Hormone Inspired Controller Architecture for Adaptable Robots

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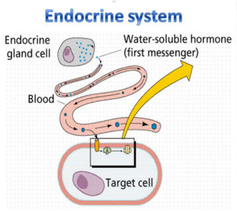
1. Introduction

Adaptability is an essential ability of autonomous robots working in real-world human-hazardous environments. These kinds of environments are dynamic and full of unexpected circumstances caused by environmental changes. In fact, changes can happen in both the internal and external systems of the robots.

Inspiration from Biology

Endocrine system is one of the main systems responding to homeostasis, a process which helps maintaining internal states of an organism over environmental variations. In general, endocrine system can be viewed as a system of glands which secretes hormones in response to changes of environments and also helping other functions of an organism. This is a key process which helps an organism to adapt and survive in dynamic environments.



2. Research Aim

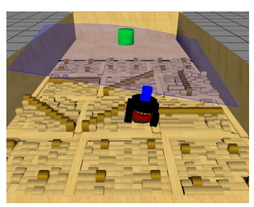
The main purpose of this research is to utilize artificial hormones in order to provide adaptability for an autonomous robot in such a way that it can cope with both internal and external environmental changes. Changes of terrain roughness and faults that occur in the robot's components are considered in this research as external and internal changes respectively.

Test Scenario

Robocup Rescue Robot competition is a project which has an aim to develop robots working in disaster search and rescue scenario, one of the applications which exemplifies the necessity of robots to be able to adapt to environmental changes. The competition uses situations and environments imitating real-world disaster environments. This research mimics environments used in the competition.

The robot and environments used in this research are all implemented in Gazebo, an open-source 3D physically-realistic robot simulator.

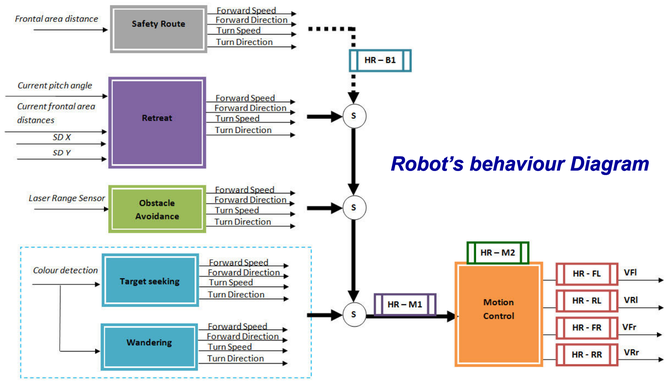
A Robocup Rescue Robot competition environment



Our test environment simulated in Gazebo, 3D robot simulator

3. Hormone Inspired Controller Architecture

In order to execute the desired tasks, a 4-wheel autonomous robot is equipped with a behaviour-based controller as shown in the picture.

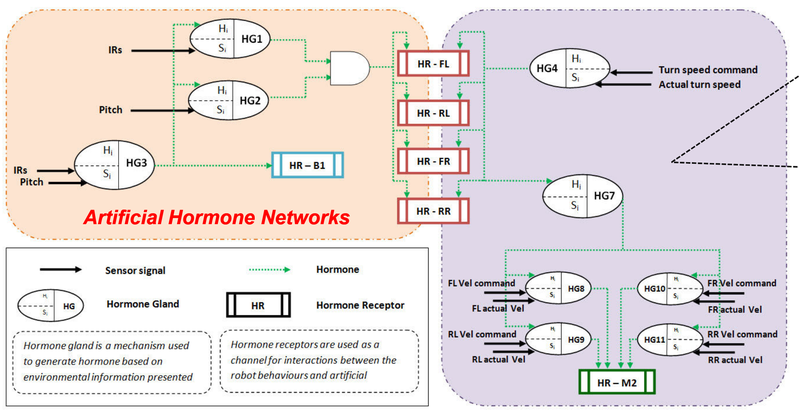


Artificial Hormone Network

On top of the controller, there are artificial hormone networks designed to help the robot deal with environmental changes.

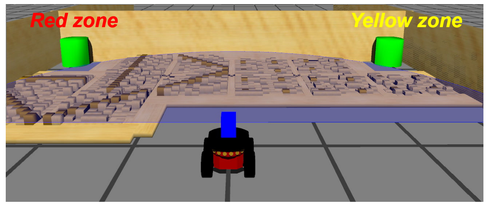
Generally, each hormone is secreted by a specific hormone gland. In addition, each hormone concentration is varied depending on the quantity and time interval of the particular environmental information presented at each gland.

Finally, the artificial hormone networks have affects over the robot by changing its behaviours related to each hormone receptor connection.



4. Preliminary Experiment

The main purpose of this experiment is to investigate the use of a hormone in helping the robot to negotiate a rough terrain environment. The robot is expected to approach two targeted objects, green cylinders, placed in two difference zones in the test environment. In doing so, the robot also has to negotiate rough terrain along the way.

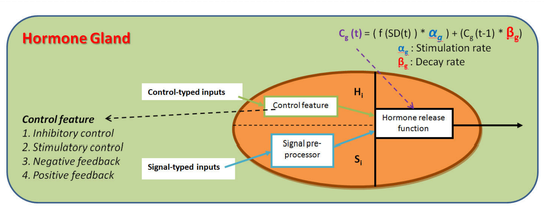


A test environment used for the preliminary experiment containing yellow and red zone. The robot is randomly placed around the bottom area of the test arena.

Experimental result

	The Number of tests	The Number of Time Out	The Number of Tip Over	The Number of Yellow Object Reach	The Number of Red Object Reach	The Number of Both-Object-Reach
Without Hormone system	*100*	*0*	*36*	*74*	*77*	*64*
With Hormone system	100	3	10	90	93	87

The result shows that hormone systems can help improving the robot's performance in dealing with changes to terrain roughness (The Tip Over rate is reduced by 26%. The Both-Object-Reach rate is increased by 23%).



An example of a hormone gland

HG2 is a hormone gland designed mainly to help the robot cope with movement on various rough terrains. The gland secretes a hormone when the robot is moving on rough terrain (represented by the standard deviation of the robot's pitch). The hormone affects the robot by decreasing the speed of each of the robot's wheels depending on the hormone level presented at the related hormone receptors.