路政署
HIGHWAYS DEPARTMENT

中華人民共和國香港特別行政區
Hong Kong Special Administrative Region of the People's Republic of China
25th 周年紀念 ANNIVERSARY

路政署創新科技在道路建設和維護的應用

Building and Maintaining Highway Infrastructure through Innovation in Highways Department

智能機械臂系統 — 在高速道路放置和收回交通圓筒和危險警告燈
Robot System — Placement and Collection of Traffic Cones and Warning Lanterns in High Speed Roads

引言
Introduction

路政署一向非常重視道路上的施工安全，將工地工程人員的安全放在首位，並致力提高在公路上進行道路工程的安全防護。鑑於工地工程人員在高速道路上執行臨時交通安排時，尤其於深夜時分，是一項危險的工作；因此，路政署致力研究採取自動化的方法在高速道路上放置及收回交通圓筒和危險警告燈。

Highways Department (HyD) always attaches great importance to safety in road works, accords first priority to the safety of engineering site staff and has been striving to enhance safety protection for carrying out road works on public roads. Given that implementing temporary traffic arrangement on high speed roads especially at late night is dangerous for the workers, HyD has therefore been striving to explore the possibility to adopt an automatic approach for placement and collection of traffic cones and warning lanterns on high speed roads.

智能機械臂系統
Robot System

智能機械臂系統原型 Prototype — Roadbot 1

在2017年，路政署委聘香港生產力促進局開展研發一套適合在香港道路情況下使用的智能系統，研究以機械臂和感應器裝置將放置及收回交通圓筒的工作自動化。在2019年，路政署和香港生產力促進局成功共同研發智能機械臂系統的原型 (取名Roadbot 1)，Roadbot 1 是全球首個採用鏡頭、雷達感應器和機械臂等裝置的智能機械臂系統，能認知四周環境，在高速道路上自動放置和收回交通圓筒和危險警告燈。

In 2017, HyD commissioned Hong Kong Productivity Council to carry out a research study to design and construct a traffic cone laying machine using robot arms and sensors suitable under road conditions in Hong Kong and co-invented the prototype of the robot system — Roadbot 1 in 2019. Roadbot 1 is the world's first intelligent robot system fitted with cameras, LiDAR sensors and robot arms with full cognitive abilities to understand its surroundings for placing and collecting traffic cones and warning lanterns on high speed roads.

系統提升和安裝 — Roadbot 2 的設計
Full Scale Version of the Robot System — Design of Roadbot 2

在2021年，我們在香港已把整個系統提升和安裝到工程車上 (取名Roadbot 2)。Roadbot 2 安裝在一架14噸工程車上，並由2隻機械臂、交通圓筒儲存系統、危險警告燈儲存系統、鏡頭、感測器及電源系統組成。它可以儲存超過200個交通圓筒和100盞危險警告燈，執行臨時封閉約2公里長的道路。

In 2021, the full scale version of the robot system – Roadbot 2 was successfully constructed in Hong Kong. Roadbot 2 consists of 2 robot arms, a traffic cone storage system, a warning lantern storage system, cameras and sensors as well as power system installed onto a 14-ton works vehicle. It has storage space for over 200 traffic cones and 100 warning lanterns to carry out road closure of around 2km.

組裝在工程車上的智能機械臂系統
Full scale model – Roadbot 2

Roadbot 2 每隻機械臂可以載荷60公斤，其最大伸展距離為2米，放置或收回一組交通圓筒和危險警告燈的時間只需要大約10秒。每隻機械臂均配有一隻特別設計的氣動爪，以方便放置和收回交通圓筒和危險警告燈。
此外，Roadbot 2 使用人工智能傳感器融合演算法，可從鏡頭和光線檢測中所得到的資料去進行圖像處理，以識別道路標記、交通圓筒和危險警告燈的存在，並確定其位置及精確地在道路上把交通圓筒放置在道路標記旁邊。

The robot arm of Roadbot 2 has a payload of 60kg and the maximum reach length of it is 2m. It takes about 10 seconds for each traffic cone and warning lantern placement or collection. Each robot arm is fitted with a pneumatic gripper to facilitate the placement and collection of the traffic cones and warning lanterns.
In addition, Roadbot 2 uses the Artificial Intelligence Sensors Fusion Algorithm which performs image processing from cameras and light detection to identify the presence of road marking, traffic cones and warning lanterns and to determine their positions so as to allow the placement of traffic cones precisely next to the road marking on the roads.

在直路及彎路進行實地測試
Site trial on a road with straight and curved sections

Roadbot 2 的應用
Application of Roadbot 2

Roadbot 2 已在不同的路段，包括直路和彎路，以及在不同的戶外環境進行實地測試，結果令人滿意。Roadbot 2 將於2022年第三季度，在新的快路維修合約中投入使用。

The Roadbot 2 satisfactorily performed in a series of site trials under different road configurations including straight roads, curvy roads and different outdoor conditions.
Roadbot 2 will enter into service in the new high speed road maintenance contracts in 2022Q3.

智能機械臂系統屢獲殊榮
Achievements of Robot System

Roadbot 1

第47屆日內瓦國際發明展
47th International Exhibition of Inventions of Geneva

中國代表團發明和創新優秀獎
The Honourable Mention Prize of the Chinese Delegation for Invention and Innovation

評判特別嘉許金獎
The Gold Medal with the Congratulations of the Jury

2019矽谷國際發明展
Silicon Valley International Invention Festival 2019

金獎
Gold Medal

2019香港資訊及通訊科技獎
Hong Kong Information and Communications Technology Awards 2019

交通組別金獎
Gold Award in Smart Transportation

Roadbot 2

2022年日內瓦國際發明展
The Special Edition 2022 International Exhibition

金獎
Gold Medal