2． 項目簡介

(*項目所屬科學技術領域、主要技術內容、授權專利情況、技術經濟指標及應用推廣情況*)
Micro/nano-positioning systems are demanding devices to produce the displacement with micro/nano meter/radian resolution and accuracy. As a technology breakthrough, robotic microgripper is a frontier device to realize automated micro-manipulation and assembly. In modern precision engineering applications, there is a growing need for micro/nano-positioning systems which provide large-range motion over 10 mm or 10° and possess a compact size. The invention of compact positioning systems enables broader applications in a restricted space. They are also cheaper in terms of material and fabrication, making them extremely attractive for high precision positioning applications.

The China's 13th Five-Year Plan and Made in China 2025 promote the development on advanced CNC machine tools and robots. In line with the advance trend of S&T, the objective of this project is to invent key mechanism design and control technologies for developing large-range micro/nano-positioning systems for robotic micromanipulation and microassembly applications. The invented key technologies make the following breakthroughs.
(1) Design technologies of large-range translational and rotational micro/nano-positioning stages with over 10 mm/10° motion range have been developed to invent novel compliant stages with the most compact structures and largest strokes.
(2) Design technologies of dual-servo and dual-stage micro/nano-positioning systems are successfully invented to minimize the interference behavior between the coarse and fine stages, which significantly simplify the control design for dual-servo and multi-stroke micro/nano-positioning systems.
(3) Design technologies of large-range compliant grippers are created for automated pick-and-place operation in micro/nano-manipulation and assembly applications. They are the first invention to provide two dimensional force sensing with dual resolutions/ranges using one force sensor.
(4) Control technologies for precision motion and combined motion/force regulations are invented against model uncertainties and disturbances. Novel sliding mode control, model predictive control, intelligent control, and robust impedance control algorithms have been developed for micro/nano-manipulation and assembly tasks.

The application of the core technologies leads to the cost reduction of the products, and the project has significant impact on the academic society. During five years execution, the project has trained/under training 2 PhD, 10 MSc, and 16 BSc students, and led to 60 publications including 2 monographs by Springer and Wiley publishers, 2 book chapters, 25 journal papers (22 SCI), and 31 EI int. conf. papers (11 CPCI). Among them, 13 papers are published in prestigious IEEE/AIP journals, including 5 papers in IEEE Trans. Industrial Electronics (IF: 6.498, rank: 1/58 in AUTOMATION & CONTROL SYSTEMS). The publications have been cited by 296 times by peers in Google Scholar. One paper is ranked Highly Cited Papers by ESI of Thomson Reuters. The involved students have been nurtured with sufficient knowledge. Even the BSc students, after a training of less than one year with their hard work in final-year projects, get recognized locally and internationally.

Owing to the novelty and utility of the invented technologies, 2 China Patents are authorized and 2 US Patents are pending. It is the first time that such patents are granted to Macau in micro/nano-robotics field. The invented technologies of large-range compliant micro/nano-positioning systems have demonstrated wide applications in the fields of biomedical engineering, micro/nano-manipulation, and micro/nano-manufacturing, etc. The results of the project have substantially contributed to the advancement of S&T and industry field in Macau and beyond. In view of the professional personnel shortage in Macau, the commercialization of the invented robotics technologies in the future work will contribute to the solution of this issue.

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