Repurposing factories with robotics in the face of COVID-19

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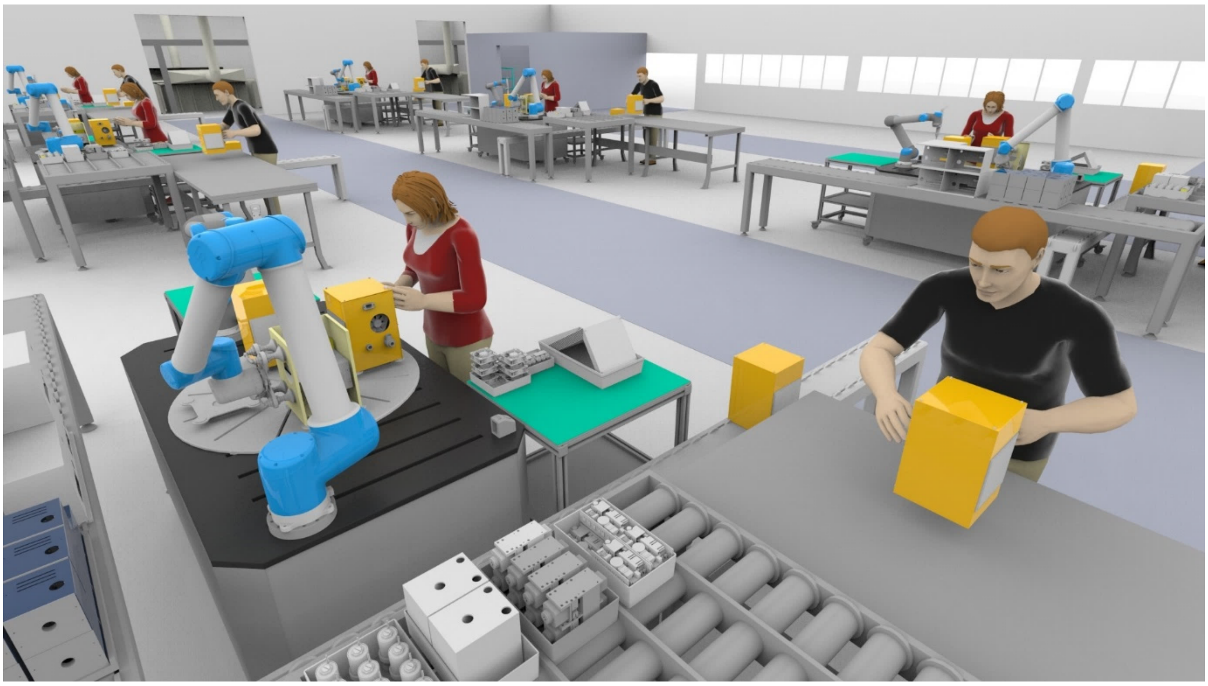

Highlights

- Can collaborative robots ramp up the production of medical ventilators?

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Repurposing factories with robotics in the face of COVID-19

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Abstract: *Can collaborative robots ramp-up the production of medical ventilators?*

Movie 1: Human-robot teams to ramp-up production of ventilators (1:31).

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COVID-19 has affected more than 4.5 million people (confirmed cases) with 307,565 confirmed casualties by 17 May 2020 [1]. The World Health Organisation (WHO) estimates that one in every six COVID-19 patients will need artificial breathing support through medical ventilators in intensive care units (ICUs). At the start of the pandemic there were 62,188 ventilating machines available in USA [2], this accounts to one ventilator for every 31 patients requiring ventilation support [3]. The EU average of available ICUs was 11.5 for every 100,000 population while this average was 3.7, 3.6 and 2.5 for India, Bangladesh and Pakistan respectively - the three most populated countries in South Asia comprising nearly one quarter of the global population [4]. Crucially, not all ICUs are equipped with mechanical ventilators. The situation is worse in Africa where 10 countries have no ventilators at all, while the WHO estimates that there are fewer than 2,000 working ventilators to serve 41 African countries [5].

Ramping-up the production of ventilators is clearly very high on many national agendas. Governments across the world have been encouraging medical and non-medical device manufacturers to repurpose their factories to increase the production of ventilators. Manufacturers such as JCB, Rolls Royce and others will need to take a range of actions from sourcing design and manufacturing information to tooling up production lines and training workers to assemble and test the ventilators, all of which may take months to complete.

Meeting this high demand is also challenging because existing manufacturing systems, aimed at mass production, are designed with automation solutions that are not flexible enough for large scale reconfigurations [6]. There is a lack of general-purpose automation solutions while many processes, such as assembly, require a high level of human involvement.

While conventional automation has been effective in substituting human efforts (relieving them from physical tasks and boosting production volume) it can't coexist with humans. Correspondingly, in the time of current pandemic, very few companies are equipped with sufficient technical and human resources that could help address the rising demands amid supply chain disruptions. Moreover, they are not specialised in producing ventilators.

In recent years there has been interest in deploying robots as co-workers, referring to them as collaborative robots (or cobots). Cobots have emerged as a new class in industrial robotics [7]. They don't require closed-off areas. Instead, by combining the flexibility of humans and strength of robots, they can cooperate or collaborate to share the workload. Furthermore, they are simple to program (or repurpose) and are more portable than existing approaches. Cobots have been successfully integrated into several industrial applications in the past years from simple to complex tasks.

The cobots can help in a time of pandemic by:

- Ramping-up existing ventilator production by automating approximately 40% to 50% of assembly tasks (case studies of cobots in other production domains [8] exhibit high automation potential for pick and place, screw driving and gluing tasks that are also used in the production of medical ventilators)
- Repurposing existing non-ventilator (e.g. airplane, jet engine, car, digger or vacuum cleaner) production to ventilator production
- Curtailing person-hours by half will reduce the number of human operators required (the relieved operators can stay at home or do other essential duties)
- Maintaining social distancing in factories
- Providing a resilience measure for future production

Strict social distancing measures brought by COVID-19 not only reduce the number of people able to go out for work but also introduce challenges for those working in factories as well. Cobots, as machine-colleagues of humans, can support the social distancing strategies on the factory floor.

Re-purposing a factory requires adaptability to new tasks and requirements. A responsive and evolvable human-robot collaborative (HRC) system can be designed exhibiting a modest initial production capacity but with the ability to add additional capacity and functionality as the demand fluctuates [9].

Modularization can be an ideal solution for achieving reconfigurable HRC assembly systems. Fluctuations in demand can be addressed by adding general purpose, portable and ready to deploy hardware modules to the existing system, for example cobots with varying mechanical design, price, and safety features may be used to accomplish different types of tasks. The approach is analogous to the toy construction bricks. The concept of 'ready to deploy' hardware also exists in military settings and health service units, but it is currently limited in manufacturing because manufacturing systems are designed to have long lifecycle (> 20 years) and custom-built hardware.

A large part of the cobot programs can be reused to reprogram the cobot for new jobs assigned with variation in ventilator design or change in pick and place locations. Standard programming templates for common robotic tasks (such as palletizing, pick and place, machine tending, screwing) can support faster integration and reconfiguration.

Maintaining a digital twin of the HRC system could also be useful for validation of future modifications. A digital twin as a data connected simulation can create insights into the operational behaviour allowing optimizations before bringing solutions into the real world [10].

Cobots in combination with modern digital manufacturing technologies can be useful for production ramp-up in emergency situations. Technological enablers such as modularization, ready to deploy hardware, software templates and digital twins can be combined for faster integration, reconfiguration, and safety validation [9]. However, safety of the coexisting humans remains a constant challenge. Joint efforts are needed to evolve standards to integrate robots as teammates.

Manufacturers hold a history of facing harsh market fluctuations in the face of socioeconomic crunches often requiring them to upscale or downscale their capacities or to make products they are not experienced with. Uncommon results are often delivered through unconventional measures that often become the new normal of producing things. The learnings from using cobots during a pandemic may potentially be a step forward towards human-robot teams in future factories, which are more resilient to pandemics.

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