Form 3

Abstract of Thesis

Name （Hu Zhengtao）	
Title	Designing Mechanical Tools for Flexible Robotic Assembly with Manipulators and Two-Finger Parallel Grippers （2指並行グリッパを有するマニピュレータによる組立作業のためのツール設計）

Abstract of Thesis

This thesis focuses on designing mechanical tools for two-finger parallel grippers and enabling robots to manipulate various parts for assembly tasks. The manipulation ability of a robot heavily relies on the functions of the equipped hands. For various task requirements, instead of mounting the bulky and costly hand changers or general-purpose hands, using different tools held by a general gripper is a popular way. To be functional, the tools are always designed with embedded transmissions and power devices. Thus, the tailed cables for power supply and control are indispensable. However, the deformable cables result in a high risk of tangling robots and colliding with environment. The proposed tools in this thesis are entirely mechanical and manumotive, allowing the general two-finger parallel grippers to use without any peripheral and power supply. Provided multiple tools with different functions, robots with a simple gripper can easily adapt to various assembly requirements.

The contributions of this thesis consist of three parts. Firstly, the thesis explains the mechanism design and the structure optimization of the tools. The tools manipulated by the gripper can be viewed as a mechanism that transmits the power of the gripper and converts the gripper motion into different output motions on the tooltip. Besides, the tool requires to be firmly held in the manipulation process. The mechanisms design especially considers the transmission and the grasp constraints. Secondly, the thesis proposes to solve the problems on the aspect of tool use. On the one hand, it includes the task-oriented planning for tool poses and the grasp/regrasp planning for pose reorientation. On the other hand, it employs force-control-based methods to manipulate the tool compliantly against uncertainty, such as inserting tools, exchanging tooltips, and screwing. Additionally, the thesis focuses on an important challenging topic in assembly, eliminating the grasp of uncertainty. A peripheral tool, triangular corner fixture (TCF), is presented to perform like a regrasp intermedia to reduce the grasp uncertainty in a sensorless way. The TCF can be used to regrasp the goal objects and also the proposed mechanical tool, which effectively helps to achieve precise grasps and increase the success rate of assembly tasks.

The concepts of using mechanical tools, the mechanism designing methods, and the manipulation strategies proposed in this thesis promote the effective solutions on adaptive robotic grasp and varying assembly manipulations. The author believes that using mechanical tools to extend the manipulation abilities of robots is a practical and low-cost approach, and would like to develop more functional tools for fitting wider application needs.

様式７

論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

本論文は，ロボットにより組立などの作業を行う際に，汎用的なグリッパを有したロボットがツールを把持して作業を行うという高いオリジナリティを有するものである．研究の目的は，産業用ロボットのフレキシビリティを拡大し，産業用ロボットが多品種少量生産に対応して種々の作業を可能にすることである．主査、副査で論文の審査をおこなった結果，いくつかの疑問点が挙げられた．それらは主に，汎用グリッパで専用のツールを把持して作業を行うことのフィージビリティに関するもの，ならびに，汎用グリッパでツールを把持した場合の先端の位置精度に関するものであった．審査の際に出た疑問点に関する議論を中心に、最終審査をおこなった。最終審査ではZhengtao Hu君は全ての疑問に回答した。これにより、主査、副査全員一致で、本論文は博士（工学）として価値があるものと認められた。