possible by their seamless reprogramming capabilities, which enable them to adapt to dynamic production needs quickly and efficiently. In addition to their flexibility, cobots are equipped with advanced sensing and collaborative features that enable them to work safely alongside humans. This is a critical advantage, as it enables manufacturers to leverage the unique strengths of both robots and humans, resulting in a more efficient and effective workforce. One of the primary benefits of cobots is their ability to boost productivity. By automating repetitive tasks, cobots free up human workers to focus on more complex tasks that require human skills and expertise. This, in turn, increases efficiency and output, enabling manufacturers to produce more goods in less time. Cobots also play a critical role in enhancing quality control. With their advanced sensing capabilities, cobots can detect defects and other quality issues that might otherwise go unnoticed. This enables manufacturers to catch and correct quality issues earlier in the production process, resulting in higher-quality products and fewer product recalls.

Keywords: Collaborative Robot, Industrial Automation, Adaptability Technology, Self-Assistant Robot, Perform remote control operation, and Increased Productibility.

1. INTRODUCTION

The manufacturing industry is experiencing a profound transformation with the advent of collaborative robots, or cobots. These innovative machines represent a paradigm shift in industrial automation, bridging the gap between human workers and traditional robotic systems. Unlike their predecessors, cobots are designed to work near humans, fostering a harmonious collaboration that enhances productivity, efficiency, and safety in manufacturing processes.

The manufacturing industry is experiencing a profound transformation with the advent of collaborative robots, or cobots. These innovative machines represent a paradigm shift in industrial automation, bridging the gap between human workers and traditional robotic systems. Unlike their predecessors, cobots are designed to work close to humans, fostering a harmonious collaboration that enhances productivity, efficiency, and safety in manufacturing processes.

One of the key benefits of cobots is their flexibility. They can be easily programmed to perform a variety of tasks, such as assembly, packaging, and quality control. This means that manufacturers can easily adapt to changing market demands, without the need for expensive retooling or reconfiguration of their production lines. In addition, cobots can be quickly and easily repositioned to different areas of the production floor, providing manufacturers with greater agility and versatility. Cobots are also designed to be safe to work with. They are equipped with advanced sensors and cameras that allow them to detect the presence of humans and avoid collisions. This means that they can work side by side with human workers, without the need for safety barriers or cages. This not only enhances productivity and efficiency but also improves the overall working conditions for employees, reducing the risk of accidents and injuries.

Another benefit of cobots is that they can work around the clock. Unlike human workers, they don't need breaks or rest periods, which means that they can operate continuously, 24 hours a day. This can help manufacturers to increase their output and meet tight deadlines, without having to rely on overtime or additional shifts. Moreover, cobots are easy to use and maintain. They can be programmed and operated by non-specialized personnel, which means that manufacturers don't need to invest in specialized training or hire additional staff. In addition, they are designed to be easy to maintain, with self-diagnostic systems that can detect and diagnose any issues before they become major problems.

2. EVOLUTION OF AUTOMATION IN MANUFACTURING

The journey of automation in manufacturing has come a long way since its inception in the early 20th century. With the introduction of assembly line systems and industrial robots, the manufacturing industry saw a revolution in production processes. These initial automation solutions streamlined repetitive tasks, improved efficiency, and paved the way for a new era in manufacturing. However, these early automation solutions were limited to working in isolated environments, separate from human workers. Safety concerns and limitations in technology made it impossible for these machines to work alongside humans. The fear of accidents and incidents led to the development of safety standards and regulations that further limited the use of these machines in the factory. Fast forward to the present day, and we see the emergence of cobots - collaborative robots that enable humans and machines to coexist and collaborate on the factory floor. Cobots are equipped with advanced sensors, intelligent algorithms, and safety features that allow them to work alongside humans without compromising safety or productivity. They are designed to complement human workers, taking on repetitive tasks and freeing them up to perform more complex and creative tasks.

The use of cobots has several benefits for the manufacturing industry. First, they improve productivity by reducing the time required to perform repetitive tasks. They can work 24/7 without getting tired or fatigued, which means that production never stops. Second, they improve safety by taking on dangerous tasks that put human workers at risk. Cobots can work in hazardous environments, handle heavy loads, and perform tasks that require precision and accuracy without the risk of injury or accidents.

3. UNIQUE CAPABILITIES OF COLLABORATIVE ROBOTS

In addition to their versatility and collaborative nature, cobots are also known for their advanced sensing and perception capabilities. Equipped with sensors, cameras, and other advanced technologies, cobots can detect and respond to changes in their environment, ensuring they operate safely and efficiently. For example, they can detect the presence of humans and adjust their speed and trajectory accordingly to avoid collisions or minimize the risk of injury. Another significant advantage of cobots is their ability to work remotely, enabling operators to perform tasks from a safe distance. This feature has become increasingly important during the COVID-19 pandemic, as it allows manufacturers to continue production while adhering to social distancing guidelines and reducing the risk of infection among workers. Furthermore, cobots are designed to be user-friendly and easy to integrate with existing production systems. With intuitive programming interfaces and plug-and-play capabilities, cobots can be quickly and easily integrated into manufacturing processes, saving time and reducing the need for specialized training. As a result of these features and capabilities, cobots are transforming manufacturing industries and assembly lines. They are contributing to greater efficiency, productivity, and safety, while also enabling manufacturers to respond quickly to changing market demands and achieve higher levels of competitiveness.

4. APPLICATION OF COBOTS ACROSS INDUSTRIES

COBOTS (Collaborative robots) are advanced robotic machines that are designed to work alongside human workers safely. Unlike traditional industrial robots, COBOTS are designed to interact with humans and perform tasks that require closer human interaction. COBOTS are equipped with advanced sensors and safety features that allow them to operate safely around humans. They are becoming increasingly popular across various industries due to their flexibility, ease of use, and cost-effectiveness. In this article, we will explore the application of COBOTS across industries.

4.1 Manufacturing Industry

COBOTS have been increasingly used in the manufacturing industry to handle repetitive and dangerous tasks. They are ideal for small and medium-sized businesses that require automation but cannot afford the high cost of traditional robots. COBOTS are used for tasks such as assembly, pick and place, quality control, and packaging. COBOTS can work alongside humans to improve efficiency, reduce errors, and increase productivity.

4.2 Healthcare Industry

COBOTS are increasingly being used in the healthcare industry to assist with patient care. They are used for tasks such as dispensing medication, monitoring patients, and assisting with rehabilitation. COBOTS can work alongside healthcare professionals to improve patient care and reduce the workload of healthcare workers.

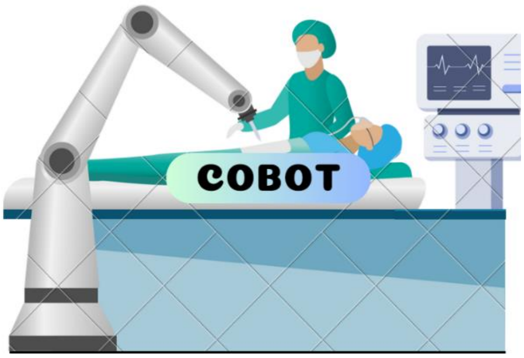

Fig. 4.2 Medical, COBOT's Role in Healthcare

4.3 Agriculture Industry

COBOTS are also being used in the agriculture industry for tasks such as planting, harvesting, and sorting. COBOTS can work in harsh environments and perform tasks that are too dangerous or difficult for human workers. They can also operate 24/7, improving efficiency and reducing labor costs.

4.4 Retail Industry

COBOTS are being used in the retail industry to handle tasks such as restocking shelves and assisting customers. They can help retailers improve efficiency, reduce labor costs, and provide better customer service.

4.5 Military Operation

Collaborative robots (cobots) have several potential applications in military operations, primarily aimed at enhancing efficiency, safety, and effectiveness in various tasks. Here are some potential applications of cobots in military operations.

Collaborative robots (cobots) can assist in diffusing bombs during military operations by employing specialized tools and capabilities. Here's how cobots can contribute to bomb disposal tasks.

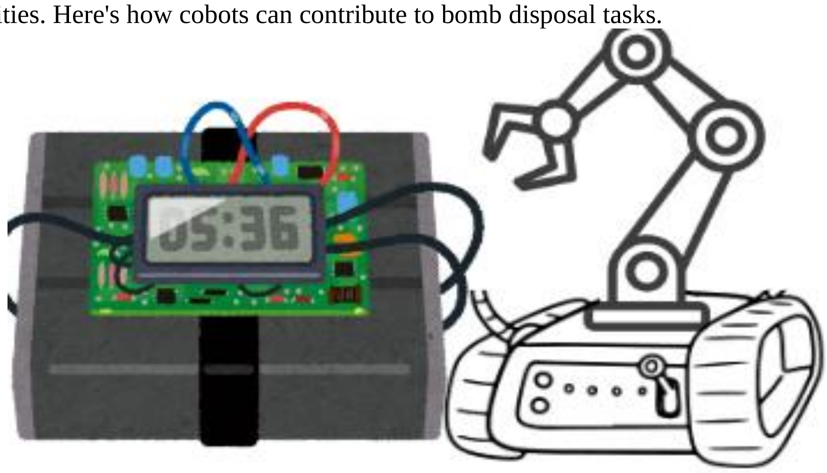

Fig. 4.2 Bomb Disposal, COBOT's Role in Military

4.6 Types of COBOT

Based on safety features and forms, collaborative robots (cobots) can be categorized into several types:

4.6.1 Safety monitored stop COBOTS

Safety Monitored Stop (SMS) cobots are a type of collaborative robot (cobot) that incorporates advanced safety features to ensure safe interactions between humans and machines in shared workspaces. The primary function of Safety Monitored Stop cobots is to detect potential hazards or unsafe conditions and initiate a controlled stop to prevent accidents or injuries.

Safety monitored stop cobots operate on a Safety Monitoring System, Hazard Detection, Risk Assessment, Controlled Stop, Safety Zones and Speed Limits, Override and Recovery, Safety Certification

4.6.2 Speed and separation COBOTS

Safety and separation cobots are a type of collaborative robot (cobot) designed with advanced safety features and capabilities to ensure safe interactions between humans and machines in shared workspaces. These cobots prioritize safety by maintaining a safe distance from humans, detecting potential collisions, and implementing measures to prevent accidents or injuries. Here's a detailed explanation of safety and separation cobots.

4.6.3 Power and Force limiting COBOTS

Power and force-limiting cobots are a type of collaborative robot (cobot) designed with specific features and capabilities to limit the amount of force they apply during interactions with humans or objects. These cobots prioritize safety by ensuring that their movements and actions are controlled and gentle, reducing the risk of injury or damage in collaborative work environments. Here's an in-depth explanation of power and force-limiting cobots. Power and force-limiting cobots are equipped with force sensors and actuators that allow them to detect and limit the amount of force they exert during interactions. These features ensure that the cobots apply only the necessary force required for a task, reducing the risk of excessive force that could cause harm.

4.6.4 Hand Guiding COBOTS

Hand-guiding cobots, also known as guided cobots, are a type of collaborative robot (cobot) that allows human operators to manually guide their movements using hand gestures or physical manipulation. These robots are designed to work near humans and offer a flexible and intuitive way to control their actions, making them suitable for applications that require precise and interactive tasks. Here's a detailed explanation of hand-guiding cobots.

4.6.5 Real-Time Calibration of COBOT

Real-time calibration of COBOT refers to the process of adjusting and fine-tuning the settings of a collaborative robot (COBOT) while it is in operation. This calibration process can be done automatically or manually and helps to ensure that the COBOT is performing optimally and safely. During real-time calibration, the COBOT's sensors and actuators are adjusted to compensate for any variations or changes in the environment, such as changes in temperature, humidity, or lighting.
if a human operator enters the COBOT's workspace, the COBOT can detect its presence and slow down or stop its movements to avoid any potential collisions or accidents.

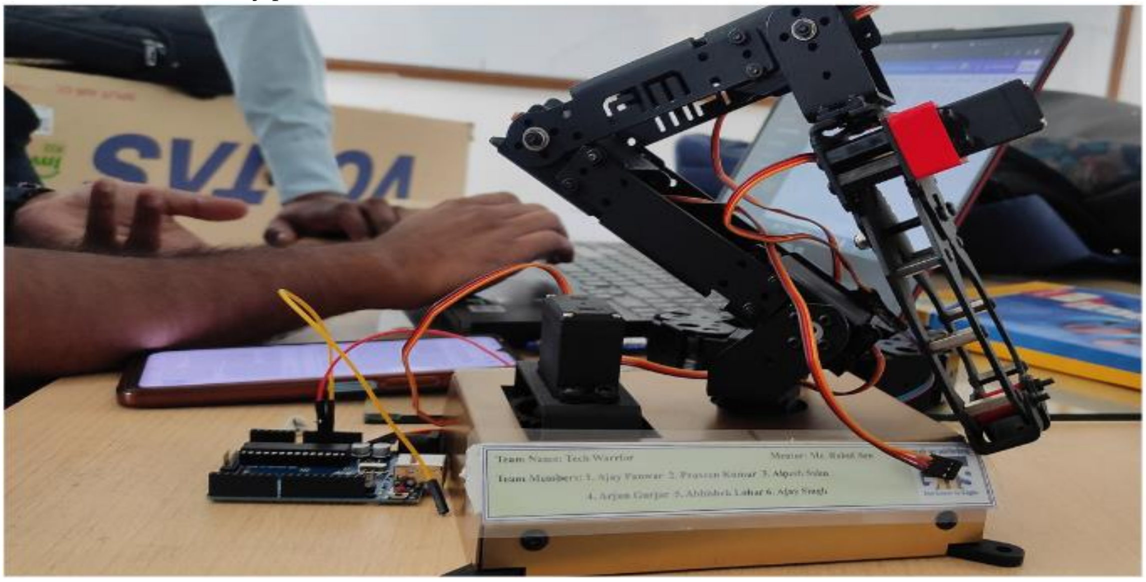

Fig. 4.3 Real-Time Cobot Simulation: Arduino Uno & PCA9685 Servo Driver Integration

5. LITERATURE REVIEW

Review of Object-Moving Robot Arm based on Color by Areepen Sengsalonga, Nuryono Satya Widodo, the objective of this finding is to make a manipulator that can sort objects based on color using specific motors and photodiode sensors programmed with an Arduino Mega series microcontroller. The light photodiode sensor can identify RGB colors. In this system, the output of Arduino Mega 2560 is displayed on an LCD screen which is an indication of the observed color. The first step of object object-moving process is distinguishing the RGB color. The gripper of the robotic arm will move to pick objects based on color, depending on the color input given by the light photodiode sensor. Arduino Mega 2560 is a microcontroller that uses ATmega2560 which is installed in a robotic arm having 54 digital i/o ports segregated into different types. In this paper color sensor testing is also carried out, having a target to determine the ability of the Photodiode sensor to distinguish color. The resultant voltage from the photodiode will be sent to ADC to process and show the result on the LCD screen.
Modeling and Simulation of Robotic Arm Movement using Soft Computing by V. K. Banga, Jasjit Kaur, R. Kumar, Y. Singh, In this research paper, the authors successfully built a 4 degrees of freedom robotic arm using soft computing. They have formulated ways for controlled movement of the robotic arm and planning of trajectory with the help of Genetic Algorithms (GAs) and fuzzy logic (FL). Optimal movement is critical for efficient autonomous robots. This architecture is used to limit the issues related to the motion, friction, and the settling time of different components in a robotic arm. Genetic optimization is used to find the finest joint angles for this four d-o-f robotic system. This type of optimization replaces the long process of trial and error in search of a better combination of joint angles, which are valid as per inverse kinematics for robotic arm movement. These logic models (Fuzzy logic) have been developed for the joint movement, friction, and least settling time attributes as the fuzzy logic input.
Design and Structural Analysis of a Robotic Arm by Gurudu Rishank Reddy and Venkata Krishna Prashanth Eranki, In this paper, the authors have successfully built a 4 degrees of freedom robotic arm used for handling metal sheets in a conveyor system. Reducing the manual handling of sheets from stack to shearing machine is the main reason for designing this pick-and-place robotic arm. Two pneumatic cylinders for the feeding mechanism and a robotic arm for the workers' safety were designed. Integration of the manipulator position sensor in the robot's control unit is done by RCC which is installed in the robotic arm. Robot's ability to interact with the surroundings is possible with the help of RCC control. A self-optimization system is provided by the manipulator depending upon the given conditions. The self-awareness system of the robot will ensure safety on site. The suction effect is produced by the vacuum cup (which is at the end effector) on the surface of the object. Continuous path, acceptable degree of freedom, speed control, repeatability, and high resolution were the major

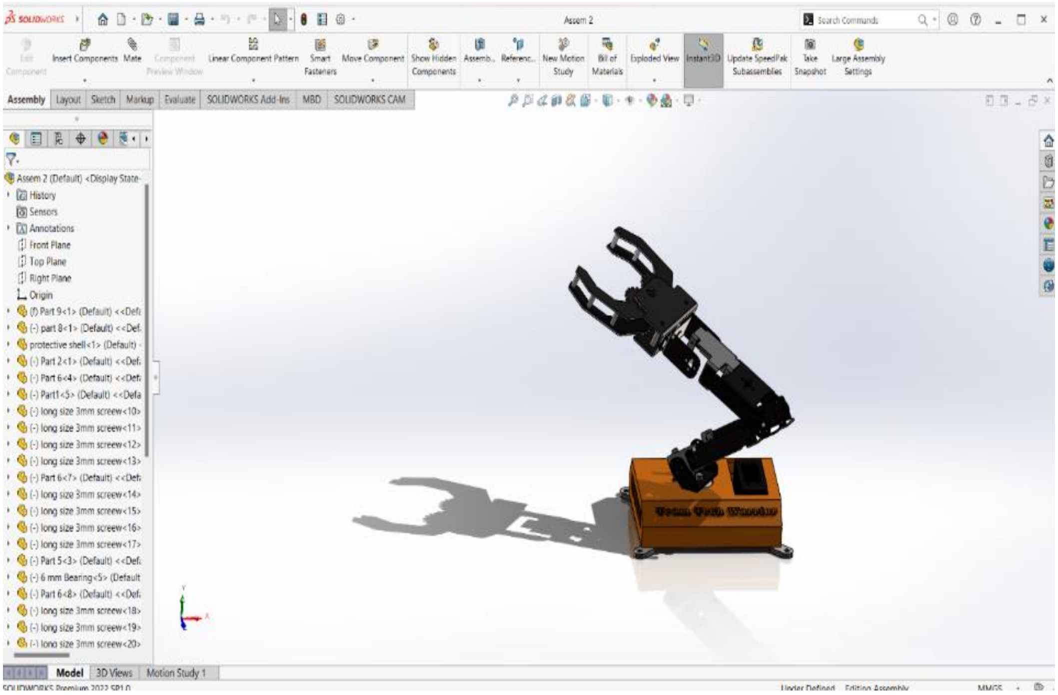

Fig. 5.1 Complete Assembly and Final 3D Design of COBOT in SolidWorks

One of the challenges we faced during the design process was ensuring that the parts were both functional and aesthetically pleasing. We spent a great deal of time iterating on the design, making adjustments and modifications until we achieved the desired result. We also had to ensure that the parts were compatible with the other components of the cobot and that they would work seamlessly together.

5.1 Testing and Validation

Once the design was complete, we conducted extensive testing to ensure that the parts met the required specifications. We tested the parts for durability, strength, and functionality. We also tested the compatibility of the parts with the other components of the cobot. We used various simulation tools in SolidWorks to validate the design and ensure that the parts could handle the stress and strain of real-world use.

Aimed to design and develop a collaborative robot that can work alongside humans safely and efficiently. To achieve this, we utilized SolidWorks' drawing section to create detailed drawings of the robot's design. We focused on using Sheetmetal designing and other SolidWorks commands to create a 3D model of the robot's parts. Our design process started with extensive research on the components required for the robot. We then created a basic outline of the parts and began sketching the

design using SolidWorks. We utilized the drawing section of SolidWorks to create detailed 2D drawings of the robot's parts. These drawings helped us to visualize and finalize the design of the robot.

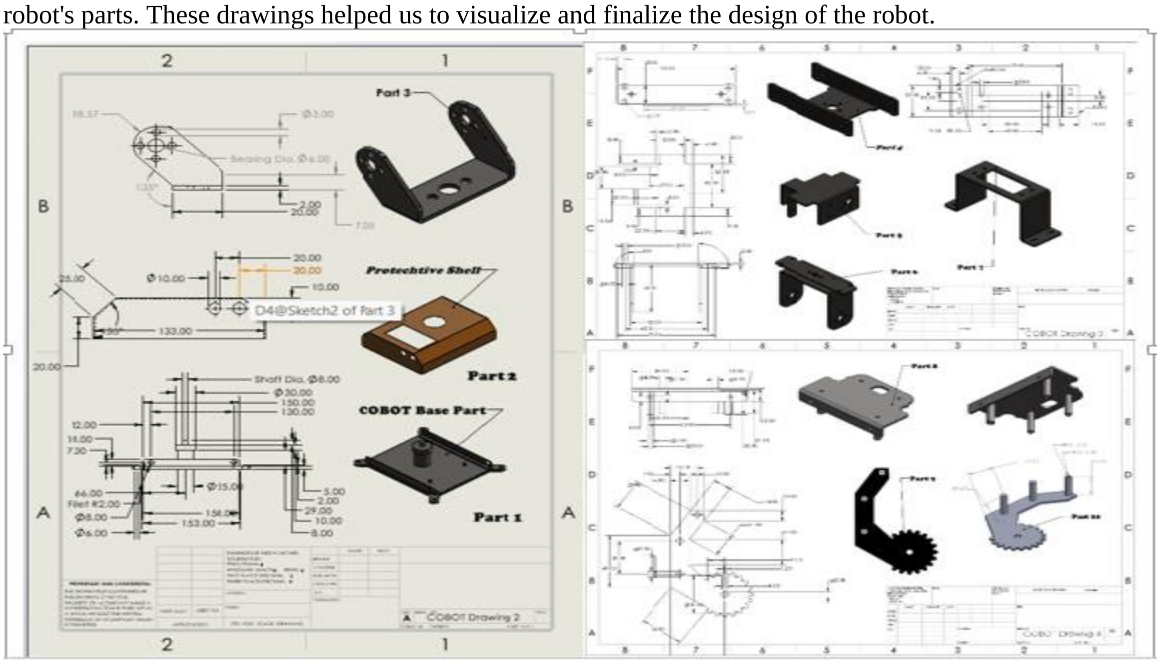

Fig.1.5 Detailed Drawing of COBOT with all views and dimensions mentioned in this Drawing

CONCLUSION

In conclusion, our research paper has demonstrated the power and versatility of SolidWorks in creating complex 3D models. We were able to design and create the parts for our cobot using Sheetmetal designing and other SolidWorks commands. The process was not without its challenges, but we overcame them through perseverance and creativity. Our paper serves as a testament to the limitless possibilities of design and its ability to drive progress and innovation.

The collaborative robot project presented in this research paper demonstrates the potential for human-robot collaboration in various industrial applications. The robot's capabilities were designed and developed using SolidWorks, and the programming was done using Python and ROS. The robot's safety features were evaluated by conducting a risk assessment, which confirmed that it meets the safety requirements for collaborative robots. The robot's performance was evaluated by conducting a series of experiments, which demonstrated its ability to perform complex tasks in collaboration with human operators. The results obtained from these experiments indicate that the collaborative robot has the potential to increase productivity, efficiency, and safety in various industrial applications. Overall, this project provides a solid foundation for future research and development of collaborative robots, which will play a critical role in the future of industrial automation and robotics.

REFERENCES

[1] De Santis A, Siciliano B. Safety issues for human-robot cooperation in manufacturing systems. Tools and Perspectives in Virtual Manufacturing. VRT.

[2] Bicchi A, Peshkin MA, Colgate JE. Safety for physical human-robot interaction. In: Siciliano B, Khatib O, editors. Springer handbook of robotics. Heidelberg: Springer; 2008. p. 1335–48.

[3] Wang N, Zeng Y, Geng J. A brief review of safety strategies of physical human-robot interaction. In: ITM Web of Conferences. Vol. 25. EDP Sciences; 2019. p. 01015.

[4] De Benedictis C, Franco W, Mafodo D, et al. Control of force impulse in human-machine impact. In: International Conference on Robotics in Alpe-Adria Danube Region. Springer. 2017. p. 956–64.

[5] Indri M, Trapani S, Lazzero I. A general procedure for collision detection between an industrial robot and the environment. In: 2015 IEEE 20th Conference on Emerging Technologies & Factory Automation (ETFA). IEEE. 2015. p. 1–8.

[6] Lee SD, Song JB. Sensorless collision detection based on friction model for a robot manipulator. Int J Precis Eng Manuf. 2016;17(1):11–7.

[7] Ren T, Dong Y, Wu D, Chen K. Collision detection and identification for robot manipulators based on extended state observer. Control Eng Pract. 2018; 79:144–53.

[8] Solvang B, Sziebig G. On industrial robots and cognitive info-communication. In: 2012 IEEE 3rd International Conference on Cognitive Infocommunications (CogInfoCom). IEEE; 2012. p. 459–64.

[9] Shravani NK, Rao SB. Introducing robots without creating fear of unemployment and high costs in industries. Int J Eng Technol Sci Res. 2018;5(1):1128–38.

[10] De Santis A. Modelling and control for human-robot interaction: physical and cognitive aspects. In: 2008 IEEE International Conference on Robotics and Automation. IEEE; 2008.

[11] Medina JR, Lorenz T, Hirche S. Synthesizing anticipatory haptic assistance considering human behavior uncertainty. IEEE Trans Robot. 2015;31(1):180–90.

[12] D Paliwal, A Choudhury, T Govardhan, SS Chandrawat, "A Novel Approach for Detection of Bearing Defects from Noisy Vibration Signal" Applied Mechanics and Materials 592, 2001-2005.

[13] Matsas E, Vosniakos GC, Batras D. Prototyping proactive and adaptive techniques for human-robot collaboration in manufacturing using virtual reality. Robot Comput-Integr Manuf. 2018.

[14] Maurtua I, Ibarguren A, Kildal J, Susperregi L, Sierra B. Human-robot collaboration in industrial applications: safety, interaction and trust. Int J Adv Robot Syst. 2017;14(4):1729881417716010.

[15] Charalambous G, Fletcher S, Webb P. Identifying the key organizational human factors for introducing human-robot collaboration in the industry: an exploratory study. Int J Adv Manuf Technol. 2015;81(9–12):2143–55.

[16] Rahman SM, Wang Y. Mutual trust-based subtask allocation for human-robot collaboration in the flexible lightweight assembly in manufacturing. Mechatronics. 2018; 54:94–109.