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The Use of Collaborative Robots in Manufacturing.

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Introduction

In the age of technology, robots are becoming prominent in factories across the world. They are implemented to become more cost and time efficient, whilst saving space and increasing productivity of the current workforce. Traditional robotic technologies have been used in industry for over fifty years (Sakovich, 2019). Manufacturing processes can utilise methods to increase their efficiency by combining traditional operating methods, robots, and collaborative robots (cobots) to increase manufacturing efficiency.

The aim of this assignment is to investigate how the introduction of cobots can influence manufacturing processes. Although cobots can improve cost, efficiency, and safety there are concerns over jobs for employees, operator perception and implementation of these methods.

Fundamental principles

Robots have been utilised in manufacturing for some time, cobots however are designed to be safer, coinciding with the human workforce. Unlike traditional industrial robots, which require safety fencing and other measures, cobots are designed to work alongside humans. For example, some cobot technology utilise sensors which can detect the proximity of staff and immediately cease production if required (Elprama, et al., 2016). This is a growing area of manufacturing, expected to reach \$3 billion by 2020 (Shirley A. Elprama, 2016), and \$5.7 billion in 2027. (Xiao, 2019). Cobots can be used for a range of processes, including strength amplification, pick and place and guidance of objects (Maurice, 2017) (Zeng, et al., 2018)

When “robots” and “manufacturing” are said in the same sentence it is natural to assume that robots will take every human job; however, this is not the case. The design of a cobot is to work with operating roles into higher skilled programmers and maintenance technicians (Esben H. Østergaard, 2017). There is a significance in this collaboration because robots are only as clever as they are programmed to be. By this, robots can only replicate what a human has told it to do. It cannot use experience or think of a new method to achieve a role (Esben H. Østergaard, 2017) (Vysocky & Novak, 2016). Whilst cobots are flexible and can undertake a new task, even if it has not been programmed to do so.

With the growing accessibility of cobots, and how manoeuvrable they are, they can be transported from a mirrored assembly line, where the cobot can be programmed and tested before going onto a fully functional assembly line. By doing this it ensures that the downtime on the assembly line is minimal, whilst the introduction to the operators and process is in its early phase where it is still being understood on its possibilities. Once the cobot is in place, it is very easy to update and change its programming. A laptop with the appropriate software will function as a “plug and play” system, and the cobot can give exact readings of its operating readings without causing the production line to halt.

Cobot design

Cobot design varies depending on industry and use. There is testing currently underway for cobots to recognise hand signals from humans, as audio cues in loud factories would be very difficult. (Ilias El Makrini, 2018) developed a method by which hand poses could be detected by sonar/red-green-blue (RGB) video which would allow for command recognition. This would be beneficial for repetitive pick and place tasks, where an image of the component would be visible on a screen and the cobot will move the part to the required location. The cobot can be responsive with a range of responses from hand gestures shown in *figure 1*.



Figure 1 Hand gestures used for COBOT cues. (Ilias El Makrini, 2018)

These gestures could be used to change tasks for example, from pick and place to assembly. The use of gestures increases the adaptability of cobots and could be utilised to alternate between tasks, even those not previously learned (Association, 2020). Studies also suggest that the use of these gestures and social cues will help people accept cobots into the workplace. (Elprama, et al., 2016) As well as recognising hand gestures, future cobots could be programmed to utilise facial recognition. This could be used when working in larger groups to understand how certain individuals work within a team and respond accordingly; such as knowing how quick on average a task is completed on person A, the cobot could change its tempo to accommodate that worker.

Traditional manufacturing processes

A human operator is perfectly capable of doing repetitive tasks for their working day, whether they are efficient at the role is different, however. Over the period of an average 8.5 hours a day, a human cannot physically or mentally work at a maximum rate for that length of time, even with the breaks allowed (Skidelsky, 2018). When comparing the efficiency of a human to that of a cobot at completing a repetitive movement, the human will suffer from motor fatigability. This is when the action speed begins to slow down over an extended period (Marc Bächinger, 2019).

Humans are limited by fatigue, human error and can also introduce safety and managerial issues within the workplace. Therefore, the introduction of cobots into the production line is extremely beneficial.

Use of cobots in manufacturing

Automation of processes is a common strategy used in industry to maintain competitiveness in production, this is especially the case in wealthy countries (Schröter, 2016). The automotive industry utilises traditional robots routinely, for example, in the body shop executing high accuracy joining of heavy loads. Alternatively, engine assembly is less automated as this is considered a more flexible and complex operation traditionally completed by trained operators. In this setting, cobots offer a productive solution to this by working to support the operator (Schröter, 2016). Traditional robots tend to be preprogrammed and are unable to adapt to the human workforce or identify their own errors (Kragic, 2018). Due to their flexibility and compact size, cobots however can fit into almost any manufacturing role. Pick and place, soldering, drilling, assembly to name but a few (Zaataria, 2019). These actions are traditionally human tasks that are repetitive and will always carry a margin of human errors such as lapses, violations, or mistakes (HSE, 1999). Cobots can be utilised in these situations to improve production efficiency. They can be used in bottleneck areas where there is a high input rate but a low capacity of output, the cobot will perform accurate tasks at a higher speed than humans when programmed and implemented correctly. These parts will not need reworking, due to the consistent conditions of the cobot, easing the bottleneck in this process but moving it up the production line (Zaataria, 2019).

Ethical impacts

The use of cobots in production may increase supply chain control as operators use a more consistent method. In addition to this, the increased safety protocols installed in cobot systems may create a safer working environment. However, the implementation of these technologies is often met with resistance as operators feel their jobs are threatened. Much of the research into cobots focuses on the technology used in their design. Increasing their safety, capabilities, and flexibility. With the increased use of cobots in production however, there is the risk to the human workforce linked to job security. Despite concerns over cobots replacing the operator, many found that the cobot reduced their workload. Some early studies have shown that cobot design is linked to operator perception of the machine (Elprama, et al., 2016) (Sauppe & Mutlu, 2015). Cobots able to respond to social cues and gestures are better received by operators. Anthropomorphic designed cobots, with human like features such as arms and eyes have also been tested (Elprama, et al., 2016). More work is required into this area to improve operator use and perception of these machines.

Health and safety

Safety is a key component in any manufacturing line, the use of cobots relies on the programme that it will function as intended when faced with a threat. The danger will almost always come from human error, as using the theory of industry 4.0, cobots communicate with each other and will not collide. Humans however are unpredictable, and the reason why cobots are equipped with pressure sensors (UniversalRobots, 2020) (COBOTS enables Xiamen Runner Industrial Corporation to achieve flexible manufacturing., 2017). The cobots themselves will have 0 to minimal pinch points visible (where a hinge or moving part is found) to protect people around it (Briefs, 2019).

Almost 50% of industrial workers report musculoskeletal problems linked to their job, this is a significantly high proportion of the workforce (Maurice, 2017). This is linked to the often-strenuous nature of production line work in addition to poor posture in the workplace (F. Caputo, 2018). Studies have suggested that poor posture may be designed out of production (Maurice, 2017). Cobot assistance can be utilised to help reduce injury in the workforce. This solution is best utilised for tasks which are complex yet physically demanding, allowing co-manipulation of objects by the workforce with the help of a cobot. The worker can use the cobot system to reduce the physical demands of their role whilst reducing risk of injury and increasing efficiency. For this to be successful, an appropriate ergonomic assessment of the robot-worker system is required. This can now be completed by digital assessment and design which can decrease cost as well as development time (Pauline Maurice, 2017).

Impact of cobot use in manufacturing

The COVID-19 pandemic has highlighted the benefits of cobots in manufacturing. Since February 2020, Europe has seen thousands of manufacturing sites grind to a halt (BBC, 2020), as most were deemed non-essential. However, in May the same year many of these sites have been given the go ahead to start production but only if social distancing measures of at least 2 meters can be put in place. Companies have found it extremely difficult to begin where they left off in terms of output. Compared to companies that already have cobots implemented, they can be used at a much higher congregation to human input, to keep the human interaction low whilst programming the cobots to work in tandem to increase productivity. *Table 1* summarises the advantages and disadvantages of cobot use in manufacturing.

Cobots can be utilised as part of a hybrid manufacturing process, with the use of humans and supplementary cobots. Classic automation of processes by robots can be expensive. Cobots however can be used to lower unit cost in production where complete robot automation is not viable as they can increase the efficiency of the workforce. The design of these hybrid systems must be considered

as it is often a complex and costly process. Operator and cobot tasks must be designed in an efficient way (Schröter, 2016). The use of cobots introduces a dynamic system enabling operators to work more efficiently, reducing production times, and increasing output (Kragic, 2018)

Advantages of cobots	Disadvantages of cobots
• Can be programmed to complete repetitive tasks with increased efficiency. • Reduce musculoskeletal problems in operators. • Utilised collaboratively with operators. • Programmed with safety features to enable human interaction. • Improve operator productivity. • Increased semi-automation of more complex tasks. • Increase efficiency and productivity of manufacturing processes.	• Complex design to utilise operator and cobot. • Initial increased cost linked to installation and planning. • Potential operator concerns. • Difficulties planning implementation of cobots in an existing manufacturing process.

Table 1: Table showing advantages and disadvantages of cobots in the workplace.

These disadvantages can be addressed in a manner that will make both employees and company content with the introduction of cobots. By having a dedicated team to understand how to fully utilise cobots to their full potential and understand where they can be used successfully. This will lower the failure rate of cobot introduction, becoming a cost and time effective process. The team could include a selection of operators, management, and a specialist in cobots to understand the potential. Including operators can cause discussion on how changes can be introduced to ease concerns and feelings of unease on the production line. Whilst a cobot specialist discusses any problems that arise.

(Schou, et al., 2018) stated that on floor operators can programme cobots by using device primitives such as a force sensor, camera, and robot arm to teach the cobot basic skills that are then utilised at a higher level of technicality. The cobot is taught skills that remembers parameter that has been set for a task, these skills can either be taught through programming and setting the parameters initially, or by a human operator doing the task whilst the cobot has been attached to key points of movement on an operator. These skills can be executed instantly.

Comparing the time it takes for a human operator to learn new skills and to complete them unsupervised and consistently it could take months to train to a high standard. The cobot has a minimal negative affect on the production timing as they can be programmed within minutes. (PPMA, 2020)

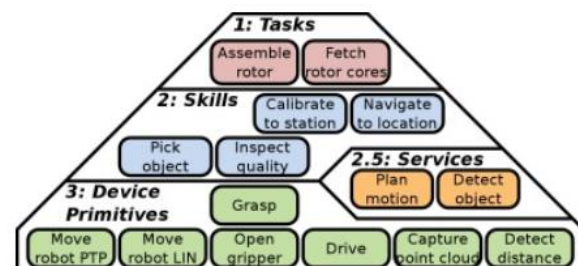


Figure 2 (Schou et al., 2018)

The price of a cobot with a 5kg payload, the UR5 – which is a low-medium grade cobot costs £28,000 (Bélanger-Barrette, 2020). The start-up cost is high compared to the monthly average salary for a factory operator in the UK at £8.71*40hrs*4= £1,395.2 before tax. (Indeed.co.uk, 2020) This equals an annual cost of £16,742.4 before tax.

The difference in price will benefit the company to invest in a cobot, due to the predictability of the cobot compared to humans, as discussed in this paper.

Other uses

There is increasing scope for the use of these assistive robots in many other fields including medicine. The use of cobots during medical surgeries is being tested and developed which again offers the benefit of reduced human error and fatigue. There are already examples of surgeons practising surgery with the aid of cobots and VR technology.

Using non-destructive quality testing methods to touch and inspect high tolerance components would be a realistic achievement (Blyler, 2020).

Conclusion

In conclusion, there is still a demand for using humans in a production line. However, the overall health of employees in a factory, that are doing menial tasks such as pick and place would benefit greatly from cobots being implemented. For my company that relies heavily on factory workers to maintain a high and accurate workload, having cobots that can do exactly that whilst operating at a continual speed would increase the whole production process. Specifically, in the pick and place and assembly lines. This would also lead to less low skilled jobs in the area, with a higher demand for roles such as maintenance and programming, which would decrease the musculoskeletal problems from the repetitive tasks and increasing the local economy with richer job roles.

Although there is a higher initial cost, the capacity of the production line increases with a higher accuracy, meaning there is more product output. Along with the time efficiency of training a cobot to that of a human, I believe a push for implementing cobots into the production line will be extremely beneficial to my company.

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