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学位論文の題目	Soft Robot with New Pneumatic Rubber Actuators for Medical Assisting Device (空気圧ラバーアクチュエータを用いた医療支援用ソフトロボット)
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学位論文内容の要旨

The thesis is divided into five chapters. In Chapter 1; which is the Introduction, the background of the study is discussed. It covers the explanation of soft actuator, soft robot and fluoroscopy medical examination, where the problem statement is identified and how the soft robot can be potentially employed to facilitate the medical procedure. In addition, the introduction of soft actuator and soft robot are also presented to give a general idea about the branch of actuator and robot. Besides explanation of research purpose, this chapter also highlight the aim and contribution of this research to be acknowledged and appreciated.

In second chapter of the thesis, represented by Chapter 2, a review on the development of soft actuator, soft robot and issue regarding stomach fluoroscopy examination are presented. The soft actuator, which hold the basic mechanism for the soft robot movement is the main subject of this study and required a complete review. From the review, any gap and disadvantage of existing actuator is identified and stem the idea to create a new mechanism for the new soft actuator. Then, the literature on soft robot is explained to provide the current progress in soft robotics field. The final part of Chapter 2 discusses the impact of stomach fluoroscopy examination towards life threatening cancer with case study conducted in Japan.

Chapter 3 discussed the development of soft actuator. It covers the design of the soft actuator, its operating principle and parameters associated with the design. The simulation works are described in order to achieve the optimum design of the actuator which assists the fabrication process. Afterwards, the description of fabrication process is presented including Computer Aided Design (CAD), mold design, Computer Aided Machining (CAM), etc. until the prototype of the actuator is obtained. Then, the validation of all the theory and hypotheses from the previous works is demonstrated through series of experimental works.

In Chapter 4, the development of soft robot is discussed. The discussion focused on the design and operation of the soft robot. This includes the theory of locomotion gait and locomotion pattern in order to identify the thrusting force and robot ability to perform the omnidirectional locomotion. Then, fabrication process is explained until the prototype of the soft robot is achieved. In order to control the soft robot, the development of both software and hardware are presented. From the configuration, a series of experiments managed to be performed and explained in this chapter. The results from the experiments contribute to the characteristics and behavior of the robot based on input parameters applied to the control system.

Chapter 5 reports on the works of combining the soft robot with pneumatic pillow as medical assisting device in stomach fluoroscopy examination. The pneumatic pillow which has been tested under X-ray examination and confirmed its workability, is implanted on the top of the robot. The compatibility between the two subjects is investigated through a series of experiments is presented. Results from the experiments provide the evidence for potential ability of the combination of soft robot and pneumatic pillow, to be used as medical assisting device in fluoroscopy examination.

The final Chapter 6 summarizes the works and outcome of the investigation. The accomplishment of the research is compared to the previous aim and objectives in order to reflect the achievement of the works. In addition, any drawback in every aspect during the study is addressed and possible improvement is suggested. This benefits the future works of the study and to ensure a continuous and active research progress in the area of soft robotics.

論文審査結果の要旨

本研究では、ゴム材料の成型による空気圧アクチュエータを応用して、医療支援用ソフトロボットを複数の空気室からなる多自由度の移動を可能とするソフトアクチュエータによって実現することを提案している。このロボットは柔軟な構造を持つため身体との親和性が高く、X線を透過しやすい特性を持つ。この特性を生かし、胃X線検査時の圧迫装置移動機構への応用を提案している。

初めに、ソフトアクチュエータに関する研究動向と医療支援機器の状況について調査を行った結果に基づき、本研究の背景を示した。さらに、胃X線検査支援の状況と関連研究の動向についてまとめ、胃X線検査支援へのソフトアクチュエータ応用について検討を行った。続いて、空気圧ラバーアクチュエータによる移動原理について理論的検討を行い、シミュレーションと試作したアクチュエータを対象とする実験により検証を行った。この結果からアクチュエータの特性に基づくソフトロボットの構成を考案し、試作機を用いた実験による検証を行った。さらに、X線照射下でのソフトロボットの特性評価の結果に基づいて透過性を高めるための検討を行い、改良を行った。

以上のとおり、理論的検討に基づく試作を行い、実験的検証を行うことにより、医療支援用ソフトロボットへの空気圧ラバーアクチュエータ応用について有効性を示した。

本学位審査委員会は、学位論文の内容ならびに参考論文等を総合的に判断し、博士（工学）の学位に値するものと判断する。