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Study of Water-Jet as Propulsive Source Implemented on Slim, Long-Length Robots

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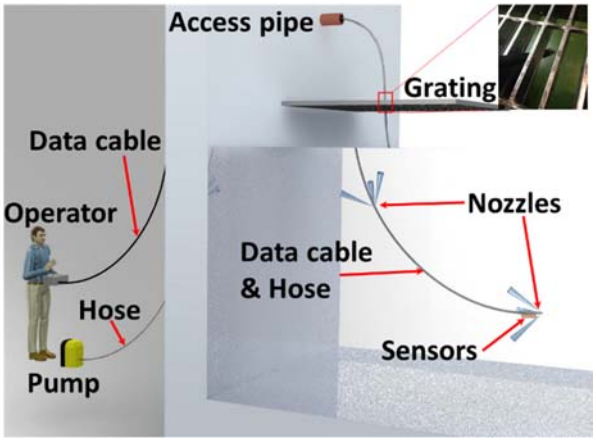
Abstract: The objective of this research is to establish foundations of the water-jet as a locomotion source for long and thin systems that could be used for inspection tasks. Taking into account the limitations of the current systems that use water-jet, I aim to understand the elements involve in the generation and control of the thrust force of the water-jet in order to develop new systems. The specific objective of this research is the development of systems with the minimal features necessary to perform inspection inside the Fukushima Daiichi nuclear power plant. Additionally, in this work is considered the development of tools propelled by water-jet that could be used to assist in the inspection labors. Furthermore, the design and evaluation of some prototypes are presented.



Chapter 1 - Introduction: Chapter 1 presents an investigation of the decommissioning of nuclear facilities. In this investigation is studied more in detail the problems occurred during the decommissioning of Fukushima Daiichi NPP and the difficulties in the inspection inside the primary containment vessel in unit 1 and 2. Taking into account the requirements necessaries to perform a better inspection, different systems that fulfill some of the requirements of the inspection are studied in order to find the most suitable actuation method able to be implemented in a new system to fulfill the minimal requirements of the inspection. This study displayed the water-jet as a suitable propulsion option to be implemented in a new device.

Chapter 2 -Proposal of a Slim Long-Length Robots with Water-Jet Propulsion: Chapter 2 explains the proposal of a device that uses water-jet as a propulsion source. This device is aimed to solve the limitation of the systems used in the inspection of the PCV in Fukushima Daiichi NPP introduced in chapter 1. Furthermore, a detailed explanation of the elements required to develop the proposal is presented. Additionally, three possible system configurations considered to test the viability to the concept are described. Finally, these configurations are analyzed in order to find which one is easier to be implemented.

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Chapter 3 - Water-Jet Propulsion Analysis: Despite the fact that the water-jet have been used for a long time, its implementation on robotics systems is limited. This chapter gives a background of the different water-jet utilizations, as well as an overview of systems that have adopted this kind of propulsion. Taking into account the characteristics of the system required, an analysis of the variables involve in the water-jet generation is presented. An experimental evaluation of the variables in different configurations such as different output diameters, different number of output orifices, and different output inclination, is performed in order to understand the behavior of the variables and find different options to maximize the thrust force in the system.

Chapter 4 - Development of a Prototype Robot: Chapter 4 describes detailed the mechanical and electronic elements that defines the developed system of 40 m length and 20 mm diameter. Furthermore, the selection of the components chosen is also explained. Additionally, it is explained the way the input data from the operator is converted into the signals that regulate the speed of each of the water pumps and how is conducted the synchronization of them in order to generate the desired thrust force. Furthermore, it is explained the way the data acquired from the posture sensor are integrated to the data supplied from the user to generate the final control.

Chapter 5 - Evaluation of Performance of the Prototype Robot: Chapter 5 describes the evaluation of the developed system in different environments such as on the ground, in the air and in water. The complete description of the experiments performed is presented as well as the strategies used in order to improve the motion in some environments.

Chapter 6 - In-Pipe Locomotion System Using Water-Jet Propulsion: Chapter 6 describes the problematic to deploy special sensors in the pipe system of the Fukushima Daiichi NPP nuclear plant in order to monitor the status of specific areas. The study and evaluation of existing alternatives that partially could solve this problem are presented. Based on the evaluation, a proposal is manufactured and tested. Additionally, the implementation of water-jets along the devices is analyzed and tested.

Chapter 7 - Conclusions: Chapter 7 summarizes the overall contribution of this research work, gives final comments and discusses about the future work.