Automated Robot Cranes for Ports

DETAILS

SECTOR | Transport and Energy

STAGE | Operations and Maintenance

TECHNOLOGIES | Artificial Intelligence, Sensors, Cameras

SUMMARY

Automated Robot Cranes (ARC) are cranes that are integrated with Artificial Intelligence (AI) technology. The ARC can perform tasks autonomously or be controlled remotely by humans. ARC have object detection capabilities which enable them to identify workers or objects nearby in order to avoid collisions, accidents and delays during operations. The popularity of ARC is growing, particularly in the freight and logistics industry. ARC can be installed at shipping ports and container terminals to replace traditional driver operated cranes. To transition to ARC, operators need to undertake multiple changes in the existing infrastructure (including the control centre, maintenance facilities and communication system upgrades).

An efficient and affordable freight industry is important to enable world trade. About 90% of the world's commodities are transported by the international shipping industry[1]. The numbers of shipping containers that are transported between ports around the world is increasing as economies grow. As this demand increases, port operators need to improve their operations efficiency to meet this demand.

Traditional cranes perform repetitive and routine tasks and require skilled workers to operate them. These tasks can require considerable operation time, and are susceptible to human error, which can result in damage to equipment or freight, accidents and delays. Human error can also result in mistakes being made, such as the movement of the wrong container. Thus, wasting time to correct the error and causing delays to cargo, which will result in knock-on effects further down the supply chain.

By merging AI technology with crane machinery, ARC can optimize the performance of these tasks whilst reducing the risk of mistakes, accidents, injury and delay. Through this optimization, cost savings can be made for the operator associated with the reduction in time taken to perform tasks, reduction in damage to equipment and cargo, reduction in workforce injuries and enhanced asset capacity, which can enable cost savings at every level of the supply chain.

Future trends are moving toward fully autonomous shipping ports and freight facilities (*see also the Autonomous Shipping Ports use case)*. Autonomous ships and Smart Shipping Containers (*see also the Smart Containers use case*) are being developed and implemented around the world (e.g. China and the Netherlands). In the near future, it is expected that the freight shipping network will become fully automated where Smart Containers and Autonomous Ships will be able to communicate with ARCs throughout operations.

[1] "The Port of the Future", Future Platform, Accessed 5 May 2020.

VALUE CREATED

Improving efficiency and reducing costs:

- Accelerate the time to complete tasks by optimizing operations using artificial intelligence and therefore increasing productivity.
- Improve asset capacity enabling more freight to be processed.
- Reduce costs associated with delays to cargo and worker injuries by minimizing human errors.

Enhancing economic, social and environmental value:

- Improve worker safety by utilizing automated machinery that will perform dangerous tasks without human intervention and can detect potential hazards thereby avoiding accidents.
- Improve freight service for customers by minimizing delays and improving accuracy of operations.
- Enhance trade by improving port operations for more efficient and accurate cargo transfer.

POLICY TOOLS AND LEVERS

Legislation and regulation: Governments must develop regulations that outline the standards for ARC operations and maintenance and the requirements and testing they must undergo to be considered safe (e.g. load capability, detector system reliability).

Effective institutions: Collaboration between freight companies and crane suppliers is critical to ensure the ARCs are fit for purpose. Once installed, continued collaboration is required to enable further updates and maintenance of the machinery and systems.

Transition of workforce capabilities: A shift to ARCs will create a need for technically skilled workers to oversee crane operations, detect issues, perform services and maintenance of hardware and software. Several capabilities in areas such as technical engineering, software engineering and system integration are required. Where possible, these skills should be brought in house to enable workers displaced by the machinery to fill another role and enable prompt issues identification and corrective actions.

Funding and financing: Many implementations of ARC technology to date have been undertaken by private freight operators. However, the Port of Rotterdam (managed by the public entity the Port of Rotterdam Authority) is undertaking (from 2019) a project to make its operations autonomous, including the installation of ARCs. There are several private funds for ARCs projects around the world. For example, a private company (DP World) invested in the upgrade of Port of Brisbane, Australia. Several private companies have partnered to transition the Port of Caofeidian in China to a fully autonomous port.

IMPLEMENTATION

Ease of Implementation 	Many companies are already making the transition to using ARC. The AI technology has been implemented in different sectors and industries to ensure its capability in task performance. The transition to ARC will result in the change in crane operation processes, machinery maintenance requirements and human resources. The operation around ARC should be strategically designed to ensure a seamless transition to the ARC, including appropriate training of employees and updated safety procedures. Each port operator will have specific requirements for ARCs, such as the size of the ARC, the loading capability and power supply, etc. Operators must select a supplier that can meet their requirements. An operator can calculate the numbers of ARCs it would need by calculating how many containers one ARC can process per day and also needs to make sure there is enough space at the port to accommodate the required number of ARCs, which will likely result in some reconfiguration of facilities. Once operational, the AI component will need to be updated regularly to ensure it is learning and no errors or biases have been programmed.
Cost 	The capital expenditure associated with ARCs is higher than that of a traditional crane. However, the operational cost of ARCs is lower due in part to the reduction in labour cost. ARC can also eliminate possible human errors that could lead to accidents and cargo errors thereby reducing the cost associated with damage and delays and improve operational productivity.
Country Readiness 	ARCs have been installed at port facilities in several parts of the world including Europe, Asia and Australia. A key requirement to implement this technology is a reliable energy network to power the automated cranes. Electricity regeneration technologies can be deployed to capture heat energy and put it back into the network. Physical and virtual fencing can be implemented to ensure automated operations stop when people come into proximity with the cranes. Therefore, a reliable GPS, WiFi or cellular network is required.
Technological Maturity 	ARC technology is stable and mature enough to meet the existing operational and service demands. Many shipping ports around the world (e.g. Port of Shanghai, Port of Caofeidian, Port of Brisbane) have already implemented ARCs partially or fully in their operations. Additionally, AI required to optimize operations are mature and are being utilized in multiple sectors to enable improved performance and demand forecasting. Key equipment control systems are needed to oversee the movements of the automated cranes, but currently there is no standardization of these controls.

RISKS AND MITIGATIONS

Implementation risk

Risk: ARCs are designed to perform repetitive tasks without human interference. In the case that an unprecedented event occurs during operation the AI may be limited in being able to respond to it. This may result in the crane operations ceasing, thereby causing a delay, or may result in unintentional harm.

Mitigation: Until further development of AI technology can enable these machines to deal with unexpected incidents, the ARCs should remain under supervision by human operators. These specialist workers should be poised to step in if an unforeseen issue arises.

Social risk

Risk: ARCs will replace human employees who previously performed these tasks. This could result in the need to transition staff to alternative tasks.

Mitigation: Employers should develop a strategy to minimize the number of staff made redundant. Existing staff can be trained to perform more technical roles in supervising and maintaining the machinery.

Safety and (Cyber)security risk

Risk: The ARC operation is based on a computer network or internet-based system. Therefore, there is a risk that the system would be hacked due to cybercrime or sabotage. For example, in some cases, gaming bots powered by machine learning were able to hack the simulations they were being tested in.

Mitigation: Organizations should ensure their systems are robust to eliminate the risk of a cybersecurity breach. Furthermore, governments should set legislative frameworks to outline the requirements of these systems to repel cybersecurity attacks.

Environmental risk

Risk: A transition to ARC will result in the need to dispose of existing traditional cranes, which could result in considerable industrial waste if the cranes are not recycled or reused.

Mitigation: Companies should develop sustainable waste and disposal strategies, whereby machinery that is no longer required but remains within its asset life can be sold on for continued use or the components broken up for recycling or reuse.

EXAMPLES

Example	Implementation	Cost	Timeframe
Automated Container Terminal, Shanghai	The terminal is operated by 26 bridge cranes, 130 autonomous vehicles and 120 rail-mounted gantry cranes which are remotely controlled.	The development cost USD 2.15 billion. The operator hopes to save up to USD 80,000 in terminal operation costs per vessel via a 70% reduction in labour costs and a 50% increase in handling efficiency. Carbon emissions are also expected to decrease by 10%.	The automated container terminal started its operation in late 2018.
Port of Brisbane	The Brisbane port operator added two new automatic stacking cranes to its operation.	The port of Brisbane invested AUD $250 million to upgrade the port to semi-autonomous operation in 2014.	The port operator placed an order for the two new cranes, the cranes were delivered in 2016 and became operational in early 2017.
Victorian International Container Terminal	The new Melbourne facility includes five Neo-Panamax ship-to-shore cranes designed to lift loads of up to 65t and 20 automatic stacking cranes, which handle the interchanges between trucks and the container stacking blocks.	The facility cost AUD 650 million to develop. It provides an additional 33% capacity to the Port of Melbourne.	The container terminal became operational in January 2017.