Research Assessment Exercise 2020
Impact Case Study

University: City University of Hong Kong
Unit of Assessment (UoA): 15. chemical engineering, biomedical engineering, other technologies (incl. environmental engineering & nautical studies) and marine engineering
Title of case study: Intelligent Sensors for E-Channel Auto-pass Systems for Passengers at the Hong Kong Immigration Gate

(1) Summary of the impact

Yearly, approximately 260 million passengers pass through the immigration gate of Hong Kong. An intelligent sensor system to detect the status of passengers at the E-Channel is crucial to the smooth operation of the auto-pass system. Prof. Dong Sun from City University of Hong Kong and his team developed an intelligent P-beam sensor system, with a China patent number of CN ZL 2009 2 0218477.1 [1]. In 2012, the technology was transferred to local industry for commercialization. The sensor is used at the HK immigration gate, which has been producing an annual revenue of more than HK$10 M since 2013 [A].

(2) Underpinning research

The auto-passing gate is a self-service entry and exit inspection system for a wide range of passengers, such as for subways, trains, cars, and other transportation stations. When the gate is opened or closed, the position of the passenger must be detected for judgment whether the switch between the gate opening and closing is safe. The detection is made by a sensing device [1] installed on the gate, which distinguishes the position of the passenger. The sensing device transmits the detection data to the control unit of the gate, which gives the instruction to control the opening and closing of the gate. The sensing device of the gate is generally an infrared detecting device, whereby an infrared transmitting tube and receiver are paired and applied. When the infrared receiver receives the infrared light emitted by the infrared emitting tube, the infrared receiver judges after the data analysis whether an object is blocking infrared radiation. The accurate position of the object can be determined by the array of the infrared emitting tube and the infrared receiver. In the array of the existing infrared emission tubes, the distance between the two emission tubes was larger than 10 cm. This distance was not accurate enough to detect passenger motions. Therefore, the detection equipment was unable to meet the need for high accuracy in the application of the auto-passing system.

The invention is a new infrared detecting system applied to a gate to detect user motions [1, 2]. The system comprises a control as well as infrared-emitting and infrared-receiving boards. The control board comprises an MCU (MicrocontrollerUnit). The infrared emitting board comprises a plurality of segmented infrared emission tubes. The infrared receiving plate comprises a plurality of infrared receivers equal to the infrared radiation tube, and the distance between two adjacent infrared emission tubes is equal and does not exceed 5 cm. The distance between the two adjacent infrared receivers is the same as the distance between two adjacent infrared emission tubes. The control board, coupled with a 40 MHz crystal oscillator that increases processing speed, is connected to the infrared emitting and receiving plates in a parallel transmission manner. The radiation plate includes two pairs of infrared emission and infrared receiver tubes or eight pairs in total.

The invented infrared detection system reduced the distance between the infrared emission tube and the infrared receiver compared with the other commercial products. An energy-saving and environmentally-friendly segmented launch was adopted to reduce the effect of the infrared

emission tube on other infrared receivers, thereby improving the resolution of the acquired information. This invention clearly detects the situation inside the infrared beam, and understands the action of the targeted object, which satisfies the accuracy requirement of the detection system [3-6].

(3) References to the research

1. D. Sun, S. M. Chan, C. H. Lo, S. K. Chak, "PE-beam inspection system (紅外線檢測系統)", China Patent, CN ZL 2009 2 0218477.1
2. D. Sun, and X. Shao, "Modular multi-axis motion control and driving system and method thereof", USA Patent, US 7,194,321 B2, 2007.
3. X. Shao and D. Sun, "Development of a new robot controller architecture with FPGA based IC design for improved high-speed performance", IEEE Transactions on Industrial Informatics, vol. 3, no. 4, pp. 312-321, 2007.
4. D. Sun, X. Y. Shao and G. Feng, "A model-free cross-coupled control for position synchronization of multi-axis motions: Theory and Experiments", IEEE Transactions on Control System Technology, vol. 15, no. 2, pp. 306-314, 2007.
5. D. Sun, "Position synchronization of multiple motion axes with adaptive coupling control", Automatica, vol. 39, no. 6, pp. 997-1005, 2003.
6. D. Sun and J. K. Mills, "Torque and current control of high-speed motion control systems with sinusoidal PMAC motors", IEEE/ASME Transactions on Mechatronics, vol. 7, no. 3, pp. 369-377, 2002.

(4) Details of the impact

Prof. Dong Sun from City University of Hong Kong and his team developed an intelligent P-beam sensor system, with a China patent number of CN ZL 2009 2 0218477.1 [1]. The patented research was subsequently transferred from a CityU Enterprise Group Company to a company in the local industry in 2012. This invention has been used in the E-Channel auto-pass systems for passengers in the Hong Kong immigration gate since 2013. According to a statistics report, an average of 260 million passengers per year enter and leave Hong Kong via customs in Lo Wu, Lok Ma Chau, Shenzhen Bay, and the Hong Kong International Airport. The invention has enabled the E-Channel auto-pass systems to operate efficiently and successfully. According to a report from the local industry, this invention has produced an annual revenue of more than HK$10 M since 2013). [A]

In addition, the patented research in motion control (US 7,194,321 B2, 2007) [2] developed by the team was also used for the E-Channel auto-pass system of customs in Shenzhen.

Prof Dong Sun together with his team has received numerous prestigious awards [B] for the achievements in automation and biomedical engineering, including 2019 China's Top Ten Scientific and Technological Development in Intelligent Manufacturing, the Hong Kong Awards for Industry in 2012 for CNC automation, the Hong Kong Awards for Industry in 2003 for the achievement in motion control, and the Gold Award (in category of Parts/Components) of the Hong Kong Electronics Fair 2006 (Hong Kong Electronics Fair is Asia's largest and the world's second largest exhibition in electronics).

In addition, Prof Dong Sun was elected as a fellow of Canadian Academy of Engineering in 2019 [C] and received the Natural Science Award, 2nd Class, Education Ministration of China, 2019 [D] for his impactful contribution to biomedical engineering. The research and achievements were widely reported in the news [E].

(5) Sources to corroborate the impact

[A] Letter from a company in the local industry to corroborate the impact
[B] Certificates of awards: China's Top Ten Scientific and Technological Development in Intelligent Manufacturing, the Hong Kong Awards for Industry, and the Gold Award of the Hong Kong Electronics Fair
[C] Award certificate for the Fellowship of Canadian Academy of Engineering in 2019.
[D] Award certificate for the Natural Science Award, 2nd Class, Education Ministration of China, 2019
[E] Press coverage on research and achievements during 2014-2019