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著者(和文)	シルバ・リコ・ホセ・アントニオ
Author(English)	Jose Antonio Silva Rico
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

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学生氏名： Student's Name	SILVA RICO JOSE ANTONIO	指導教員（主）： Academic Advisor(main)	遠藤　玄
		指導教員（副）： Academic Advisor(sub)	鈴森　康一

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

This thesis entitled "Study of Water-Jet as Propulsive Source Implemented on Slim, Long-Length Robots" consists of the following seven chapters.

Chapter 1 "Introduction" describes the research background and objectives of this work. In order to investigate narrow and dangerous places where people cannot enter, in particular, the Fukushima Daiichi Nuclear Power Plant, where after the incident in 2011, the development of small diameter long length robots for the localization of radioactive fuel distributed inside the reactor is necessary. More specifically, it is necessary a device to access the container from its top part through the piping. Furthermore, this device should be able to move in a route of at least 20 m and conduct inspection in the water that is accumulated at the bottom of the container after passing through a grating that divides the container. Therefore, an investigation of robots used to conduct the preliminary inspections as well as alternative technologies was done. The objective of this investigation is to find a method for a drive mechanism capable generate the propulsive force, as well as the control necessary for the inspection.

Chapter 2 "Proposal of a Slim, Long-Length Robot using Water-Jet" describes 4 basic elements required for the proposal presented in this work. These elements are a pump placed at the base of the system, which generates a high-pressure flow; a long, thin, and flexible hose used to transfer the water from the base; a nozzle that redirects the flow and generates the water-jet; and a posture sensor to measure the orientation of the tip of the system. Finally, taking into account the elements of the proposal, 3 different configurations are suggested. These configurations are analyzed in order to find their advantages and disadvantages. Finally, one of these configurations is selected to evaluate the proposed concept.

Chapter 3 "Water-Jet Propulsion Analysis" presents the theoretical analysis and the experimental results of tests performed by using a test apparatus that was developed in order to understand the behavior of the thrust force, the pressure, and the mass flow rate. Furthermore, different features of the nozzle such as the diameter of the output orifice, number of orifices, and output inclination were modified in this evaluation in order to find a way to maximize the thrust force.

In Chapter 4 "Development of a prototype robot", the proposed configuration of 3 independent pumps and flows presented in Chapter 2 and the results of the thrust force obtained in evaluation presented in Chapter 3 were used to define the design of the prototype. The developed prototype with the three hoses attached together has a transversal diameter of around 20 mm and a length of 40 m. Additional to the mechanical design, the electronic design with all the elements necessary to process and transfer the signal from the posture sensor placed at the tip of the devices and the user interface is introduced. Finally, a proposal for the control of the device in order to solve the lack of control around the longitudinal axis of the devices is presented.

In Chapter 5 "Evaluation of Performance of the Prototype Robot", the mobility performance and the control of the tip of the prototype in 3 environments is clarified. First, it was tested the mobility of the robot on the ground, where the aim of the task was to reach two targets separated from each other a distance of 7 m. Next, the same targets were used to evaluate the behavior of the system by keeping the tip gliding in the air. In this experiment, it was possible to maintain the tip of the system in the air at least for 1 min. Finally, in the evaluation in aquatic environments, the system reached an average speed of around 0.5 m/s and it was possible to reach four targets placed at different depths within a volume of 5 m x 2 m with a depth of 2 m.

In Chapter 6 “In-Pipe Locomotion System Using Water-Jet Propulsion”, another proposal focused for the in-pipe locomotion with water-jet propulsion is presented in this chapter. The aim of this proposal is the development of a device able to move in piping with a diameter of 20 to 25 mm, several branches and changes of direction. Additionally, it should be able to overcome a small diameter orifice located in the middle of the piping. In order to fulfill these requirements, a drill part that is propelled forward and rotationally by water-jet is proposed. This drill has the aim of expanding the orifice in the piping and also possess a passive joint that is used to bend and adapt at the curved pipe parts. Furthermore, the addition of intermediate nozzles was also considered to assist in the motion of pipelines with several changes of direction. Finally, prototypes of the drill and intermediate nozzles were manufactured in order to evaluate the behavior of the proposed system and found the problems on their design.

Chapter 7 “Conclusions” summarizes the contribution of this thesis work, gives final comments and discusses the possible future work.