論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Utilization of Environmental and Robotic Characteristics for Environment Mapping towards Fukushima Daiichi Decommissioning
著者(和文)	汪 振宇
Author(English)	Zhenyu Wang
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12356号, 授与年月日:2023年3月26日, 学位の種別:課程博士, 審査員:遠藤 玄,鈴森 康一,松永 三郎,木倉 宏成,髙山 俊男
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第12356号, Conferred date:2023/3/26, 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： Department of, Graduate major in	機械 機械	系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（ 工学 ）
学生氏名： Student's Name	汪 振宇		指導教員（主）： Academic Supervisor(main)	遠藤 玄	
			指導教員（副）： Academic Supervisor(sub)	鈴森 康一	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The title of the dissertation is "Utilization of Environmental and Robotic Characteristics for Environment Mapping towards Fukushima Daiichi Decommissioning", which consists of 6 chapters listed below.

In Chapter.1 "Introduction", the research background is set in the decommissioning tasks of Fukushima nuclear power plants after the disaster in 2011. Currently, the decommissioning tasks have come to the investigation phases of fuel debris retrieval process. Three problems are picked as the research targets of this thesis, including (1) when detecting the fuel debris and water leakages, underwater camera's spatial awareness was limited by turbidity and radiation level. (2) feasibility of conventional tough manipulator was limited by weight, conventional actuator deployment, etc. (3) the low compatibility of conventional environment mapping methods due to their inability to fully utilize the environmental and robotic characteristics, including grating textures in reactor and robot's specific motion patterns. To solve the underwater camera problem, a new robotic investigation system using ultrasonic sensor to replace underwater camera is proposed; A light-weighted flexible manipulator using wire drive mechanism is proposed as an alternative option of conventional tough manipulator; Three improvement methods are proposed to allow conventional environment mapping methods to utilize environmental and robotic characteristics as prior knowledge. Experimental verification of the proposed robotic systems as well as the proposed improvement methods with hardware prototypes is the research objective of this dissertation.

In Chapter.2 "Proposal of a Mobile Robotic System with Ultrasonic Sensors", the components of the proposed robotic investigation system "RhinoUS-II" are presented, including the wheeled robot structure, winch mechanism refinement, overview of the ultrasonic sensor and synchronized camera system. The feasibility of the ultrasonic sensors for underwater fuel debris and water leakages localization is also experimentally verified along with the working principle's introduction.

In Chapter.3 "Utilization of Grating Texture and Motion Patterns of a Mobile Robot for 2D Map Building", two robustness improvement methods designed for Visual Odometry are discussed. (1) A perspective transformation method is implemented to transform the original inclined view to top view, thus able to utilize grating textures by counting the number of past grating lattices. (2) an autonomous feature tracking failure compensation method, which uses specific motion patterns of the wheeled robot with velocity planar decomposition into translation and rotation to conduct trajectory clustering and map correction. Through experiments with hardware prototype, the effectiveness of the proposed improvement methods is verified, which successfully generated intuitive bird view map, and corrected the error map areas by improving the grating smoothness rate from 62% to 90%. Furthermore, the localization accuracy of the refined visual odometry is experimentally evaluated, which meets the required error rate of 100mm/1500mm. The available ranges of camera setup parameters to keep the required error rate are also studied through experiments.

In Chapter.4 "Proposal of a Light-weighted and Flexible Wire Drive Manipulator", the proposed robotic investigation system "Bundled Wire Drive Arm" is presented, including the key features of deploying bundled wires on the same pathway while allowing them to slide to each other, and placing all actuators in base. Compared with the conventional tough manipulator, the proposed manipulator turned out to be much light-weighted and flexible. While, the corresponding problem occurred that the motion controllability might degrade due to low joint stiffness, and leading to the compatibility problem between flexible manipulator and environment mapping method.

In Chapter.5 “Utilization of Motion Patterns of a Flexible Wire Drive Manipulator for 3D Reconstruction”, the degrees of image quality degradation due to motion controllability degradation including positional deviation and motion blur are experimentally evaluated. The results show the necessity of avoiding multiple joints movement as well as motion blur in dataset creation process. On the basis of the experimentally evaluated robot’s motion pattern features, a dataset creation method is proposed to create overlapping rotation trajectories and filter blurry images. Through effectiveness verification experiment, the proposed dataset creation method turned out to be able to create image datasets with better image quality for further environment 3D reconstruction method, by utilizing the flexible manipulator’s motion pattern as prior knowledge.

In Chapter.6 “Conclusion”, the findings of this dissertation are concluded and discussed from a higher dimension, including how to apply the proposed methods to more general environment and robots. At last, future topics are discussed.