Manufacturing Processes and Automation (18WSP600)
Automation Coursework
Human-Robot Collaboration for future manufacturing

Introduction

Robotic systems have just turned out to be fundamental parts in different industrial sectors. Until now, robots have always been big, strong devices that are designed to work on specific task. To ensure the safety of the surrounding workers, the robots have been kept in hard guards and it requires high programming skills to set up these robots. While safety is one of the most important consideration in manufacturing systems, these robots need to have the ability to work safely alongside humans. Recently, the idea of Human-Robot collaboration has produced more interests. Human workers have exceptional critical thinking aptitude, sensing various capabilities of the machine ,but are confined in precision(Green *et al.*, 2008; Krüger, Lien and Verl, 2009). So, this Human-Robot collaboration can minimize the working gap between the human and robots by increasing the overall performance.

Human-Robot Collaboration

Human-Robot collaboration is also termed as Cobot (short for collaborative robots) is the passive mechanical device introduced to support and aid humans in solving industrial tasks (Colgate and Peshkin, 1992). These robots directly collaborate with human workers as a team to solve industrial task or serves as an assistant alongside the human workers. Nowadays manufacturing companies are trying to implement safety working zones where the collaborative robots will be the suitable device as it can provide higher speed, higher repeatability and better productivity.

These robots are designed with additional safety features that can work around humans and there are four types of collaborative features of robots that are Safety Monitored Stop, Hand Guiding, Speed and Separation Monitoring and Force Limited Robots (Bélanger-Barrette, 2018). Safety Monitored Stop will be discussed in the following section.

Hand Guiding- Some robots have the collaborative feature of hand guiding or path teaching. It is a simple technique for the programmer to teach robots what to do. The robots are taught to position by simply moving the robots with their hand to the desired position (*Patti Engineering*, 2018).

Figure 1: *Robotiq FT300* (*Robotiq*, 2018).

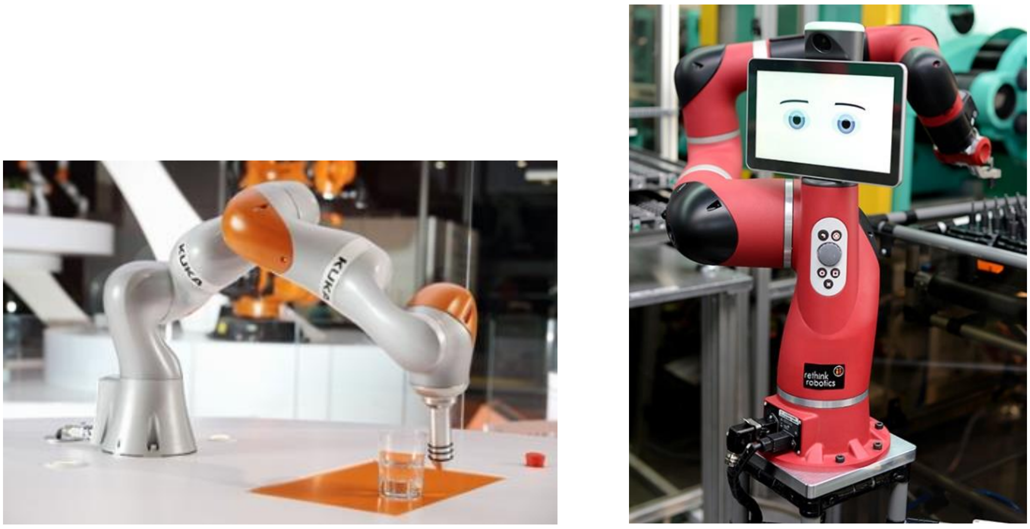
The most popular device for this type of collaboration is a Force Torque Sensor such as Robotiq FT300 in Fig 1. It is device that are built for compatibility with universal robots, reads the forces applied on the robot tool and hand-guided robot movements (*Robotiq*, 2018). The robot still needs to have safeguarding in workplace when its functioning in other modes.

Speed and Separation Monitoring- This type of robot is suitable where the workers are constantly interacting with the robots. The working speed of the robot is automatically controlled when the employee enters the robot zone, it slows down its process when they enter Danger zone and stops when the employee enters stop zone, the robot pauses until the employee has left the zone. The robot automatically resumes its operation once the employee leaves the zone (Bélanger-Barrette, 2018). One of the examples of this robot is Yaskawa Motoman robots (America Yaskawa, 2017), which has the vision system to detect the proximity of the worker and improved efficiency.

Force Limited Robots- These robots have a built-in force torque sensor which detects the impact and abnormal forces. These robots are designed to work alongside human without any additional safety devices. When the employee hits the robot, it detects the event of collision and stops to ensure the safety of the workers. No need of fencing or other vision systems when the robot is properly configured (*Patti Engineering*, 2018).

Some of the Industrial collaborative robots are ***Universal Robots (UR3, UR10), Rethink Robotics (Baxter, Sawyer), KUKA (LBR iiwa), ABB (Yumi), Fanuc (CR-35iA).***

Modular robots are used in the manufacturing industries and also construction site for material distribution process, which extensively includes material handling tasks (Gambao, Hernando and Surdilovic, 2012). These collaborative robots are flexible, easily accessible and could perform high-tech handling tasks making the human-robot interaction easier.



(a) ***(b)***

Figure 2: (a) *KUKA's iiwa Pick and place glass of water* (Bernier, 2013) ***(b)*** *Sawyer Robot at work place* (*Rethink Robotics*, 2018)

Safety of Collaborative Robots

Collaborative robots should have controlled risk to allow employee access to the robots. One of the collaborative features is Safety monitored stop, allowing the employee to enter its workspace to perform a secondary operation (Bélanger-Barrette, 2018). For example, if an employee wants to perform a task while the robot is still handling the part. The robot stops its work and brakes are on until the employee leaves the workspace.

Safety plays the important role between the human-robot interaction. Thus, the safety requirements in manufacturing environment explained by *A.Zanchettin* (Zanchettin *et al.*, 2016) as the robot velocity to be reduced when the distance between the human and robots becomes smaller. On the other hand, the robot velocity should return to normal when the separation is larger. So, the safety is ensured by the separation distance between the human and robot as graphically represented in Fig 3.

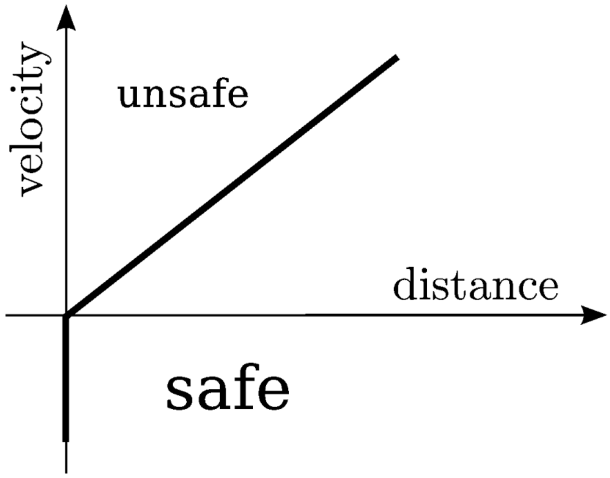


Figure 3: *Graphical representation of minimum separation distance* (Zanchettin *et al.*, 2016).

The robots are designed for collaboration based on three working zones namely, Zone A, Zone B and Zone C as shown in Fig 4 (Tan *et al.*, 2010). Zone A is defined as the high-risk zone where the robots operate in high speeds, but the movement is low in Zone B. In Zone C which is within human area, restrictions in speed is applied.

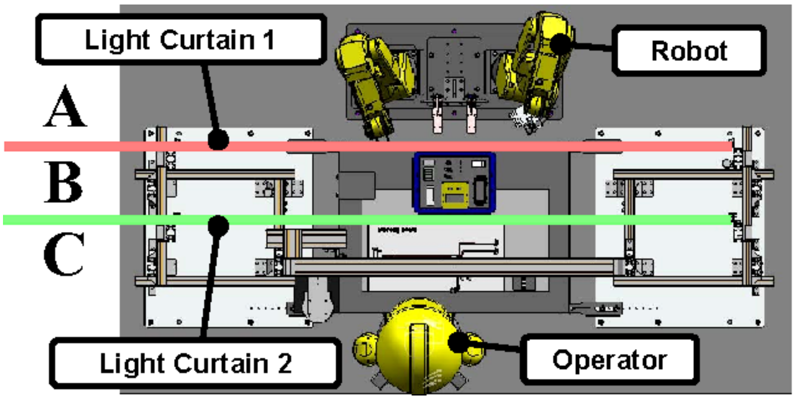


Figure 4: *Safety robots working zones* (Tan *et al.*, 2010).

Some of the safety standards are used for robots and machinery. The International Organisation of Standardization is responsible for reviewing standards for industrial robots and enabling the safe use of the new technologies. The latest safety standards for robots in Europe is ISO 10218-1:2011 and ISO 10218-2:2011 for robot systems (Fryman and Matthias, 2012). And no collaboration robot should be implemented without completing the risk assessment.

Benefits of Cobots in industry

Collaborative robots are redefining human-robot relationship across the manufacturing industry. This set up can increase the efficiency of the work as the humans and robots work at the same workspace. The efficiency increases the production typically in the larger industries. It is also suitable for small-scale production industries as it doesn’t require a high setup process and can be used for the cutting, shaping, lifting and packaging purposes (*RoboticsTomorrow*, 2017). Due to its better efficiency and flexibility, industries experiences increased Return of Investment reducing the labour and maintenance cost. The collaborative robots are able to safely handle the complex and dangerous task (*Kundinger*, 2017) which prevents the human error causing an unwanted loss to the production unit.

Other than Manufacturing industry, the collaborative robots are also used in medical and entertainment industry (Beaupre, 2014). In medical industry, robot-guided LINAC is used in radiation surgery where the robot is positioned providing optimal delivery angle.

Future of Human-Robot collaborative robots

Collaborative robots capable of safely working alongside human workers with a few applications such as packing, quality testing, assembly, welding and many more are expected to experience the largest growth in the industries. According to recent report by global robotics, collaborative robots are expected to jump from 3% to 34% of all robot sales (*Collaborative Robots Market Update 2018*, 2018) in 2025.

Some of the upcoming collaboration robots are DENSO WAVE – COBOTTA, which is going to be a super-safe lightweight table top robot (*CobotsGuide.com*,2018), TATA – BRABO, which is the first “built in India” robot (*India Today*, 2016).

Conclusion

This paper began by showing the need for the human-robot collaboration and its features while operating in the industry. Safety measures to be ensured and risk assessments of the collaborative robots are discussed. The benefits of the cobots in the automation industry is reviewed and discussed on the future scope of the collaborative robots. Thus, implementation of collaborative robots in the manufacturing industry can reduce the complexity of material handling and increase the efficiency between the human and robots performing difficult task.

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