

論文 / 著書情報
Article / Book Information

題目(和文)	スーパーマイクロサージャリ用ロボットシステムの開発
Title(English)	Development of a Robot System for Supermicrosurgery
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出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第11818号, 授与年月日:2022年3月26日, 学位の種別:課程博士, 審査員:只野 耕太郎,小俣 透,初澤 毅,八木 透,吉村 奈津江
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第11818号, Conferred date:2022/3/26, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

(博士課程)
Doctoral Program

論文要旨

THESIS SUMMARY

系・コース : 機械 系
Department of, Graduate major in ライフエンジニア コース
 リング

申請学位 (専攻分野) : 博士
Academic Degree Requested Doctor of (工学)

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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

Supermicrosurgery is a technique of anastomosis of vessels with diameter between 0.3 and 0.8 mm. This technique beyond the human ability requires an improved precision than the conventional surgical robot systems for reconstructive surgery. The study aims to develop a robot system using a leader follower operation, for supermicrosurgery with an improved operating precision. The realization of improved precision is expected to contribute to the advancement of the procedures and targets of supermicrosurgery. In addition, the robot system included a force feedback function, which is the challenge of the general surgical robot system.

To establish a leader robot system for supermicrosurgery, this study proposed a combined grip scheme and a hand rest function.

A combined grip is the gripping type which make an operator to utilize the advantages of the gripping types as selectively as needed, such as the pinch grip motion for precise work and the power grip motion for large movement. The combined-grip-handle was designed to be adjustable in the distance and the direction of the fingertips for a pinch grip motion around the holding axis of a power grip motion during the operation. A pointing experiment was conducted for the combined grip and the conventional gripping types with the leader follower operation under several manipulating conditions. The results shows that the condition of using the combined grip recorded fewer failures and required shorter time and length of trajectory drawn by the follower manipulator under the same condition in scale factors and forearm fixation. Based on the results, it is verified that the positioning operation could be performed better with the combined grip than with the conventional gripping types.

Adopting the combined grip scheme, a leader manipulator, which integrated the motion input and hand rest functions, was proposed. The hand rest function, which generates the stable pivot point, was realized by switching the impedance value in admittance control with a simple operation of the interface, such as a foot switch, in the translation section of the leader manipulator. The leader manipulator enables force feedback at the gripping fingertips on a stable hand condition with a hand rest function. With leader follower operation, it is verified that the position of the hand rest in the direction of gravity could be arranged at the intended position. Additionally, a pointing experiment was conducted for evaluating the manipulating method during precise positioning by focusing on the operating conditions of the hand rest function in terms of time required, number of failures, length of trajectory. It is verified that the optimal manipulating condition of the leader manipulator was the condition that the hand rest function adopted sufficiently high impedance and did not fix the hand rest completely. Furthermore, it is verified that the condition of using the force feedback on the hand rest function applied the smallest force to the experimental target during operation through the 8-drawing experiment.

To establish a follower robot system for supermicrosurgery, this study proposed a manipulator that enables to achieve the improved positioning precision in precise motion with extended orientation range in larger motion of supermicrosurgical procedures. For this, this study proposed and adopted a semi-decoupled mechanism which selectively follows a coupled kinematics for larger motion and a decoupled kinematics of translation and orientation for precise motion, as needed. Furthermore, the follower manipulator implemented the force sensing ability for force feedback. The workspace which enables all designated range of orientation was identified using the MATLAB simulation. Then, positioning and force sensing precisions were experimentally evaluated by microscopic measurements and comparing the measured force information in the external force sensor. It is verified that the specifications of the follower robot system surpass the requirements of microsurgery, and is adequate

to supermicrosurgical procedures.

Finally, a robot system with a leader follower operation was constructed. The robot system involved a three-dimensional visual system and a force feedback function. With the leader follower operation, a needle driving experiment was conducted using an artificial vessel with a diameter of 0.2 mm to verify the feasibility of the robot system for supermicrosurgery. In the experiment, all participants including a microsurgeon and novices completed the experimental tasks without impairing the vessel. Then, a vessel transporting experiment was performed with the artificial vessel to evaluate a force feedback function. The results suggest the possibility that the gripping and contact force feedback functions contribute to the improvement of surgical performance by reducing the force applied to the surgical subject.

Based on the results, it can be assumed that the leader robot system can contribute to effective supermicrosurgery ultimately, by enabling precise manipulation of the leader manipulator, and that the follower robot system showed the performance capable of performing supermicrosurgical procedures. Accordingly, it also indicates the feasibility of the developed leader follower robot system for supermicrosurgery.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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