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Design of Co-bot Machine for Human and Automotive Industry

***Dr. Amit S. Chaudhary*[1]*, Somesh Chandak*[2]*, Kirtish Jaiswal*[3]*, Rushikesh Lomte*[4]*, Akshay Dandade*[5]**

[1]Asso. Professor, Department of Mechanical Engineering, DIT, Pimpri, Pune.
[2,3,4,5] Students, Department of Mechanical Engineering, DIT, Pimpri, Pune.

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ABSTRACT:

Human-industrial robot collaboration (HIRC) allows for a perfect blend of human perception and industrial robot efficiency. In comparison to typical manual workstations, industrial robots' strength, endurance, and precision can be paired with human intelligence and adaptability to produce workstations with greater productivity, quality, and reduced ergonomic burden. Despite several technological advancements in industrial robots and safety measures during the last decade, solutions for HIRC workstation design remain limited. Simulation software is one component in achieving an efficient design of a future workstation. As a result, the goal of this study is to create demonstrator software that simulates, visualizes, and evaluates HIRC workstations, as well as to devise a design methodology for using such simulation software in an industrial setting. The thesis consists of five papers that describe the creation of HIRC simulation software and the design process that goes with it. Two existing simulation software tools, one for digital human modelling and the other for robotic simulation, were combined into a single app. The standard programme contained evaluation measures for operating time and ergonomic load. To describe the use of HIRC simulation software, existing engineering design methodologies were applied in an HIRC workstation scenario. Five real-world industry instances from a heavy vehicle manufacturer were used to demonstrate these advancements.

Keywords: Human–robot collaboration, Collaborative Robots, Cobots, Industry 4.0

1. Introduction:

A General Overview

Collaborative robots, or cobots, are the more personable and approachable successors to traditional industrial robots. Because of intuitive software, they're smaller, less expensive, and easier to programme for non-experts. Built-in safety features expand their range of activities and allow them to work alongside humans on more complex procedures. They can even be reprogrammed to perform different jobs within the same facility, making them extremely adaptable and cost-effective. Manufacturers who thought robotic automation was beyond their reach should think again.

What are Cobots, exactly?

Traditional industrial robots are built and programmed to perform a specific task while keeping workers on the factory floor or assembly line at a safe distance. They exist in a range of shapes and sizes and are typically used to process large quantities of single things, such as welding, drilling, spray application (paint, adhesive), transporting items throughout a region, and loading and unloading heavy items. They are enormous, heavy, quick, and incredibly powerful, making them dangerous to people and demanding their containment with fence or other barriers. Because they operate independently of the people around them, traditional industrial robots work in parallel rather than in partnership.

Figure1.1: Human interaction between co-bots

The features of the robot that make it safe and beneficial for working alongside people, rather than the task completed, define collaboration. A machine and a person can work on the same task, assembly, object, or activity at the same time in the same physical space, such as a work cell, station, or work bench.

Sizes, payload capacities, reach distances, and speeds of cobots are all accessible. They're typically small enough to fit on a workbench or a sturdy cart. Ground-mounted variations are available in larger sizes (or ceiling, or wall, depending on the application).

Cobots are often integrated into areas of a process that are repetitive or dull enough to cause errors or harm, rather than totally replacing human labour. They are perfect assistance for activities requiring small parts or intricate positioning, such as those performed by workers on workbenches and on the manufacturing floor, because to their small size and nimble mobility. Following are a few examples:

- Pick And Place (E.g. Moving Item From Conveyor To Tray)
- Machine Tending (E.g. Injection Molding Or CNC Machines)
- Packaging And Palletizing
- Process Tasks, When Equipped With End Effector Tools (E.G. Gluing, Drilling, Welding)
- Finishing (Sand, Polish, Deburr, Trim)
- Quality Inspection, When Equipped With A Vision Camera
- Assembly
- Dispensing (E.g. Adhesive, Lubricant, Sealant)
- Painting, Coating, Dipping

On a more technical level, what distinguishes a robot as "collaborative" is its ability to identify anomalous activity in its environment through force limitation or visual monitoring.

These sensors allow humans and robots to work together without being physically separated. Most notably, COBOT satisfies the fourth criterion of safe collaboration, which is the limiting of force and power. In reality, all collaborative robots contain force sensors in their joints, which cause them to cease moving if they come into contact with something. This allows you to run the robot at full speed without worrying about the kinetic energy carried by the robot arm posing a threat.

Why are robots being used?

The primary purpose of robotization is to improve a process. To put it another way, obtaining the highest goal at the lowest expenses; Errors are reduced, staff has more time to focus on other tasks, productivity rises, and the end result is a better operating result. Co-bot involve an initial expenditure to set up, but it saves money and even earns a profit in the long run.

Robotics

For a long time in industry, industrial automation has been a significant notion. The term "automation" refers to the transfer of a portion of a production process, or even the entire process, to a single machine. Machines for processing and assembly, automatic material handling systems, and other applications where a machine performs work are all examples of automation.

Industrial automation evolves over time and in a progressive manner. It is also claimed that there are several levels of automation advancement. The first stage is to concentrate on the fact that manual labour is being replaced by machines, implying mechanization. The machine is also given in the man's controlling functions in the second step; these regulating functions are known as automated or numerical control. The final and most advanced level is fully automated manufacturing, in which objects are made directly from raw materials without the need for human intervention or effort.

Collaborative Robots

This section will provide an explanation of what cobots are and what their purpose is. To gain a better grasp of what a cobot is, definitions will be provided, as well as distinct sets and how the cobot functions.

Interaction between people and robots

One of the aspects impacting human-robot interaction is human-robot integration (HRI), which explains the exchange of information between robots and people. In order to interact, the robot and the human must share the same workspace and exchange data and information. The robot must be able to perceive, participate in, and recognize diverse communication scenarios in order for this integration to operate.

The many circumstances could be explicit, such as when a person speaks to the robot, or implicit, such as when a human, for example, points to an object. The robot must understand that it must engage in mutual activities like planning and recommending strategies, as well as be able to operate and move objects safely and efficiently.

Cobots

The cobot provide different benefits for this performance, such as virtual surfaces that are useful for the human operator since the human operator uses the payload as maneuvering. When it comes to the safety of the human operator, the cobots must be safe. For the cobot to certify safety, the cobot has sensors which make the cobot detect if any human motion is in the workspace of the cobot and also ensures the cobot to work at very slow speed or even stops to ensure the safety of the human.

2.RESEARCH METHODOLGY

Aim:

"Our work is inspired by advancements in robotic technologies for manufacturing, particularly cobots, and their potential to change human-robot collaboration on the potential implications of cobots in manufacturing".

Objectives

- The status of human-robot collaboration for assembly applications is reviewed and key current challenges for research community are presented.
- challenges highlight the future research directions in human-robot interaction for industrial applications
- To reduce the cycle time of the machining process by reducing the number of human interventions
- By monitoring the temperature of COBOT's joints, we can boost safety while working and ensure COBOT's health.
- To minimize Manual operation of picking, placing and performing other operation requires employment.

Hardware

- ATmega328P
- Motor Driver(L293D)
- Buzzer
- Dc Motor
- Power Supply
- Temperature Sensor
- Ultrasonic Sensor
- Touch Sensor

ATmega328P

There are hundreds of applications for ATMEGA328P:

- Used in ARDUINO UNO, ARDUINO NANO and ARDUINO MICRO boards.
- Industrial control systems.
- SMPS and Power Regulation systems.
- Digital data processing.
- Analog signal measuring and manipulations.
- Embedded systems like coffee machine, vending machine.
- Motor control systems.
- Display units.
- Peripheral Interface system.

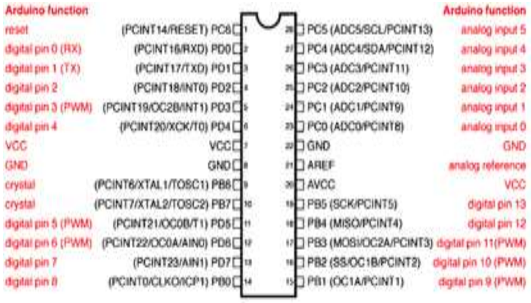


Figure1.2: Pin configuration

Where to Use ATMEGA328P

Although we have many controllers ATMEGA328P is most popular of all because of its features and cost. ARDUINO boards are also developed on this controller because of its features.

- With program memory of 32 Kbytes ATMEGA328P applications are many.
- With various POWER SAVING modes it can work on MOBILE EMBEDDED SYSTEMS.
- With Watchdog timer to reset under error it can be used on systems with minimal human interference.
- With advanced RISC architecture, the controller executes programs quickly.

Also with in chip temperature sensor the controller can be used at extreme temperatures

L293D (MOTOR DRIVER)

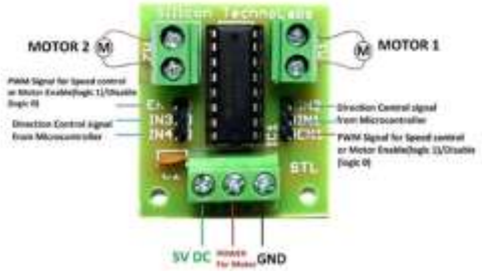


Figure1.3: Motor driver

Specification of L293D Motor Driver IC:

- ✓ Wide Supply-Voltage Range: 4.5 V to 36 V
- ✓ Separate Input-Logic Supply
- ✓ Internal ESD Protection
- ✓ High-Noise-Immunity Inputs
- ✓ Output Current 600 mA Per Channel
- ✓ Peak Output Current 1.2 A Per Channel
- ✓ Output Clamp Diodes for Inductive Transient Suppression
- ✓ Operation Temperature 0°C to 70°C.
- ✓ Automatic thermal shutdown is available

Working of L293D Motor Driver IC

There are 4 input pins for direction control in L293d. Pin 2,7 (1A and 2A) on the left side and pin 15,10 (3A and 4A) on the right of the IC. The left side input pins regulate the rotation of the motor connected across the left end and the right-side input pins regulate the motor on the right-side. The motors are rotated based on the inputs provided across the input pins as HIGH or LOW signals.

- Pin 2 = HIGH and Pin 7 = LOW | Clockwise Direction

- Pin 2 = LOW and Pin 7 = HIGH | Counter clockwise Direction
- Pin 2 = LOW and Pin 7 = LOW | Idle (No rotation)
- Pin 2 = HIGH and Pin 7 = HIGH | Idle (No rotation)

In a similar manner, we can control the motor on the right side connected to pin (11, 14). For this, we need to provide HIGH and LOW input signal across pin (10, 15).

- Pin 10 = HIGH and Pin 15 = LOW | Clockwise Direction
- Pin 10 = LOW and Pin 15 = HIGH | Counter Clockwise Direction
- Pin 10 = LOW and Pin 15 = LOW | Idle (No rotation)
- Pin 10 = HIGH and Pin 15 = HIGH | Idle (No rotation)

Buzzer

An Active Buzzer Alarm Module for Arduino is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Just like what you are viewing now, it is 3.3V-5V DC Electronic Part Active Buzzer Module. Using top quality material, it is durable in use.

An active buzzer rings out as long as it is electrified. Compared with a passive buzzer, it is a bit expensive but easier to control. Typical uses of buzzers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

Specifications of Active Buzzer Module:-

- ✓ Product Name: 3.3 to 5V Active Buzzer Alarm Module Sensor
- ✓ Transistor drive module uses 8550
- ✓ with fixed bolt hole- easy installation- 2.6mm aperture.
- ✓ Operating voltage 3.3V-5V
- ✓ PCB Dimensions: 34.28 mm (L) * 13.29 mm (W) * 11.5 mm (H)

Features

Passive buzzer features are:-

- Passive internal shocks without source- so if you cannot make it with a DC signal tweet. Must be a square wave 2K ~ 5K to drive it
- Sound frequency control- you can make a “more than a meter hair Suola” effect.
- In some special cases- you can reuse a control and LED mouth

Active buzzer features are

1. An active buzzer with a concussion internal source- so long as it will be called an energized
2. Program easy to control- SCM can let a high-low sound- while passive buzzer did not

Figure1.4: Buzzer Unit

Module interface specification (3-wire)

+ External 3.3V-5V voltage (can be directly connected with the 5v and 3.3v MCU MCU)

– External GND out external microcontroller IO port

Servo Motor

Figure 1.5: Servo Motor

servomotor is a closed-loop servo mechanism that uses position feedback to control its motion and final position.

The input to its control is a signal (either analog or digital) representing the position commanded for the output shaft.

Power supply

Figure 1.6 : Power supply

Brand : VGS MARKETINGS

Model Name : SMF UPS-Emergency Battery UPS

Model Number : 12V 7 Ah

Type : AGM

Voltage : 12 V

Capacity Rating : 7

Capacity : 7 Ah

Dimensions: Width = 15 cm,

Height = 6.5 cm,

Depth = 6.5 cm,

Weight = 2 kg.

Generic Name : Solar Batteries

Temperature Sensor

Figure1.7: Temperature sensor

The MAX31820 ambient temperature sensor provides 9-bit to 12-bit Celsius temperature measurements with ±0.5°C accuracy over a +10°C to +45°C temperature range.

Over its entire -55°C to +125°C operating range, the device has ±2.0°C accuracy.

Specifications

1. Breadboard Friendly: Yes
2. Sensor Type: Temperature
3. Typical Input Voltage: 3.3VDC
4. Operating Current: 1.5mA
5. Interface: Digital
6. Communication Protocol: Dallas 1-Wire

Feature

1. Unique one-wire interface requires only one port pin for communication
2. Each device has a unique 64-bit serial code stored in on board ROM
3. Multi drop capability simplifies distributed temperature-sensing applications
4. Requires no external components
5. Can be powered from data line; 3.0V to 3.7V power-supply range
6. Measures temperatures from -55°C to +125°C (-67°F to +257°F)
7. ±0.5°C accuracy from +10°C to +45°C
8. Thermometer resolution is user-selectable from 9 bits to 12 bits
9. Converts temperature to 12-bit digital word in 750ms (Max)
10. User-definable non-volatile (NV) alarm settings
11. Alarm search command identifies and addresses devices whose temperature is outside programmed limits (Temperature Alarm Condition)
12. TO-92 package allows measurement of ambient temperature
13. Software compatible with the DS1822 and DS18B20

Ultrasonic Sensor

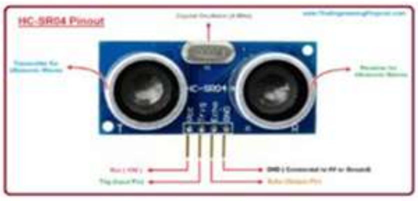


Figure 1.8: **Ultra-sonic Sensor**

- ✓ HC-SR04 is an ultrasonic sensor mainly used to determine the distance of the target object.
- ✓ It measures accurate distance using a non-contact technology – A technology that involves no physical contact between sensor and object.

Application:

HC-SR04 comes with a wide range of applications mainly targeting distance and direction measurements. Following are the major applications it can be used for

- Speed and direction measurement
- Wireless charging
- Humidifiers
- Medical ultrasonography
- Burglar alarms
- Embedded system
- Depth measurement
- Non-destructive testing

Cobot Programming

The programming process entails providing cobot with the ability to understand the state of the environment and perform actions that advance the system towards a planned collaborative goal. Traditionally, a human, the programmer, is only involved off-line for an industrial robot program.

These programs are inflexible and not human-aware, and cannot be altered during runtime, unless an error occurs and debugging is needed. Based on that, a robot functions in a deterministic environment in which an operator is not part of. However, in HRC, an operator adds stochasticity and unpredictability to the environment.

The human involvement in the cobot program goes beyond the programmer's traditional off-line role. The operator also becomes involved in the cobot program during run-time, or on-line.

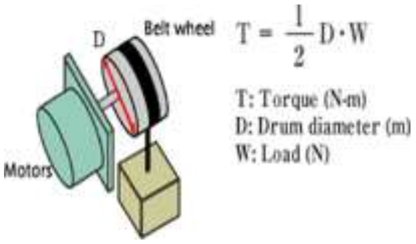
- ✓ **Communication:** An operator controls cobot through a communication channel that can be verbal (speech) or non-verbal. Non-verbal communication includes gestures, gaze, head pose, haptics and UIs. The off-line role of the programme is to program and define possible cobot’s actions and the underlying motion control. The on-line involvement of the operator is mostly explicit, triggering the cobot into pre-defined actions
- ✓ **Optimization:** Important aspects of cobot’s surroundings, such as obstacles and tool positions, are mathematically modelled as a function of the cobot actions. Those form cost functions that are optimized to generate desirable performance.
- ✓ **Learning:** A cobot learns a skill similar to how a human would, e.g., through observing demonstrations, trial and error, receiving feedback and asking questions. The off-line role of a programmer is to design the learning algorithm and provide initial data for the cobot to learn from.

Testing on Cobot

- ✓ Scope of cobots in testing Industry domains of testing applications
- ✓ **Functional testing:** Testing of physical action-based features of a device or module
- ✓ **Performance testing:** Consistent and rigorous testing of device inputs and responses
- ✓ **User testing:** Limitation of maximum possible user actions to cover DUT functionality
- ✓ **System testing:** Testing in tough or hazardous environment for end usage
- ✓ **Assisted testing:** Robot assisting human to perform repetitive tasks
- ✓ **Aerospace:** Cockpit operation,
- ✓ **User testing Medical:** Bench-top instrument testing, motion profiling for robotic surgery Industrial
- ✓ **Automation:** Machine tending, quality inspection
- ✓ **CPRD:** User testing of DUT, performance testing, GUI testing.

DESIGN& CALCULATION

The Motor Calculations



T = 1/2 .D.W

T = Torque

D = Diameter of Motor Shaft = 5mm

W = Total of Setup = 1Kg = 9.81=9.81N

T = 1/2 X 5 X 9.81 = 24.525 Nmm^{2}

= 0.024525 Nm^{2} Geared Motor

3 = Number of Motor are required

Assume the rpm of Motor to be as 60 rpm

So the the Motor we have Calculate as 0.024 N/mm^{2}

P = 2* PI * N T /60

= 2* PI* 60* 0.024/60

P = 0.150 Watts * 3

$= 0.452$ Watts

Material to Use In Developing the Clamps and Other Elements with Comparison

Aluminium is a versatile, lightweight, durable, and ductile metal. The benefits of aluminium versus steel are many. Compared to other metals, including steel, aluminium weighs less by volume. Aluminium is one-third the weight of other metals, including steel, brass, and copper.

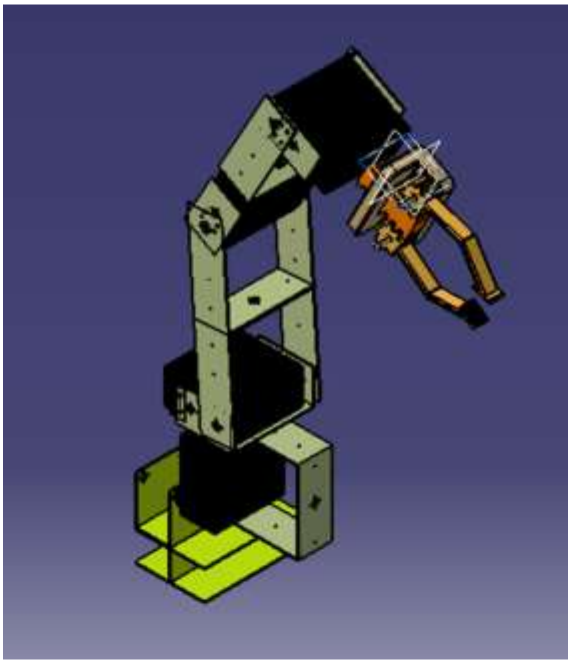
The arm cobot design will be mated to a new spherical CVT design currently in development. The previous spherical CVT design employed polyurethane in-line skate wheels. These softer rubber-like wheels allowed compliance and creep during CVT operation.

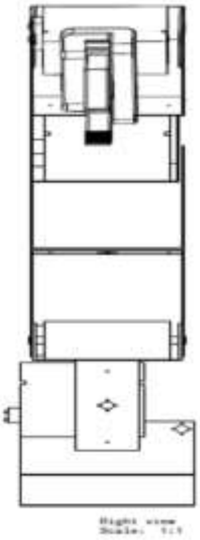
This compliance at the CVT is propagated out to the endpoint of the manipulator and is contraindicative to forming hard, high quality virtual constraints. The new spherical CVT design will employ metal-to-metal contact yielding a more controllable system with a compact design and a maximum sustainable input torque.

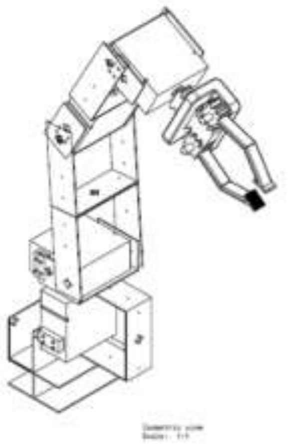
Cable and belt transmissions have been widely used in power transmission in which the belt or cable is run in only one direction.

In robotic applications it becomes necessary to accommodate for both positive and negative torques created at the joint of a manipulator. In this paper, the cable transmission design will consist of multiple pairs of capstans and complimentary pairs of cables for positive and negative torque

Joint stiffness and cobot arm weight are the main considerations during capstan design and cable selection to create a highly controllable.







IV. FUTURE WORK

The machine learning calculations enhance and different advances, for example, neuromorphic chips, empower more brilliant robots, we'll be seeing them do tasks that no one but people can do until now, with the exception of, by and large, they will have the capacity to improve.

They will have the capacity to get to incomprehensible databases, perceive individuals, machines and parts, have the capacity to determine bits of knowledge and follow up on them. That implies that robots will soon have the capacity to do short work, as well as analyze issues and devise arrangements.

They'll have the capacity to do schedule, highly monotonous work like the quality affirmation, assessing parts and completed items. Likewise, the cost of all that capacity will probably descend significantly as innovation advances and the cost of parts decreases.

V LIMITATIONS AND CONCLUSION

Our findings demonstrate the difference between the potential uses of cobots and their actual uses in real automation scenarios, and highlight specific barriers to closing this gap beyond those typically found in technology adoption. Changes to the way we design cobots and educate the workers and engineers who use them, such as those we suggest in our implications, may support a future automation workplace in which workers have an important role.

Our study is limited by a narrow representation of expertise cobots in automation due to a small sample that included only one worker. We focused on engineers and implementers to gain insight into the perspectives of those who design Cobot applications, but recognize the need for work that examines the worker perspective on these issues.

We believe future studies should expand on this work by examining these findings through the lens of workers and women in automation, with a larger more generalizable sample to better understand their actual use. We were also limited in looking at the use of robotic arm types of cobots that did not include other cobots, such as warehouse delivery cobots, in our study.

Future work that includes a larger variety of cobots may provide insights into the specific uses and needs for cobots in these areas, and recommendations that may exist for incorporating several types of cobots into one environment

References

1. Research Paper published by Mikklel Stein Knudsen, (2020), “Collaborative Robots: Frontiers of Current Literature”.
2. Research Paper published by Mustapha Aouache, Akli Isma (2019), “Human-Robot Interaction in industrial collaborative Robotics
3. Research Paper published by Shirine EI Zaatari (2018), “Cobot Programming For Collaborative Industrial”
4. Research Paper published by Tobias Kopp & Steffen Kinkel**,** (2020), “Success factors for introducing industrial human-robot interaction in practice: an empirically driven framework”
5. Research Paper published by, Vivekananda Shanmugaratnam, Lad Pranav Pratap**,** (2017), “Modeling and Control of Collaborative Robot System using Haptic Feedback”
6. Research Paper published by TSUKIYAMA Kazunari and TAKETA Saori, Omron Technics ,(2021), “Safety Design Method for Interactive Manufacturing System”

7. Research Paper published by Andrea Cherubini, Robin Passama, Andr´e Crosnier, Antoine Lasnier, Philippe Fraisse, (2017), "**"**Collaborative manufacturing with physical human-robot interaction"
8. Research Paper published by Eloise Matheson, Riccardo Minto, Emanuele G. G. Zampieri, (2019), "Human–Robot Collaboration in Manufacturing Applications: A Review "
9. Research Paper published by Helena Anna Frijns, Christina Schmidbauer, (2021), "Design Guidelines for Collaborative Industrial Robot User Interfaces"
10. Research Paper published by Martina Mara, Kathrin Meyer, (2021), "Cobot Studio VR: A Virtual Reality Game Environment for Trans-disciplinary Research on Interpretability and Trust in Human-Robot Collaboration
11. Research Paper published by Joseph E Michaelis, Amanda Siebert-Evenstone, David Williamson Shaffer, Bilge Mutlu, (2020), "Collaborative or Simply Uncaged, Understanding Human-Cobot Interactions in Automation"
12. Research Paper published by A. Adriaensen, F. Costantino, G. Di Gravio, R. Patriarca, Human Factors and Ergonomics in Manufacturing & Service Industries,, (2021), "Teaming with industrial cobots: A socio-technical perspective on safety analysis"

13. Research Paper published by David Bitonneau, Théo Moulieres-Seban, Julie Dumora,(2017), "Human-centered Design of an Interactive Industrial Robot System through Participative Simulations: Application to a Pyrotechnic Tank Cleaning Workstation"
14. Research Paper published by Ali Ahmad Malik,(2022) "Robots and COVID-19: Challenges in integrating robots for collaborative automation".
15. Research Paper published by Vinu Vijayakumaran Naira, Daniel Kuhna , Vera Humme,(2019), "Development of an easy teaching and simulation solution for an autonomous mobile robot system".
16. Research Paper published by Titanilla Komenda, Christina Schmidbauer,(2021), "Learning to share - Teaching the impact of flexible task allocation in human-cobot teams".