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A STUDY OF INSECT BRAIN USING ROBOTICS AND NEURAL NETWORKS

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ABSTRACT

Genetic algorithms have been used to construct a neural model for insect path integration in order to help understand how insects navigate.Some experiments have been carried out to simulate navigation using autonomous robots that hoped to not only explain certain factors relevant to insect navigation but also increased our knowledge toward the understanding of insect/robot modular systems.In this paper the neural model using the brain of an insect have been proposed and the concept that a simple model is best could give rise to a new generation of intelligent machines. The idea of the artificial neural network to help describe how an insect's "cognitive map" is used for navigation has been designed for use on robot control as a decentralized model, chemical intelligence and in optical predictive models among others.Technical advances in analog integrated circuitry along with micro electro mechanical systems (MEMS) have given rise to compact systems (with hardware inspired architecture HNN or Hardware Neural Networks) that may someday help us understand how insects do what they do so well.Anyhow a variety of basic insect behaviours have inspired successful robot implementations,m-
ore complex capabilities in these 'simple' animals are often changed.By looking into the general design of their nervous systems,we will be able to know how to integrate behaviours,perform pattern recognition, and combine many sensory inputs in tasks such as Navigation.Brain Hybrid system etc,which is compared with the real time insect.

KEYWORDS: GA,ANN,CA,AI

INTRODUCTION

Insect brains are small but still they are enormously complex. Artificial neural networks (ANN) simulate neurons in the brain. The simulation for neural network through software requires digital computer technology and for a hardware-based analog, ANN is used which is smaller, quicker and more directly emulates functions of biological neurons.The purpose of robot in these experiments is to illustrate a particular behavior based on the output of these ANNs. Emulation of insect behavior in these types of experiments seems the logical choice as many of the early entomological researchers have painstakingly collected an enormous amount of data on this subject while in the field.New advance in neuromorphic production may hold the key to our understanding of how the brain works. The underlying issues of understanding the genetic transfer of information to the formation of neurons may be greatly enhanced when comparable artificial neurons are produced in the laboratory. In the biological based robotics field, robots can be made use of reproducing animal behavior in order to study their interaction with the environment. Robots help to improve the perceptive of animal behavior and animals help to create efficient and robust robotic systems.. A lot of work has been done in several animal species belonging to mammals, mollusks and insects [1]. Looking into the insect world different research groups around the world are trying to design models which are able to reproduce interesting behaviors shown by insects: cooperation mechanisms in ants [2], navigation strategies in bees [3], looming reflex in locusts [4], homing mechanisms in crickets [5], central pattern generator and obstacle climbing in cockroaches [6, 7], reflex-based locomotion control in the stick insect [8], just to cite some examples.

RELATED WORKS

A. Genetic Algorithms

Some of the early models for autonomous robot control have involved a neural component with the intent to help describe common behavioral traits often observed in biological organisms. The robot serves as a proposal with various inputs and outputs that helps the researchers to evaluate the outcome. For example, Path Integration, an important routing strategy in many insects, can be computer-generated using a simple mobile robot.In earlier days many of the "brains" of these robots in the were software based artificial neural networks, a number of other methods derived from the biological concepts were also used to control robotic, that fall into a classification of

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computer programming called artificial intelligence (AI). A method called Genetic Algorithms is one such type of AI programming.

Genetic Algorithms (GA) mimic evolution and can be used to evolve certain kinds of neural networks. In Genetic Algorithm processing, data grouping are arranged into strings of binary data called chromosomes. These randomly generated chromosome strings are evaluated for fitness. Good fitting pairs are selected and new sets of chromosomes are created to form a new generation. More evaluations are then performed on the new pool of data. Randomized mutations are thrown in to make it interesting and more generations are created until an adequate degree of fitness is achieved.A genetic material consisting of integers is interpreted as a neural network. For a marker-based encoded chromosomes, each neuron is defined by a cluster of connections specified between a start and an end marker in the chromosome (Figure 1). The method allows the complete build of the network structure including the number of nodes and their connectivity which is evolved through genetic algorithms. Insects and other invertebrate animal having exoskeleton called as arthropod have inspired robotics research for some time. Robots have been built which mimic i.e to copy or imitate closely; for example, fly flight stabilisation [1] and obstacle avoidance [2], ant polarisation vision [3] and landmark navigation [4], the phonotactic behaviour of crickets [5], or the lobster's ability to locate chemical sources in marine environments [6]. Despite such examples of how insect biology has been of use to robotics, insect nervous systems have as yet been under-exploited as a potential source for robot control architectures.Many examples of insect behaviour require the integration of information from multiple sensory modalities, learning, and instantaneous control of numerous interacting behaviours, enacted by a complex body morphology.

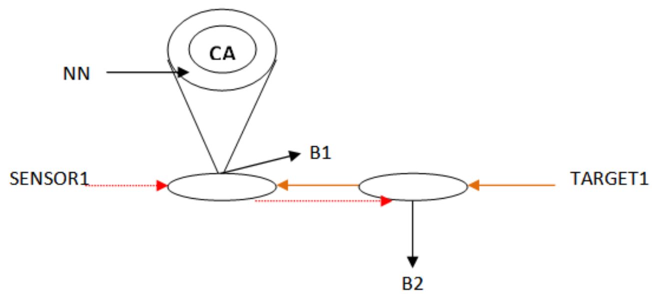

Figure 1:GA method with cellular auotmata,Neural networks and with single sensor and target

Cellular Automata (CA) are populations of interacting cells. These cells are each computers (automatons) and can represent many kinds of complex behaviors by building appropriate rules. Each cell has a state value and this value changes at each step. Change of situation is based on the predefined system and is also based on the current state of the cell and the conditions of the neighboring cells.

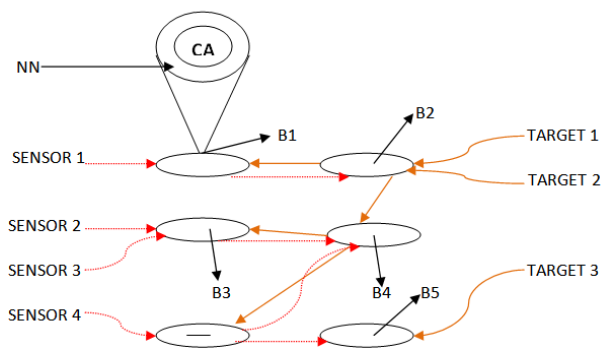

Figure 2:GA method with cellular auotmata,Neural networks and with mulyiple sensor and multiple target

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CA can model ecological systems or the performance of insects, and can be also used for image processing and the construction of neural networks.In Figure 2, as the problems become more difficult, the basic evolutionary algorithm needs to be modified in a stepwise manner. For example, if a robot moves into a new and more challenging environment, the straight line movements previously learned are compared with turning movements.Most of the CA-based neural networks module learns a man moments correctly, the successful chromosomes are copied to the next population. The robot evolves to fit the new environment and is able to make turns. Those steps are repeated till the robot learns how to navigate the new environment.

B. Brain-Machine Hybrids

In the bio-inspired robotics field, robots can be used to replicate animal behavior in order to study their interaction with the environment. Robots help us to improve the perceptive of animal behavior and animals help to create efficient and robust robotic systems.The robot engineers have often marveled at how to adapt an insect can be; how it can navigate through a wide range of obstacles and undergo any number of harsh environments and still successfully do what it has to do stay alive.The current knowledge cannot build a cockroach sized robot as agile as the real thing,but some researchers have built a cockroach control interface that communicates via a wireless receiver mounted on the roach's back. Here the remote control signals sent to the receiver causes electrical impulses to be sent to the cockroach's antenna. The impulse stimulate a touch reply sending the roach in the intended direction For similar reasons, hybrid concept have been planned for space exploration because of an insect's remarkable navigation capabilities. These “insects-in-a-cockpit” would be able to master the higher-level decision making that a space robot couldn .Fundamental analogies exist between the behaviors that insects exhibit and the basic skills that one would expect from autonomous robots in space. Insects like as bees, ants and cockroaches have become particularly appealing models for investigation in the context of biomimetic robotics since they have optimized navigational mechanisms in terms of simplicity and robustness
Figure 3 shows a proposed input/output diagram of a honeybee pilot tethered in its cockpit. Inserted into the bee are electrodes for neural registration and stimulation. MEMS-based sensors can detect motor patterns and a system is in place for offering visual and olfactory cues. The external environmental sensors can send signals to both the low level controller and the hybrid controller unit which can influence the low level control system.

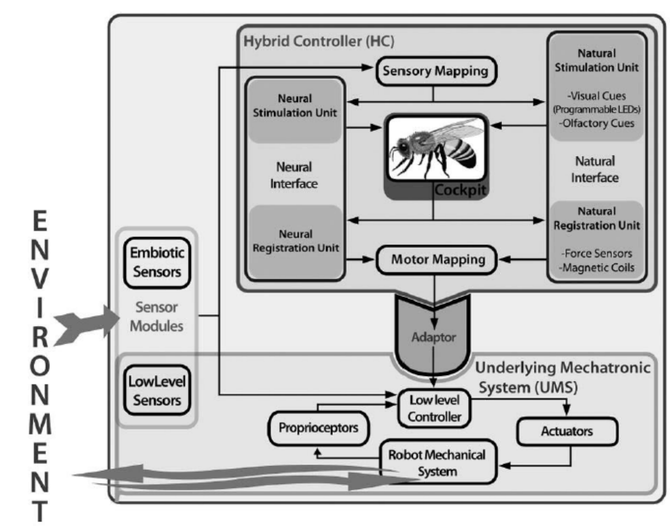

Figure 3 Scheme of a robotic platform including the hybrid control architecture.

Some unique research involving insect hybrids were used to reproduce the behavior of an insect and understand how silkworm moths process information in the brain during adaptive odor searching behavior. In this study, electrical spike from the neck motor neuron of a silkworm moth were converted into appropriate control signals for steering a two wheeled robot.Similar experimental models were used on silkworm moths to explore the neural mechanisms of odor-source searching behavior but in this case, the robot was controlled via signals from the moth antenna (electroantennogram).Figure 4 shows a comparison of stimuli processing of a hybrid system and a real organism. In the research, the sensory input is olfactory; there is a pheromone to which the silkworm moth reacts. The input to the model of brain is different in each experiment in that response signals are either from moth neck neurons or antenna output . The signals are interpreted by the brain model which sends the appropriate control signal to the robot.

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BASIC ARCHITECTURE

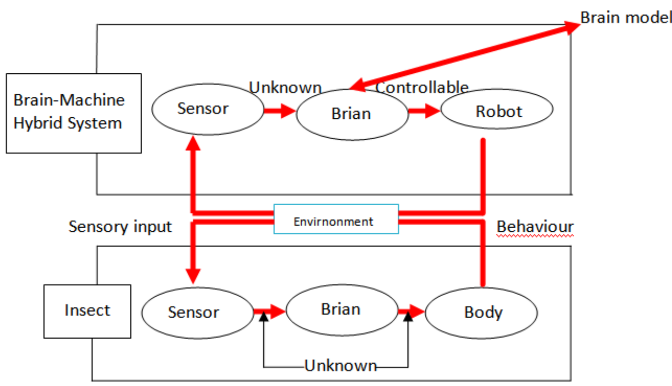

Figure 4:Frame work for Brain Hybrid System(Top) compared with a real organism(Bottom)

IMPLEMENTATIONS

Various Steps in Modeling the Insect Brain

The actual insect brain computational model is the result of a number of previous versions, that were further refined and updated, once new results, especially on the neurobiological perspective, were available. The first architecture proposed was designed and organized in various control levels consisting of functional blocks, performing either at the same level, or at distinct hierarchical levels showing the capability to learn more complex, experience-based behaviors [9].The control architecture (as reported in Fig. 2) consisted of series of parallel sensory-motor pathways that were triggered and controlled by specific sensory events in a reflexive way, giving the understanding baseline to the system. Nearly going up to the hierarchical scheme,the two relevant centers of the insect brain were considered: the Mushroom Bodies (MBs) and the Central Complex (CX). Taking into account the known facts about these centres, from a biological/neurogenetic point of view and their role in perceptual processes [9], some preliminary main functions were initially focused,that to be assessed and refined during the project activities.In particular, a function ascribed to MBs was to have a role, due to the knowledge capabilities, in the enhancement of fundamental relations arising among the basic behaviours,by exploiting the temporal relationship between sensory events; information storage and retrieval in the case of the olfaction sense; resolving contradictory cues through the visual sense by imposing continuation or adaptive termination of ongoing behaviour. Relevant functions ascribed to the CX were integration and elaboration of visual information, storing and retrieving information on objects and their position in space, controlling the step length in order to approach or avoid such objects; motor control, landmark orientation and navigation and orientation storage and othersThese learning aspects were treated using causal Hebbian rule in an array of spiking neurons for anticipation, on the basis of what already studied ,where memory structures based on Recurrent Neural Networks were considered.At a higher level of the scheme, a demonstration layer was introduced, able toprocess sensory information in order to define the final behavior.The introduction of

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lattice of non spiking neurons. Ite shows distinct characteristics of complex dynamical systems. The rising patterns of neural states take on the importance of percepts. These ones are then associated to a perfect modulations of the basic behaviors. This modulation is performed through an unsupervised knowledge process which creates associations among sensory stimuli and patterns. In this way,

CONCLUSION

In this paper,Insects were used to solve difficult behavioural tasks with miniature brains.The current state of neurobiological

research on insect nervous systems has identified essential elements of their control architecture.Even though much remains uncertain and speculative, nevertheless some interesting general features emerge.

REFERENCES

1. B. van Swinderen and R. Greenspan. Salience modulates 20-30 hz brain activity in Drosophila.Nature Neuroscience, 6:579–586, 2003.
2. D. Lambrinos, R. Moeller, T. Labhart, R. Pfeifer, and R. Wehner. A mobile robot employing insect strategies for navigation. Robotics and Autonomous Systems, 30:39–64, 2000.
3. N. Franceschini, J. Pichon, and C. Blanes. From insect vision to robot vision. Philosophical Transactions: Biological Sciences, 337(1281):283–294, 1992.
4. M. Srinivasan, J. Chahl, K. Weber, S. Venkatesh, M. Nagle, and S. Zhang. Robot navigation inspired by principles of insect vision. Robotics and Autonomous Systems, 26:203–216, 1999.
5. Saito, K., M. Takato, et al. (2012). "Biomimetics Micro Robot with Active Hardware Neural Networks Locomotion Control and Insect-Like Switching Behaviour." International Journal of Advanced Robotic Systems 9
6. Moller, R. (2000). "Insect visual homing strategies in a robot with analog processing." Biological Cybernetics 83(3)
7. Douence, V., A. Laflaquiere, et al. (1999). "Analog electronic system for simulating biological neurons." Engineering Applications of Bio-Inspired Artificial Neural Networks, Vol Ii 1607: 188-197
8. Haferlach, T., J. Wessnitzer, et al. (2007). "Evolving a neural model of insect path integration." Adaptive Behavior 15(3): 273-287
9. Kim, K. J. and S. B. Cho (2006). "A unified architecture for agent behaviors with selection of evolved neural network modules." Applied Intelligence 25(3): 253-268.
10. Kanzaki, R., S. Nagasawa, et al. (2005). "Neural basis of odor-source searching behavior in insect brain systems evaluated with a mobile robot." Chemical Senses 30: I285-i286