

Smart Robotic Warehouse Management System

智能機械人管理倉庫

Cost Effective and Work Efficient Solution for Expediting Industry 4.0
減成本增效率 推進工業 4.0

Industry 4.0 can reduce manpower and boost productivity, and thus has been the tech buzzword for a few years. However, for realising the full potential of smart factories, raw materials, parts and even finished products have to be delivered and moved efficiently. In the same line of thought, researchers from the Department of Industrial and Systems Engineering, The Hong Kong Polytechnic University (PolyU), developed a smart robotic system for warehouses. The system, which connects with the Internet of Things (IoT), engages a number of robots to carry the shelves to the workers. The system has been piloted in logistics and manufacturing companies in the Guangdong-Hong Kong-Macao Greater Bay Area, to increase efficiency and effectiveness, as well as to lower the operating cost.

Industry 4.0 refers to the emergence of smart factories, where goods are manufactured in a completely automated manner. Machines can communicate with each other via the Internet

工業4.0有效減省人手及提升生產力，因而成為近年的全球熱門話題。不過，要提升智能工廠的效率，必須先增加運送原材料、零件和成品的效率。有見及此，香港理工大學工業及系統工程學系的研究人員特意開發智能機械人倉庫管理系統，與工業物聯網（IoT）接軌，利用多部自主移動機械人，把活動貨架送到工人面前。該系統已在粵港澳大灣區的物流公司和製造商試用，冀提升運作效率及成效，同時減省營運成本。

工業4.0是指智能工廠的出現。這些智能工廠能實現全自動化生產，而所用的機器亦可通過物聯網（IoT）相互溝通，以簡化生產流程，減少監督的人手。不過，物流業必須革新，以提升交付及運送原材料、零件和成品的效率，才能令工業4.0發揮最大效用。香港理工大學工業及系統工程學系助理教授李嘉敏博士特此率領科研團隊，與精銳動力科技有限公司合作，開發與工業物聯網接軌的智能機械人倉庫管理系統，顛覆一貫倉庫管理概念。





of Things (IoT) to streamline the workflow and minimise human supervision. However, innovation in logistics is crucial to ensure that raw materials, parts and end products are delivered and moved with the same efficiency, so as to maximise the efficacy of Industry 4.0. In light of this, Dr Carman Lee, Assistant Professor of PolyU's Department of Industrial and Systems Engineering, led a research team to work with RV Automation Technology in developing an industrial IoT-based smart robotics system that disrupts pre-conceived warehouse management concepts.

Traditional Approach is Time and Space-consuming

Traditionally, warehouse management is a physically demanding job which entails heavy lifting and much walking. Workers are also highly susceptible to wear-and-tear injuries and accidents. As a result, it is getting more and more difficult to hire warehouse workers. As Dr Lee explains, "In the past, workers have to print out a picking list, walk or drive to a shelf,

visually identify and confirm an item, then lift it off the shelf and carry it or drive it back to a workstation. A warehouse usually covers over 10,000 square feet of floor space and the walking and driving time required could be substantial." In the past few years, the use of robotic arms in conjunction with RFID tags has sped up the item pickup and drop-off process. However, robotic arms take up much space and are useable only in huge warehouses with sufficient passage spaces built-in between shelves.

Smart Robotic System Saves Time and Space

The system that Dr Lee's team developed is radically different from the traditional system. Not only can it greatly increase efficiency, but also save much idle time and running cost. she says, "Instead of sending the workers to the shelves to pick up or drop off an item, we send the shelves to the workers so that they just need to stay at one spot without wasting time on travelling in the warehouse." The system

傳統系統較耗時 佔地廣

傳統倉務工作涉及大量體力勞動，工人需搬運沉重的貨物和經常來回走動，容易勞損或受傷，所以招聘倉務員愈來愈困難。李博士解釋：「以往倉務員會先打印取貨清單，步行或駕駛起貨機至貨架，用肉眼識別及確認貨物，再把貨物取下和搬回工作站。倉庫的面積動輒過萬平方呎，單是走路或駕車已花去不少時間。」過去數年間曾有結合機械臂及射頻識別標籤的倉庫管理系統出現，這些系統確實加快了存取貨物的速度，但機械臂佔地較大，貨架之間也需預留足夠空間，所以只適用於大型倉庫。

機械人更快捷 佔地少

李博士與團隊所開發的系統，與傳統倉庫管理截然不同，不但能提升效率，更可大幅減少閒置時間及運作成本。李博士表示：「工人不用走到貨架取貨，而是機械人把貨架送到工人面前，工人只需留在同一地點，毋須浪費時間在貨倉裏走動。」該系統使用的自動導引運輸車其實是由中央控制的智能機械人，其車身較薄，整輛車可進入活動貨架底部，將整個貨架抬起並運送到工作站。員工只需根據貨架上的燈號或屏幕顯示取貨，毋須列印清單、尋找貨架、確認貨物，降低人為錯誤的可能性。

李博士補充說：「系統的最大優點是佔地少。所謂寸金尺土，倉庫的通道是不會帶來收入的閒置空間。智能機械人系統能在有需要時減少倉庫的通道，以增加庫存量。」另外，智能運輸車可在原地旋轉，不需用額外空間來轉彎。系統甚至能把不必要的通道合併，以加大存貨空間。假如運

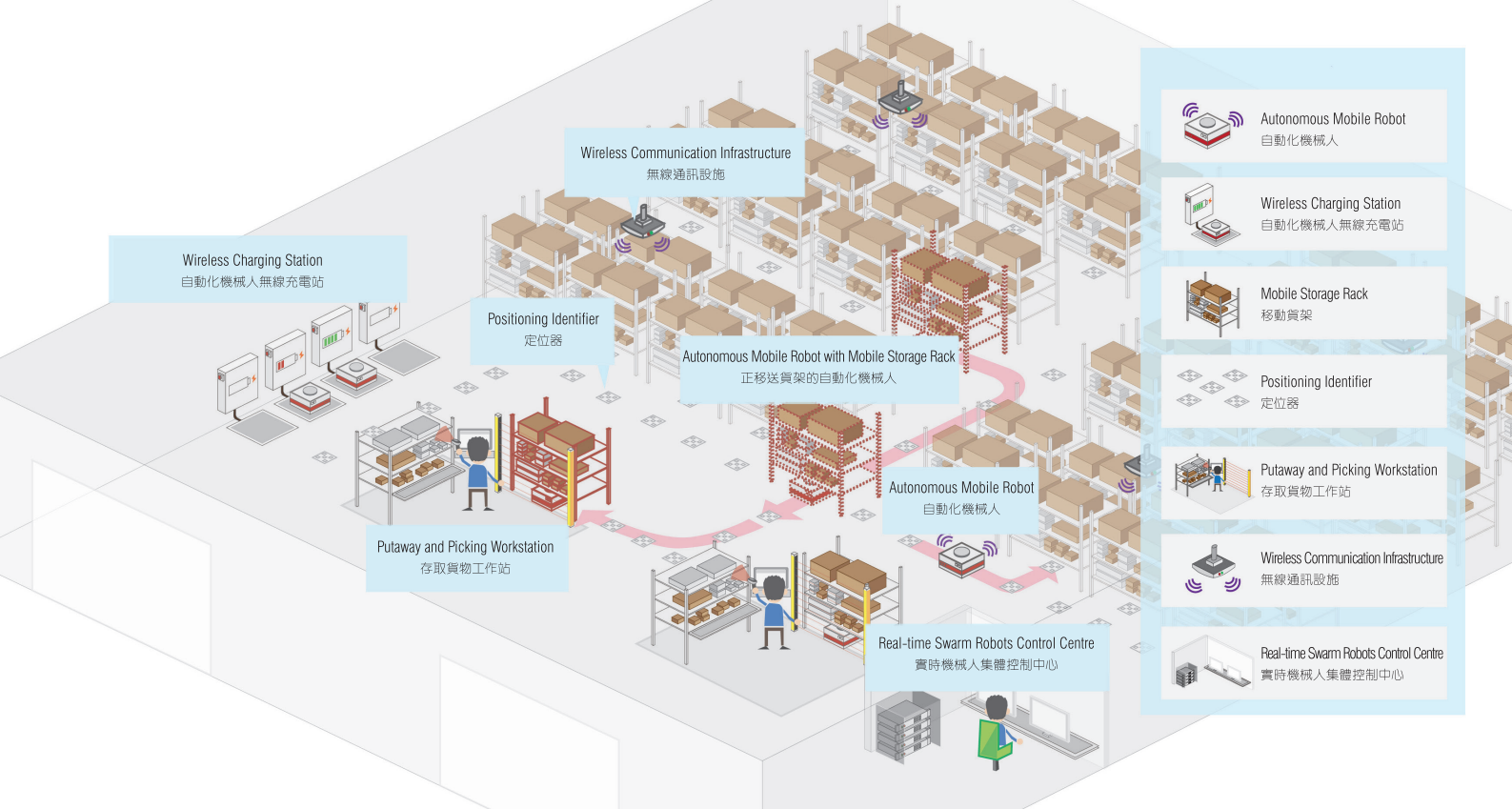


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Instead of man-to-goods, we opted for a goods-to-man approach.

我們把操作模式由『人到貨』變成『貨到人』。

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uses automated guided vehicles (AGV), which are smart robots controlled by a central system. They are thin enough to go under a shelf and strong enough to lift the whole shelf and carry it to a workstation. Lights on the movable shelves and the information shown on a screen will indicate which items need to be removed by workers. There is no picking list. Neither do workers need to walk around to locate the shelf nor do they need to verify the item by themselves. Human errors are thus minimised.

“One key advantage of our system is its less space requirement. Land is an expensive asset and passages are considered as an idle space which does not generate income for a warehouse. When number of necessary, the system may minimise number of passages to generate additional stocking capacity,” adds Dr Lee. The intelligent AGVs are designed to rotate on the spot so that no extra space is required for making turns. The system can even

maximise the use of floor space by leaving only absolutely necessary passages between shelves. To retrieve a shelf that is not readily reachable on an aisle, the central system will work out the easiest route. Then two or more AGVs can work together to move shelves that get in the way, before retrieving that particular shelf. The system also optimises AGV paths to prevent AGVs from crashing into each other and avoid any congestion in the aisles. Re-slotting is also carried out by the system to minimise retrieval time.

In December 2018, the Industrial IoT-based Smart Robotic Warehouse Management System won a gold medal and an outstanding Automation Award at the Asia International Innovative Invention Award. In April 2019, this project also won the silver medal at the 47th International Exhibition of Inventions of Geneva. 🏆

輸車無法直接到達目標貨架，中央系統會首先決定最簡單的路線，然後派出最少兩部運輸車合力把擋住路線的貨架移開，再取出所需貨架。系統甚至能優化各運輸車的路線，以免它們發生碰撞或造成擠塞。系統亦會優化重新編排貨物的工序，從而縮短以後取貨的所需時間。

「基於工業物聯網技術的智能機器化倉庫管理系統」於2018年12月在亞洲國際創新發明大獎中榮獲金獎及傑出自動化發明大獎，以及於今年4月在第47屆日內瓦國際發明展中奪得銀獎。 🏆

