Transforming Factories Through Human Machine Collaboration

Dr.M.N. Vimal Kumar, Associate Professor, Sona College of Technology, Salem, Tamil Nadu, India.

vimalkumar.mct@sonatech.ac.in

Introduction

The concept of automation, during much of the industrial age, has been that of automation as a replacement for humans – machines which would take up tasks from workers that were either monotonous, physically tough, or dangerous to them. This conception of automation is slowly being replaced by a more sophisticated one, wherein human-machine cooperation is seen as the norm, where robots, intelligent machines, and workers work alongside each other doing what they do best (Figure 1).

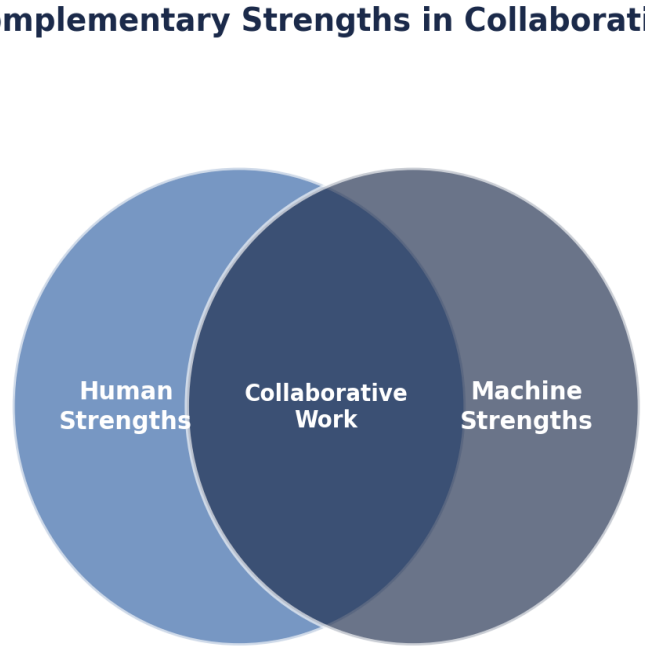

Figure 1: Process overview

This research will examine the history and development of human-machine cooperation within manufacturing, technologies that facilitate such interaction, benefits that accrue from such cooperation, and challenges organizations face in harnessing this process fully.

Automation to Collaboration

The traditional industrial automation era was marked by a distinct segregation of labor performed by humans from labor performed by machines. The machines used to function within protective enclosures and perform rigid tasks as programmed. Human beings on the other hand, stayed safely out of the way of robots. Such a system offered great efficiencies in mass production. However, it was not flexible enough to meet the needs of today's dynamic markets.

With the emergence of collaborative robots (Cobots), and technological developments such as sensing, computer vision, and artificial intelligence, things are done differently now. Machines are able to operate in the presence of human beings, sense their presence, and react accordingly, in order to ensure that no harm comes to anyone involved. This has led to shared workspaces, whereby humans and machines collaborate to do tasks together.

Complementary Strengths: Why Collaboration Works

The basis for human and machine cooperation in the manufacturing industry comes from the fact that humans and machines have very different sets of skills and capabilities when performing tasks in manufacturing.

Machines are precise, reliable and tireless in nature. Machines can repeat the same actions consistently thousands of times and they do not tire out. Machines are able to perform the tasks which are dangerous and demanding. Machines have high tolerance levels. The example could be micron assembly and operations which involve high heat temperatures.

Humans, on the other hand, are good at making judgments and solving problems. Humans are adaptable and can interpret vague circumstances. In addition, humans can use their past experiences to make decisions and solve problems quickly. Humans have manual dexterity and fine motor skills that still are impossible for robots to achieve under unstructured environments. Besides, humans can exercise judgment of the quality beyond just passing or failing.

Thus, by combining those capabilities, cooperative manufacturing environment is able to reach the results which could not be achieved by either humans or machines working separately.

Technologies Behind Human and Machine Cooperation

Collaborative Robots (Cobots)

As opposed to traditional industrial robots, cobots are explicitly engineered to work together with people in close proximity without causing harm. With such technologies as force-limited joints, collision sensing, and integrated safety mechanisms, cobots can slow down or even stop themselves in case a human worker enters their area of operations without the use of additional protective fencing.

Computer Vision and Sensors

Modern computer vision systems provide machines with the ability to analyze their surroundings, detect both objects and human workers, and adjust their actions depending on what is going on around them. In combination with depth sensing and motion sensing, such systems help machines predict human behavior and act ahead of time.

Wearable Technologies

Such devices as exoskeletons, augmented reality (AR) glasses, and others enhance people's capabilities directly, minimizing the physical burden of hard work and providing information on how to complete complex operations.

Artificial Intelligence and Machine Learning

The use of artificial intelligence in collaborative robots is increasing as such systems now can forecast maintenance requirements, provide optimum task assignment between people and machines and enable machines to learn through human demonstration without having to code each specific task manually.

Digital Twins and Simulations

Digital twins' technology enables manufacturers to simulate and model collaborative procedures between machines and humans in order to detect possible hazards, inefficiencies and ergonomics issues and optimize processes in a simulated environment before deploying them in real-world settings.

Operational Advantages of Human-Machine Collaboration

Firms that have implemented human-machine collaboration successfully tend to achieve advantages in a number of performance areas.

Greater flexibility Collaborative processes are easier to reconfigure than conventional automation processes and thus manufacturers gain increased flexibility in terms of shorter production runs, varied product range and increased need for changes.

Higher quality Collaboration through a combination of machines and human intervention will allow to get better and more consistent results in terms of quality, especially for operations requiring both precision and judgment.

Increased safety and employee Well-Being The delegation of physically intensive, repetitive, or hazardous operations to robots, while leaving complex and challenging operations to humans, will help prevent workplace injuries and increase job satisfaction, which is an important issue with manufacturing operations.

Easier implementation of automation as cobots and collaborative systems are simpler to program, reprogram, and deploy compared to industrial automation, companies, including smaller ones, will be able to automate their processes without significant engineering expenses.

Development of employees' competencies. Human-machine collaboration changes the nature of people's jobs to be supervisors rather than performers of operations, which allows workers to learn and acquire new skills.

Organizational and Cultural Issues

To enjoy all the advantages of human-machine collaboration, manufacturers will have to take into account several organizational and cultural issues.

Worker engagement and trust Initially, workers might be suspicious about collaborative automation, especially because of growing concerns about automation and employment losses. Successful projects include involvement of workers during implementation, explain how their roles will change and show how the technologies will complement rather than replace human labor.

Worker training. With roles of workers shifting from performing tasks to supervising and handling exceptions while working together with smart machines, companies need to create training programs where workers acquire skills necessary for efficient cooperation with technologies, such as troubleshooting, interacting with the system and interpreting data.

Reconfiguration of jobs and workflows Efficient human-machine collaboration sometimes involves not only using collaborative technologies but redesigning job descriptions and workflows to make this collaboration possible. It can include changing task division, shifts and performance metrics.

Safety governance Despite the fact that technologies are safe by design, companies have to implement safety protocols, evaluate risks of each collaborative application and monitor safety systems regularly to ensure that everything works properly.

Challenges and Limitations

While human-machine cooperation holds much potential, it also faces several obstacles. Cooperation with existing legacy systems might be complicated and costly, especially in facilities that were not built to support such cooperation from the start. In spite of relatively low cost of cobots, their integration with other equipment, as well as creation of safety systems and implementation of sensors, may require significant financial resources to begin with. Moreover, identifying the right split of labor between people and machines might be challenging for some processes.

Another challenge lies in using automation where it is unnecessary, as well as in underusing it when people have to perform tasks which could be automated and made safer or more efficient in the process.

Looking Ahead

With collaborative technologies developing further by increasing their capacity, decreasing costs, and becoming easier to implement, the line between man and machine in the factory of tomorrow is likely to be less distinct. Those manufacturers that think about this trend carefully, and that invest in technology as well as people, are in a position to create a factory that is efficient, adaptable, and tuned in to the needs of its workers (Figure 2).

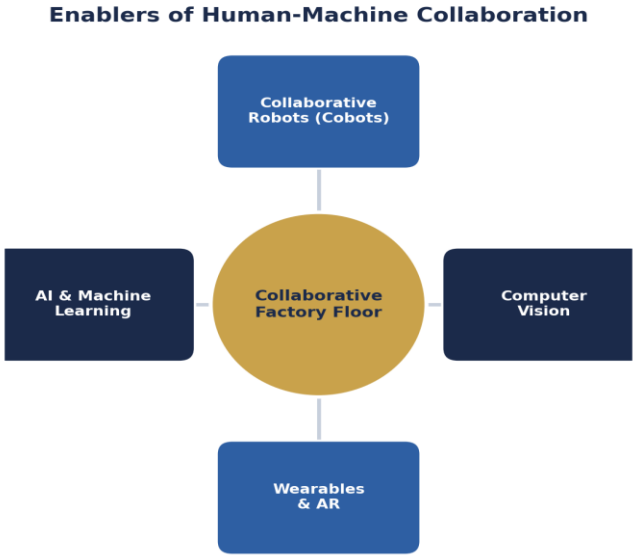

Figure 2: Key framework at a glance

Conclusion

The partnership between humans and machines is an entirely new vision of the future factory, where robots and intelligent systems do not simply serve as substitutes for human labor but as partners whose functions help humans enhance their capabilities. By merging the qualities of machines (such as precision, durability, and reliability) and the qualities of human beings (including rationality, flexibility, and the ability to solve problems), the combination of human and machine workers can produce something more flexible, more productive, and of better quality than each party could do independently. To unlock such potential, however, it takes not only the proper use of technology but also careful consideration of how to engage the workforce and create safe workplaces.