nBrains
A New Type of Robot Brain

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Abstract. The design and implementation of a possible alternative to Artificial Neural Networks (ANNs) for agent control is described. This alternative, known as the nBrain, uses the phase-space representation as the inspiration for a controller. The agent progresses to different states due to the presence of attractors in phase space, whose locations are set by the robot’s genome. Several experiments with simulated agents are described. The experiments were successful in that tasks which have been performed by ANNs in the past were successfully accomplished by nBrains under evolution. The possible advantages and disadvantages of nBrains over ANNs are discussed, and directions for future work are presented.

1 Introduction

This document describes the design, implementation and testing of a new type of agent controller, known as the ‘nBrain’. The nBrain uses the phase-space representation to make the dynamical-systems approach to cognition explicit. The aim of the project is to show that nBrains are useful controllers for autonomous agents, and that they are capable of producing some of the behaviours which are produced by ANNs.

1.1 Motivation and Background

Recently it has been widely suggested that the best way to view the brain is as a dynamical system which interacts with other dynamical systems. This view has several advantages over the alternative computational view, and many researchers are now producing work which reflects it, constructing controllers for real and simulated agents which perform many different tasks. These researchers include Beer [1,2,3], Cliff [4,5], Harvey [5,6], Husbands [5], Jakobi [5], Miller [4], Thompson [5] and van Gelder [7]. It is hoped that nBrains may be a useful tool in investigating cognitive phenomena and producing useful autonomous robots.

2 nBrains: An Explanation

This section explains the general features that constitute an nBrain. The state of an agent at any time may be represented by a point in phase space. The
genotype of an agent with an nBrain controller specifies a vector ‘force’ field in the space of some of its variables which causes the agent to trace a path through that space.

Imagine that we have an extremely simple agent, with one sensor and one motor. Then its phase space representation is a plane (see figure 1 (left)).

![Fig. 1.](image)

Left: Phase space of a simple agent with one motor and one sensor. Note that for consistency the vertical axis is zero at the top and one at the bottom. Right: A vector field in phase space which causes the agent to trace a path through phase space such that it moves when light is present and stops otherwise. Dimension 0 (horizontal) represents motor activation, and dimension 1 (vertical) represents sensor activation. When the sensor is active (near the bottom of the graph), the motor tends to become more active (movement towards the right), and when the sensor is inactive (near the top) the motor tends to become less active (movement towards the left). Note that the lines should be taken as arrows pointing from the dot, towards the end of the line.

If we were to design a simple controller for this agent, so that it moved when it saw light, and stayed still otherwise, we could plot this behaviour as a vector field (see figure 1 (right)).

The lines on figure 1 (right) indicate the direction (in the motor dimension) that the robot will move through phase space if it finds itself in any particular state. The lines do not point in the sensor direction as movement in this dimension is not determined by the robot controller but is fed in from the environment.

An nBrain is a vector field like the one shown in figure 1 (right), so that now rather than simply using the phase space diagram to describe the action of an agent controller, we use it to specify that action. In the experiments described the vector field in the space was determined by specifying a number of points which behaved like attractors, causing attractive ‘force’ towards them.

These concepts may be extended to robots with more sensors and effectors, but they become more difficult to picture, as the diagrams become many-dimensional. They may also be extended to build non-reactive agents using hidden dimensions with no direct physical meaning.