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ScienceDirect

Procedia Computer Science 169 (2020) 320–325

Procedia Computer Science

www.elsevier.com/locate/procedia

Postproceedings of the 10th Annual International Conference on Biologically Inspired Cognitive Architectures, BICA 2019 (Tenth Annual Meeting of the BICA Society)

Development automated biobot control system using AI framework

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Abstract

Inspired by the biobotics, we wanted to create an automatic control system using neural networks. This paper throw light on the subject of creating a biobots control system using deep-trained neural networks based on AI framework slitherin. Insect biobotic agents can be used for monitoring and assessing missions after natural disasters or earthquakes. Scientific and technological approaches created as a result of work on this project can cre-ate fundamentally new ways of interacting not only with insects, but also with other animals.

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Peer-review under responsibility of the scientific committee of the 10th Annual International Conference on Biologically Inspired Cognitive Architectures.

Keywords: biobotics, cyborgs, robotics, DNN

1. Introduction

This article will throw light on the subject of creating a biobots control system using deep-trained neural networks. Biobotics is the newest modern direction of robotics, in which, instead of a controlled manipulator (robot), animals with implanted electrodes are used in the nervous system, particularly cockroaches [1], flying beetles [2], rats [3] and even pigeons [4]. Over the past 30 years, as a result of the development of the Moore's law, remote control chips have been significantly reduced in size. This article describes the work steps: Creating motion tracking system; modelling creating maze arena; creating Haar classifier for detection biobot, BLE connection module with chip; adapting AI framework «slitherin» for automated control system. My previous work illustrated the ability to control roach movement from BCI Emotiv Epoc [5]. Now we describe biobot control system.

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10.1016/j.procs.2020.02.190

2. Insect Biobot

2.1. Insect Biobot

For experiments, we selected Blaberus Craniifer (South American cockroaches) because we use BackyardBrains Roboroach backpack and they designed it for this kind of roaches [6]. Their size about 65-80mm, life span about 1 year. Roach were enabled by surgical implantation of stimulation electrodes to the antennae (Fig. 1). The electrodes were 0,082mm thinkness, silver plated copper wires. Surgical implantation is described here [6].

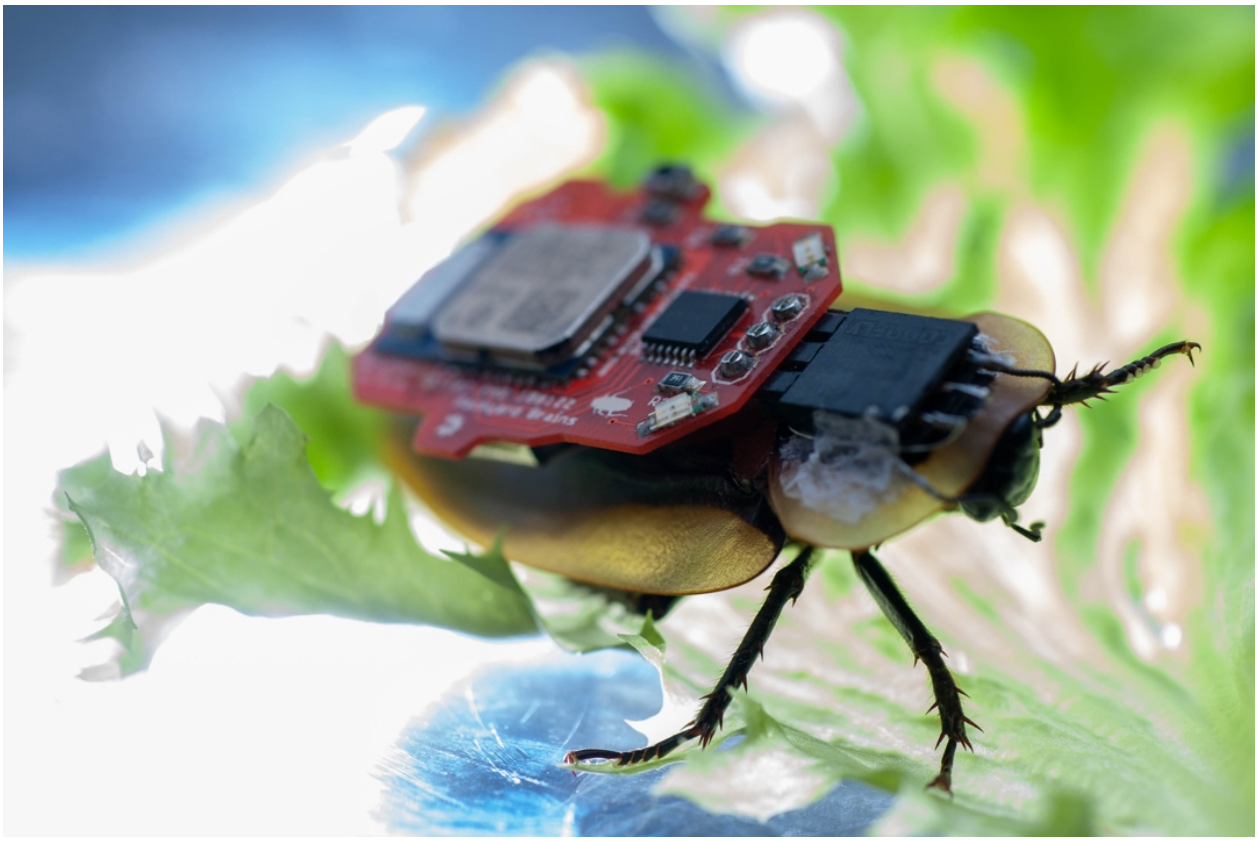


Fig. 1. Blaberus Craniifer with BYB stimulation backpack.

2.2. BackyardBrains RoboRoach backpack specifications

We used the "Backyard Brains RoboRoach" backpack(wireless stimulator) (Fig. 1). Total weight 4.5g. Stimulation Frequencies range: 1Hz-150hz. Voltage: 20mV – 2V. Stimulation Pulse Widths: 1ms-500ms. Stimulation Duration: 10ms – 1000ms.. Commutication : Bluetooth Low Energy. Battery: CR1632 [6].

For connection we use Cambridge Silicon Radio Bluetooth 4.0 dongle with USB extension cable and Pygatt 4.0.1 – Python Module for Bluetooth LE.

3. Implementation

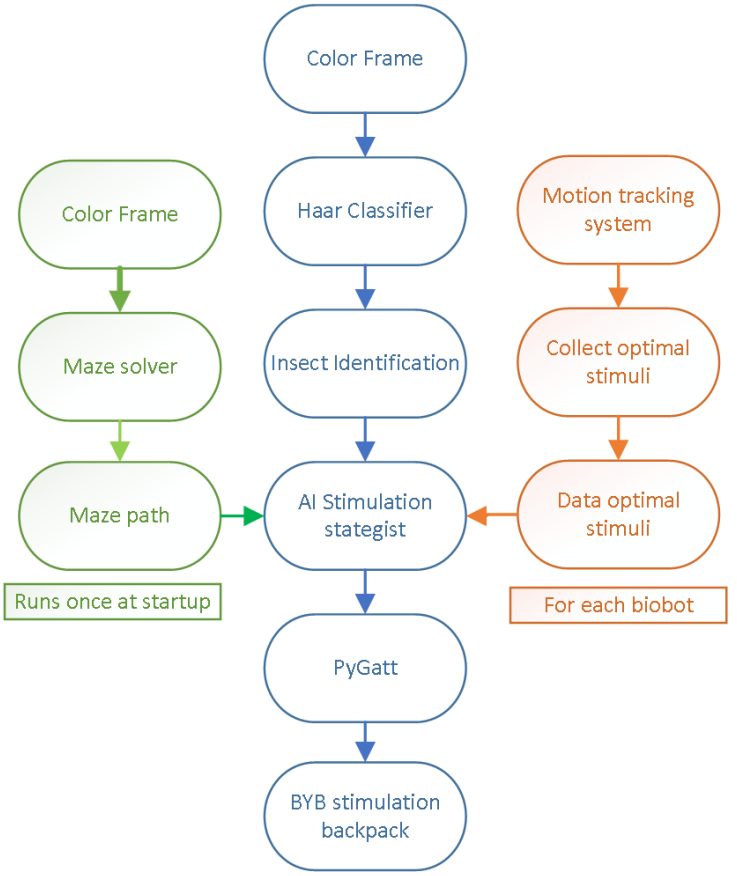


Fig. 2. Components of automation control system.

3.1. Motion tracking system

The main goal the experimental motion tracking system development is to acquisition optimal params of stimulation from the biobot. These stimulations were transmitted from the surrounding artificial environment. The motion tracking system provides the following stimuli to a biobot: constant and blinking light; air flow to cerci; electrical antenna stimulation.

At the same time, the stand allows you to read the events of the movement of a cockroach in a fixed installation.

The motion tracking system consists of Raspberry PI 3 and five GPIO pins for which signals are sent: LED, speaker and FAN. Also, the stand includes a wireless mouse on which a ball is located to acquisition the statistic data, BYB roboroach backback for antennae stimulation. Further data on the optimal range of electrical stimulations for the cockroach were sent to the input of the neural network. The figure 3 shows Motion tracking system.

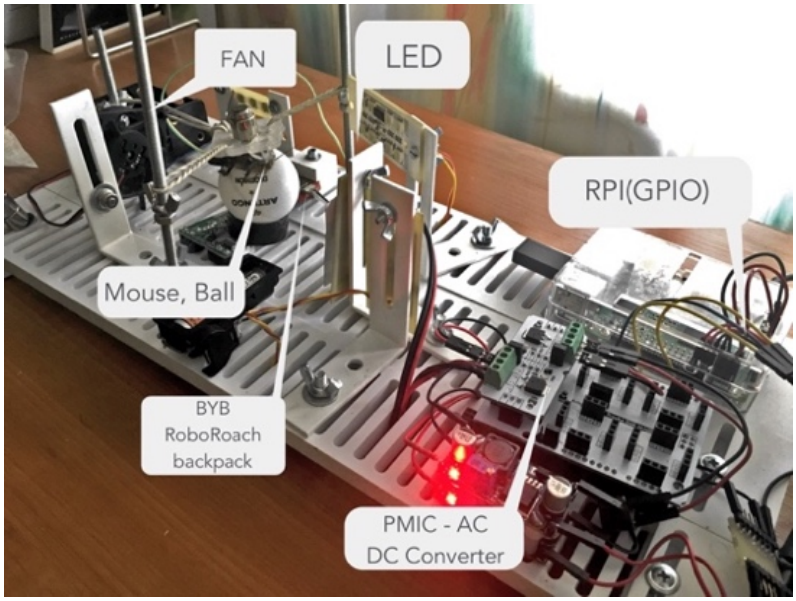


Fig. 3. Motion tracking system.

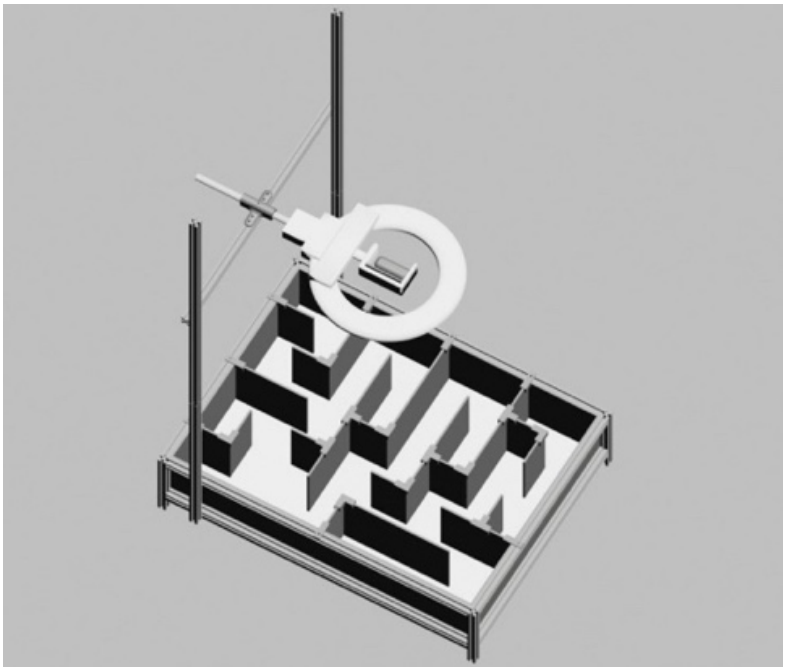


Fig. 4. 3d model of Maze Arena with light ring and camera fixator.

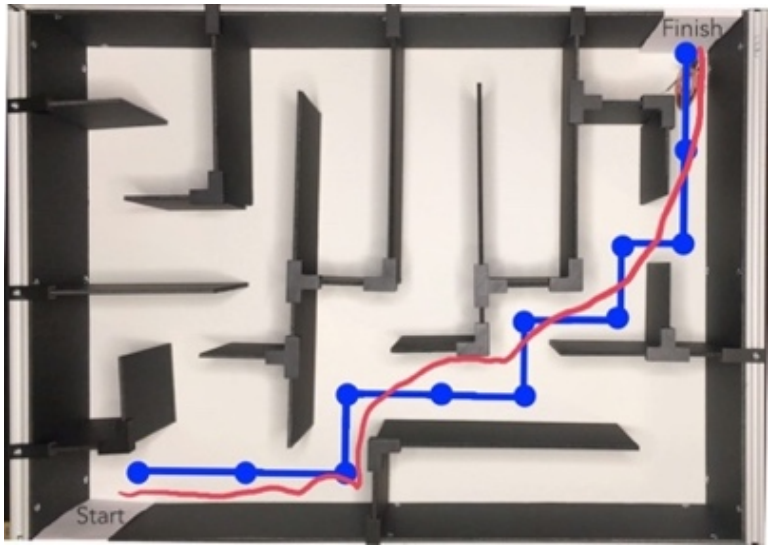


Fig. 5. Maze Arena, (red) overlay of path taken by a biobot on designated (blue) path.

3.2. Creating test bed Maze Arena

The maze arena was made of 20mm aluminum bunk structural section. The size of the testbed is 60x80x15cm. Height for mounting the camera - 140cm. A light ring is necessary to provide better and more uniform light. The camera is located above the maze arena and capture a video.

On the 3d printer "Alekmaker GT" using plastic "Total pro cf-5", spare parts for modular fixation of the walls of the maze were printed. This allows us to create various combinations of the maze.

3.3. Maze solver and Training Haar classifier

We use Logitech camera capture 1920×1080 at 30 frames per second. We created software to make image processing on the life feed from camera. We used python and OpenCV (with CUDA) for tracking a biobot and solving a maze. We use maze solver developed by I. Gulati [7]. We choosed the Haar classifier because they are widely used in robotics and the key feature highest calculation speed. We have prepared 500 biobot images. For negative images we used 10000 images. Angle determiner based on this sollution [8].

We receive a text file with the boundaries and points of the maze, then send them to the input of the neural network. Also, the optimal range of stimulation parameters obtained from the motion tracking system, as well as the coordinates of the biobot location based on the Haar classifier, arrive at the neural network input.

3.4. Stimulation Strategist (NeuralNetwork)

The research environment of AI “Slitherin”, developed using the TensorFlow and Keras libraries, was chosen and adapted as a trial model. Input layer 7 neurons [direction, left_neighbor, forward_neighbor, right_neighbor, angle_to_point, params_stimuli, maze], hidden layer 172 neurons with FA Relu 6 and output layer with 2 neurons[direction, params_stimuli].

4. Discussions, Issues, Future Works

We had a test charge on motion tracking system and found out that 2 of 6 biobots were defective (not controlled by stimuli). With 4 biobots we collected the optimal values stimulation (1.5V, 55Hz, 0.45s) and obtained similar stimulation parameters [9]. Ultimately, we conducted 20 experiments in a maze. 12 times the biobots successefully pass a maze under AI control.

Using the motion tracking system allows you to immediately cut off the defective biobots and concentrate more carefully on the experiments. Another advantage is the collection of specific data for a specific biobot. When modifying the tracking system, it can be used not only for cockroaches, but also for small mammals.

The main difficulty in conducting such experiments is neuroplasticity [10] — the impossibility of performing them for more than half an hour [6]. This puts the holding of these experiments in a rigid framework, since it requires a large number of cockroaches and time to conduct the surgery operation.

The biobiot stops while walking on and needs to be made to move forward. To solve this problem, it is necessary to use a portable backpack that can enable stimulation in cerci, as it was presented in work [9], [11]. To stop the gait of a cockroach, it is possible to apply stimulation to both antennas.

In the future we plan to use GAN systems that will interact with biobots and learn from each other. With the correct formulation of the experiment, this can create fundamentally new ways of interacting not only with insects, but also with other animals.

5. Acknowledgment

We acknowledge the Innovation Promotion Foundation for funding under “UMNIK NEURONET” (№ 11429GU/2017). Author thank Department of Entomology MSU for supply with surgery and useful consultations. Also thank Stanislav Mircic for consultations.

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