DESIGN OF A DEEP REINFORCEMENT LEARNING BASED OPTIMAL PH CONTROLLER FOR NITRIFICATION BIOREACTORS IN AQUAPONICS SYSTEMS

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Dissertation submitted in partial fulfillment of the requirements for the degree Master of Science in Industrial Automation

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May 2019

DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Signature of the supervisor: Date:

To all the people who feed us….

ACKNOWLEDGEMENTS

This research would have been another dream without the support from the following people.

First of all, I wish to express my sincere thanks to my supervisor, Dr Buddhika Jayasekara, for guiding me in the research process and providing feedback and advice over the years.

Next, I wish to thank Dr. D.P. Chamdima and Prof. K.T.M.U. Hemapala for their valuable feedback. Their feedback was extremely valuable in asking the right research questions and steering the study in the correct direction.

I wish to thank Eng. B.S. Samarasiri for mentoring me through the years and introducing me to research and product development. I would also like to give my sincere thanks to Mr. Jayasiri Kumarasinghe for all those industrial outings and for the valuable and practical industrial experience. He has taken me all over the country to see various industries and introduced me to industrial instrumentation and automation. This exposure was significant in finding the currently studied research problem.

Finally, I would like to thank my wife, my mother, my father and my brother for all the love and support they have given me and persevering with me during the entire period of the research.

ABSTRACT

Recent advances in deep reinforcement learning has produced state of the art algorithms. These algorithms have better training stability, convergence and computational performance.

In this study a state of the art deep reinforcement learning algorithm is used to implement a self-learning, model free, non-linear controller to control pH of an aquaponic system. Aquaponics is a soil-less farming system where effluent water from a fish tank is used as nutrients for growing plants. Maintaining the pH of an aquaponic system provides the optimal condition for micro-organisms that convert the ammonia rich fish effluent to nitrates, which are easily absorbed by the plants. In order to optimize this conversion process known as nitrification, pH is maintained at optimal conditions within an intermediate setup known as the nitrification bioreactor.

The implementation of a deep reinforcement learning based controller is studied in detail and the performance of the deep reinforcement learning based pH controller is evaluated by comparing the performance of a classic PID based controller in an aquaponic system.

The results show that DRL based controllers are better suited for control of dynamic stochastic control pH process and is capable of learning complex plant models and tuning itself based on the learnt model. The outcomes of this research can be applied in the design of optimal controllers that learns purely from experience to optimize various industrial processes. This type of controllers is ideal in Industry 4.0 based applications.

Keywords: Deep Reinforcement Learning, Artificial Intelligence, Aquaponics, Nitrification, Process Control

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Description
AI	Artificial Intelligence
RL	Reinforcement Learning
DRL	Deep Reinforcement Learning
MDP	Markovian Decision Process
POMDP	Partially Observable Markovian Decision Process
SISO	Single Input Single Output
MIMO	Multiple Input Multiple Output
DP	Dynamic Programming
ADP	Asynchronous Dynamic Programming
GPI	Generalized Policy Iteration
RPi	Raspberry Pi
I2C	Inter- Integrated Circuit Protocol
ReLu	Rectified Linear Unit
IoT	Internet of Things
ANOVA	Analysis of Variance

LIST OF APPENDICES