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Bio-robotic mobile platform for studying insect behavioral patterns

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МИНИСТЕРСТВО НА ОБРАЗОВАНИЕТО И НАУКАТА

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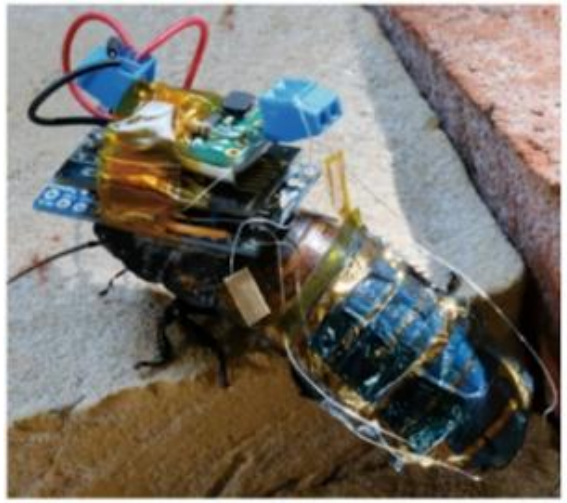
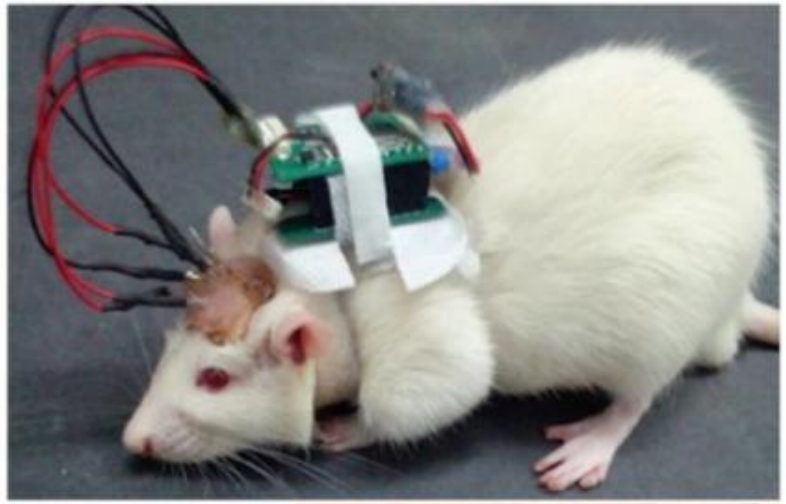
1. Introduction

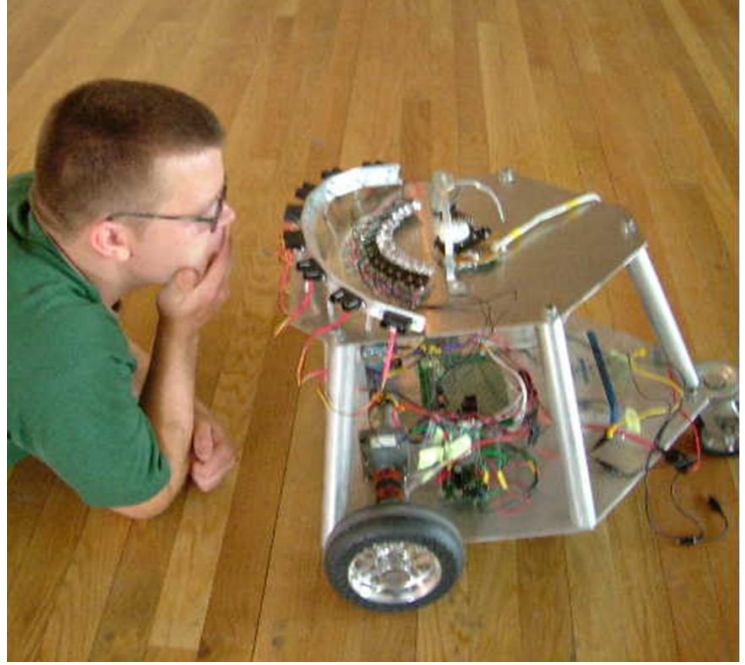
Inspiration from the living world

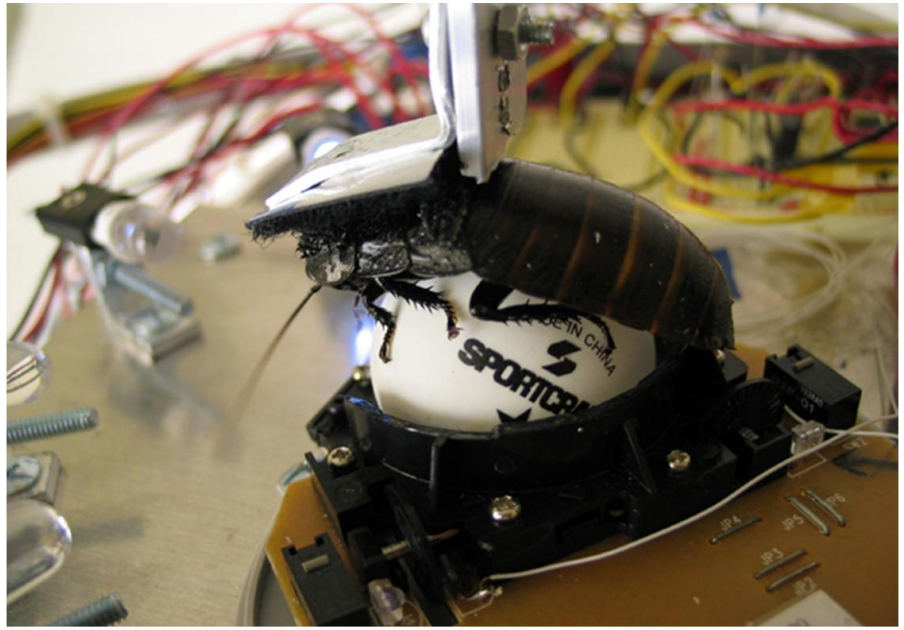
- Studying, copying and transforming the evolutionary experience.
- Cyborg-animals, controlling animals with neurological electrical stimulation.

1. Introduction

- Methods to stimulate and control walking and flying insects for navigation and obstacle avoidance.
- Applications for rescue operations, exploring and searching for targets, etc.
- ***Building models of the insects' behavior and reactions to stimulus and their implementation in the control of mobile robotic platforms.***





2004 - mobile robot controlled by a live cockroach

1. Introduction

- AI and Machine Learning would allow the classification of the collected statistical information into an algorithm that could be used directly by a mobile robot, thus avoiding the subjectivity of human interpretation.
- Many technical difficulties
  - Insects cannot be trained
  - Small sizes and physiological characteristics
  - One way control only, etc.

2008 - A mobile robot using a silk moth

2. Developed prototype of a bio-robotic platform - CYROACH

Concept and stages of the project

- **The implementation of the prototype bio-robotic mobile platform in order to register the sensory stimuli and behavior of animals. This part is the subject of the current work.**

Next stages:

- Conducting experiments with the developed platform and choosing an appropriate species of insect (cockroach). Collecting data from the experiments and improving the hardware if necessary.
- Building a software platform for registering and storing the incoming information in a database, analyzing the data and generalizing it into a control algorithm that can be used directly by a mobile robot for navigation and obstacle avoidance.
- Searching for the best result with experiments with different Machine Learning algorithms, upgrading the system with additional sensors and adding feedback from them.

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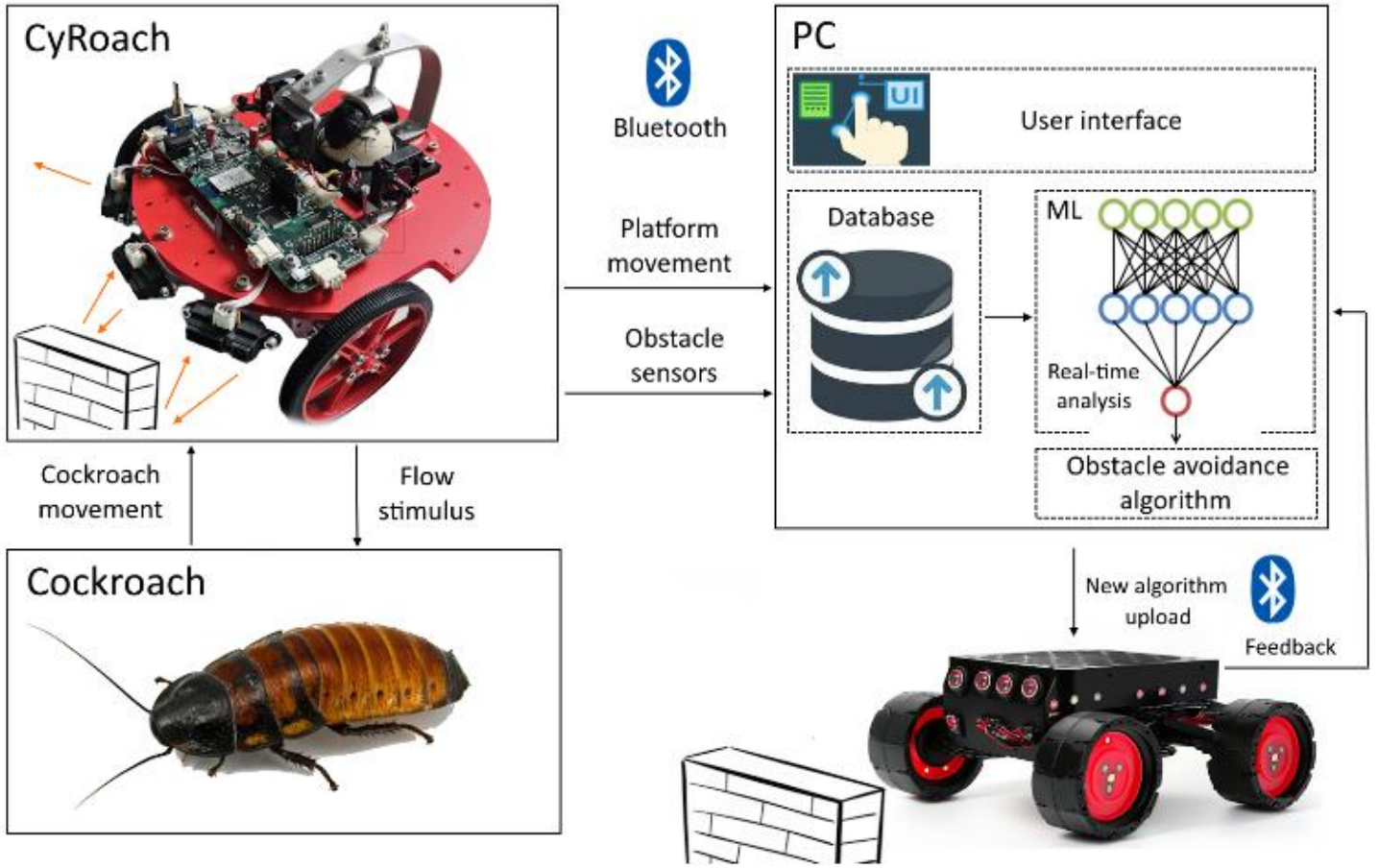
2. Developed prototype of a bio-robotic platform- CYROACH

Concept of the research

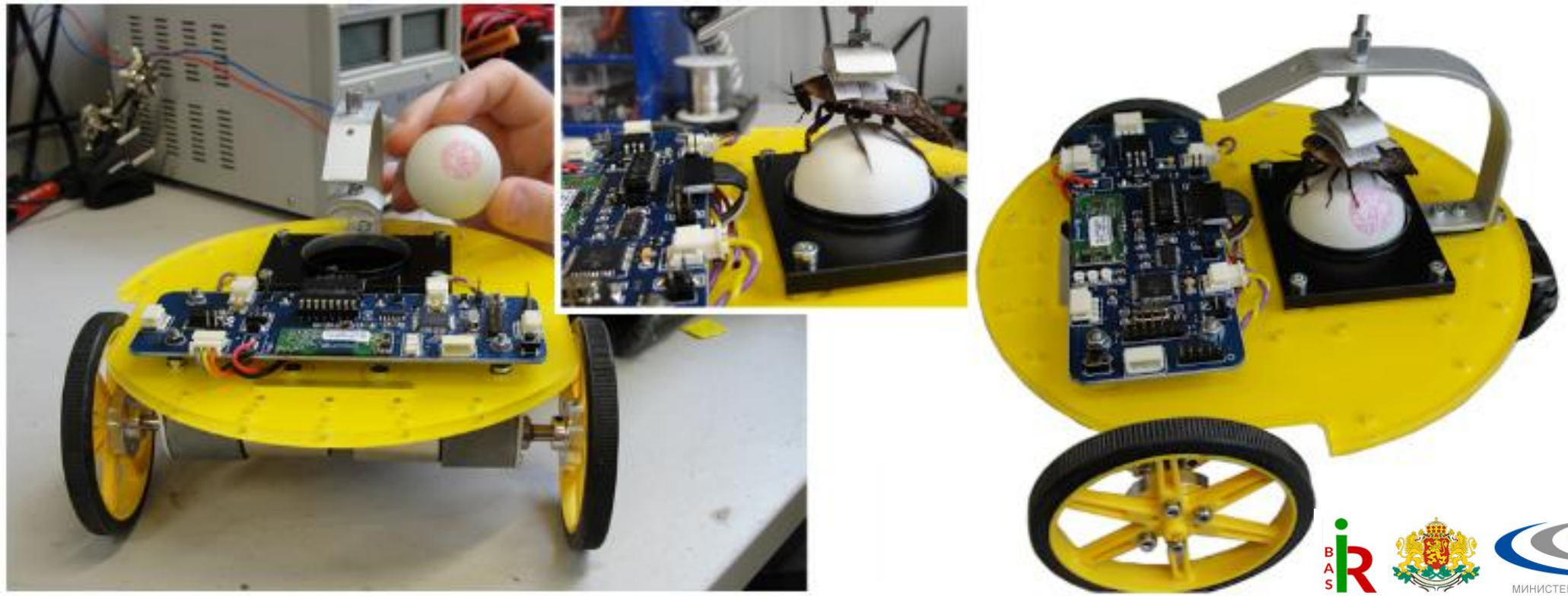
- The processes of registering and responding to the environment, and the generalization of these data into a control algorithm, should occur as much as possible in real time.
- In order to simplify the process, the control model is reduced to an algorithm for avoiding obstacles in a non-deterministic environment.



2. Developed prototype of a bio-robotic platform - CYROACH

First version of **“CYROACH”** - Cyborg Cockroach

- All the electronics and control are organized in a specialized PCB.
- Suitable for experiments are all larger and mobile cockroach species such as the species Gromphadorhina portentosa and/or Blaberus craniifer.
- It successfully demonstrated the ability of a cockroach to move the mobile platform.



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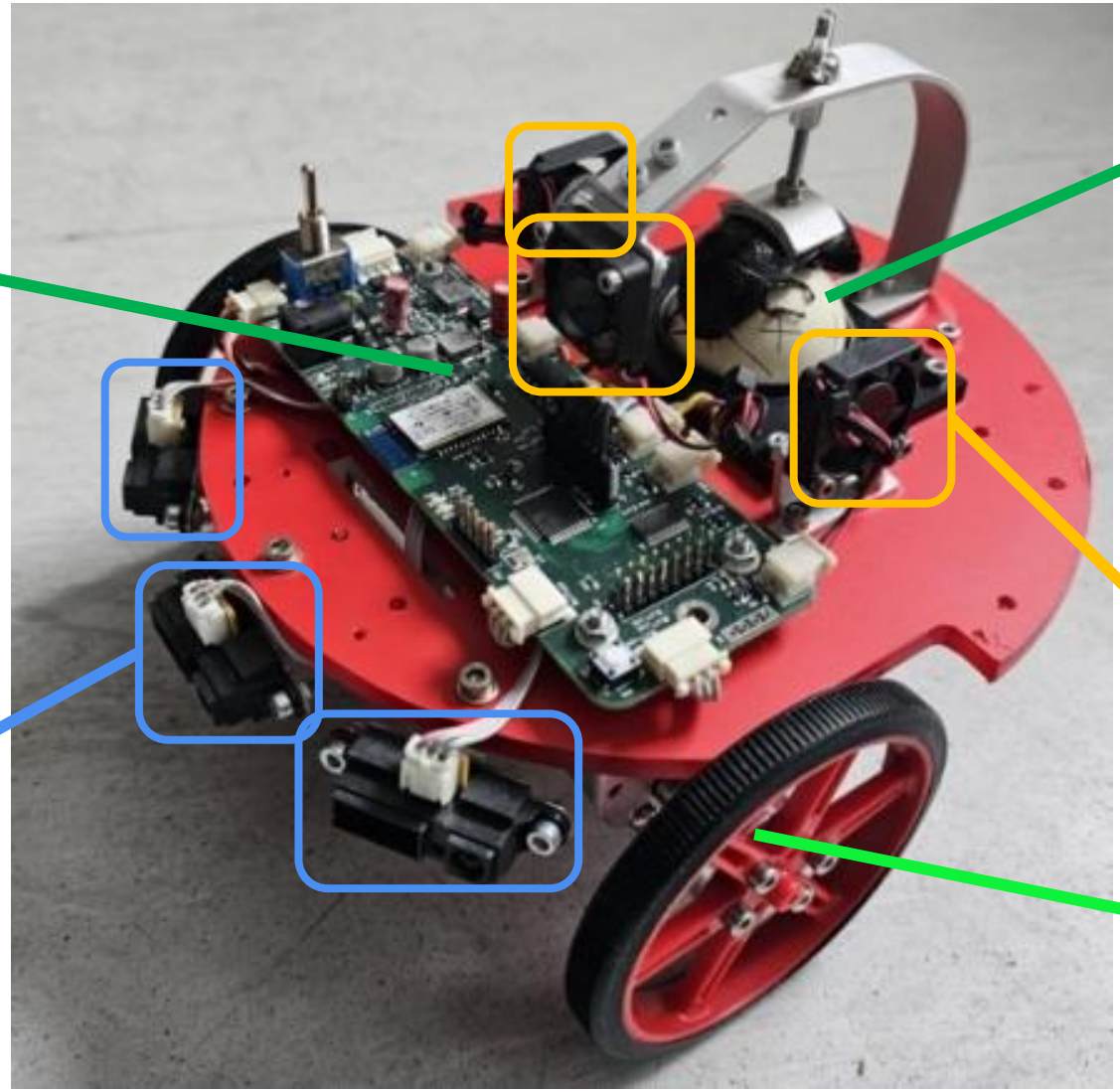
2. Developed prototype of a bio-robotic platform - CYROACH

Second version of **“CYROACH”**



Control and communication PCB

Trackball for capturing insect’s movements

3 Fans to stimulate the cockroach.

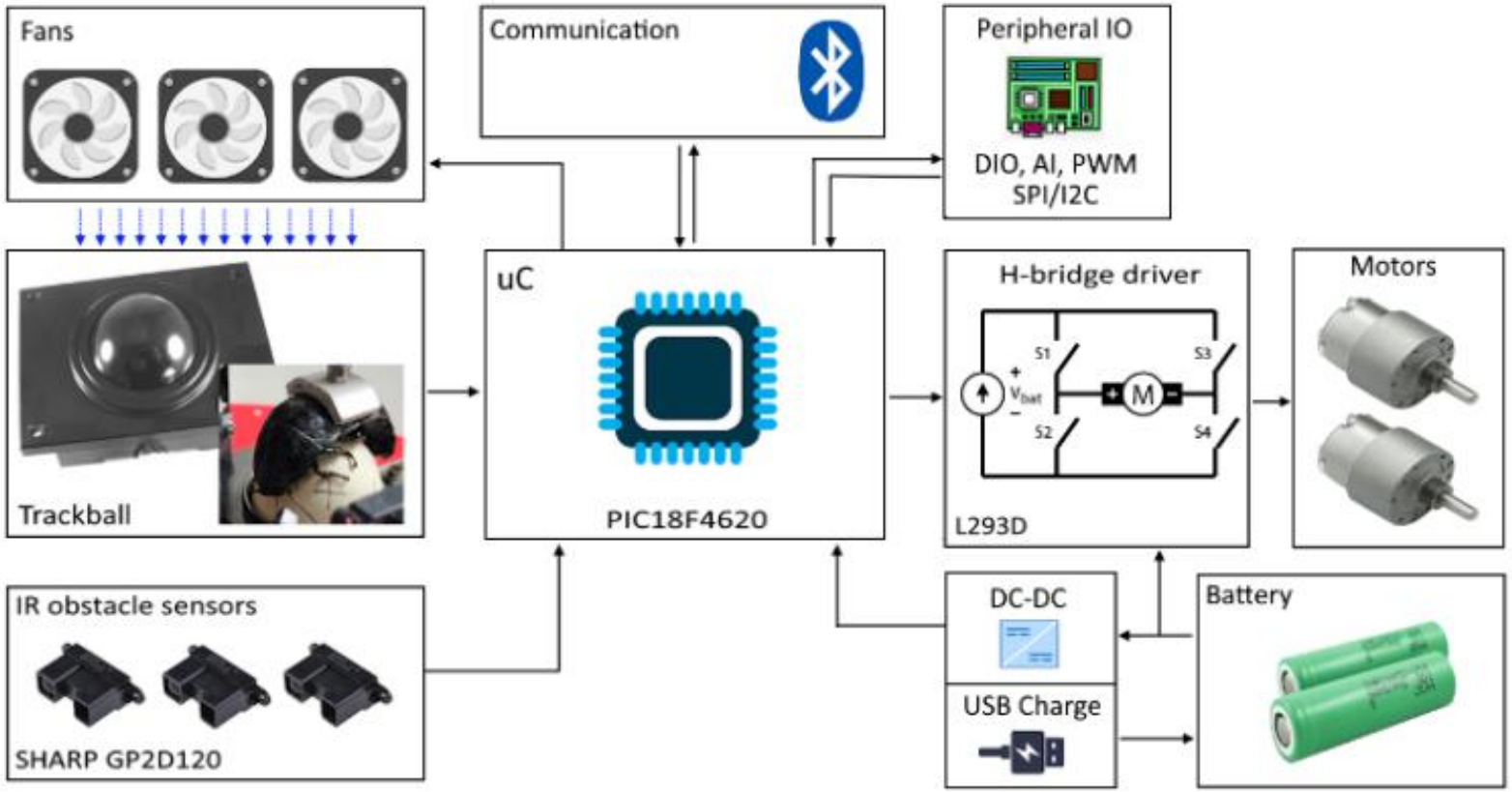
3 infrared distance sensors

2 Electric motors for moving the platform.

2. Developed prototype of a bio-robotic platform - CYROACH

Second version of **“CYROACH”**

- Trackball for detecting cockroach’s movements
- Single-chip controller **PIC18F4620.**
- Motors are controlled with a full H-bridge driver L293D and PWM speed control.
- OEM Bluetooth module.
- Infrared distance sensors - SHARP GP2D120.
- 3 fans for air flow stimulus



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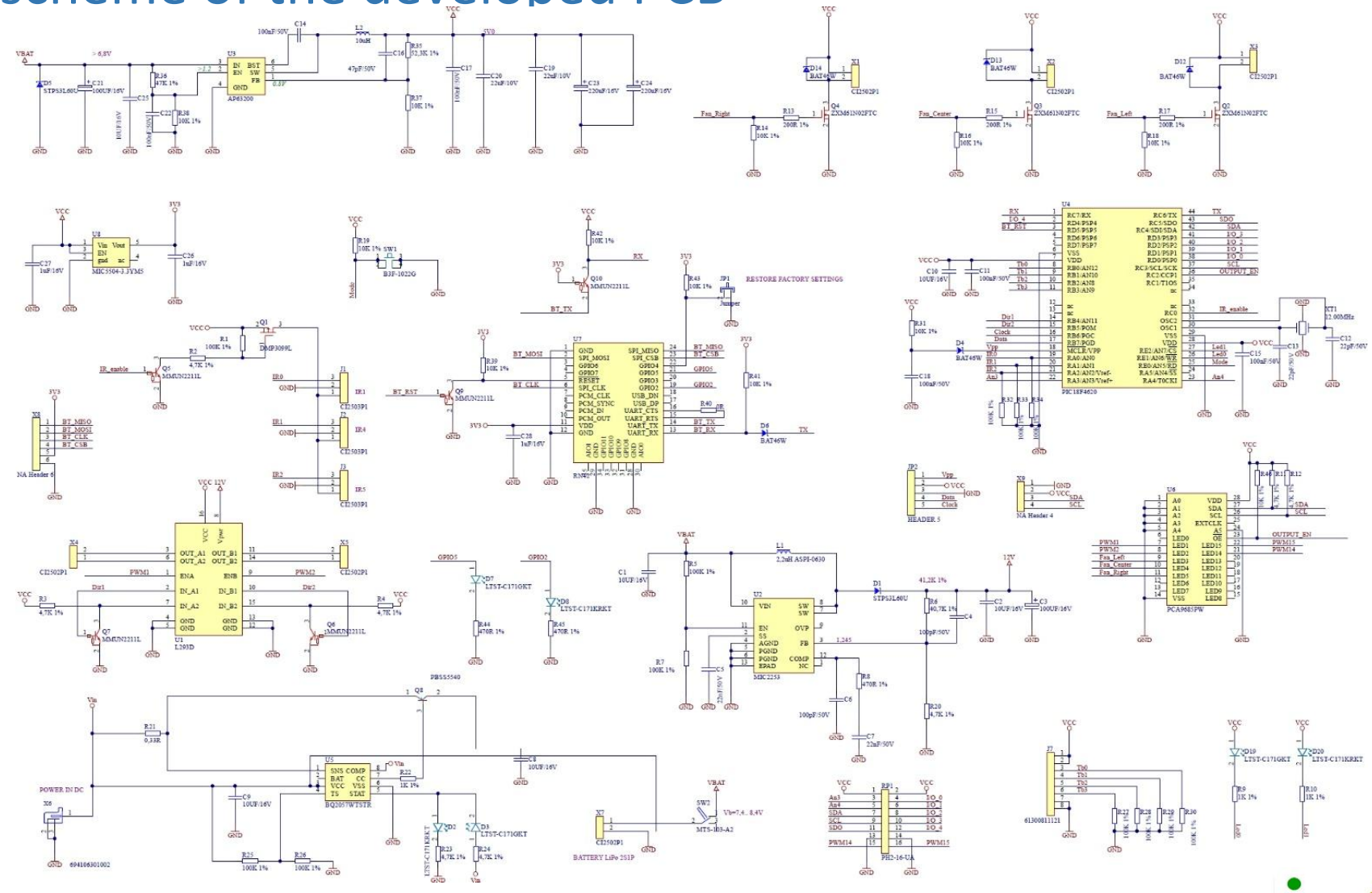
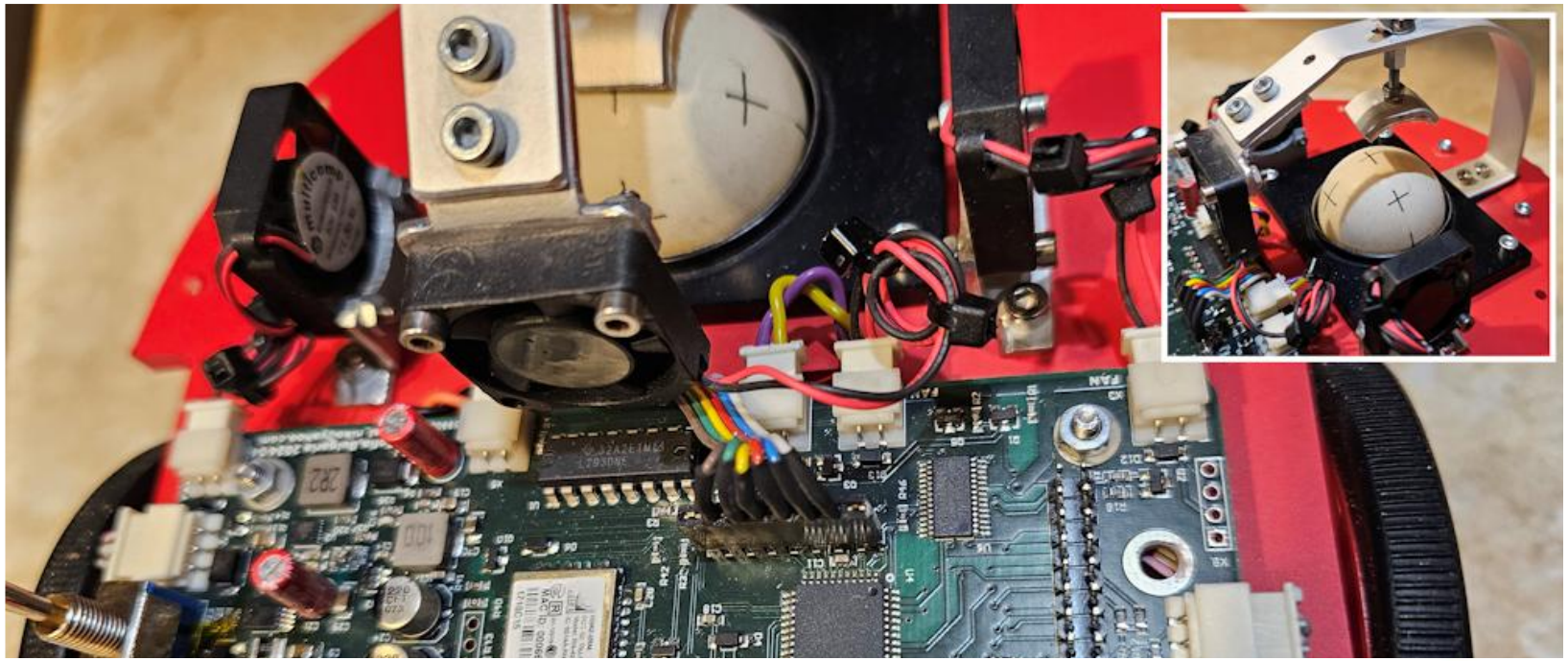
2. Developed prototype of a bio-robotic platform - CYROACH

Principle scheme of the developed PCB



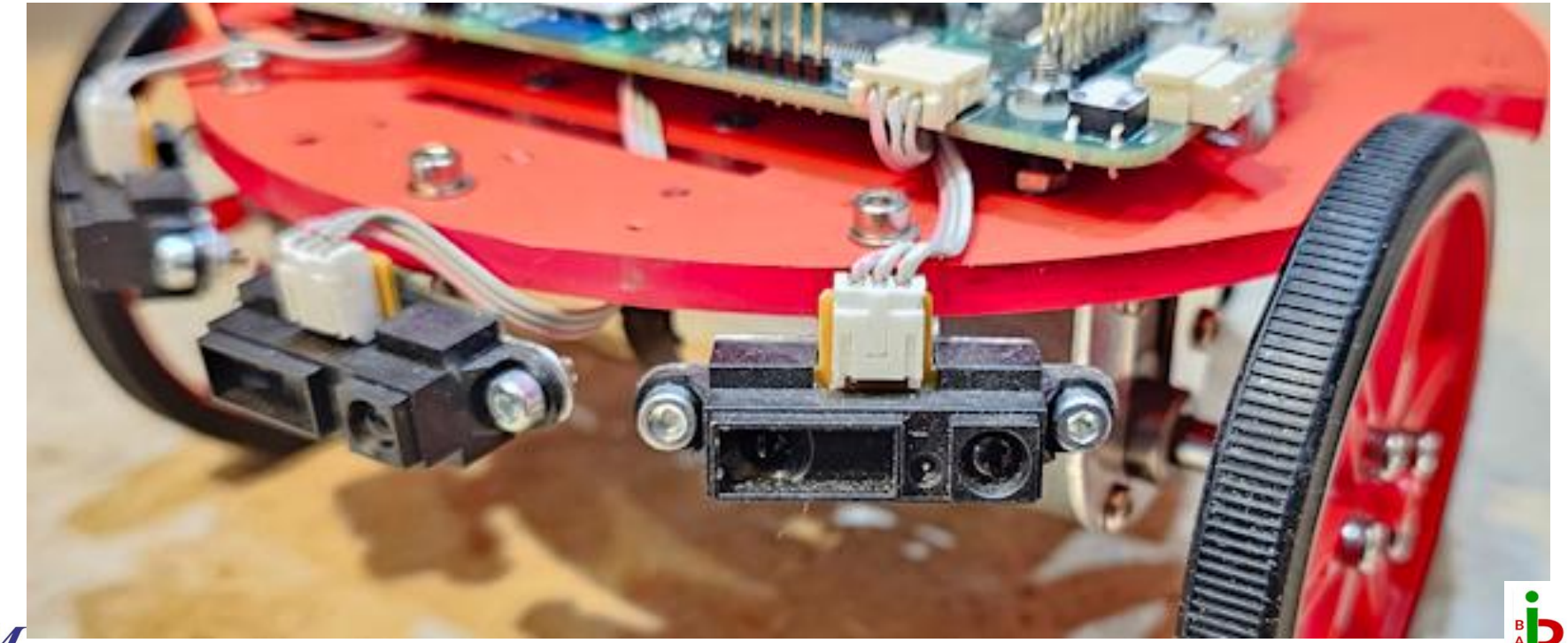
2. Developed prototype of a bio-robotic platform - CYROACH

- When the cockroach is attached to the ball, any movement is captured, causing the entire platform to move in the direction corresponding to the insect's direction of movement.
- The experiments confirmed the significantly better sensitivity of cockroaches to air flow compared to the directional and intense light. For this reason three fans, located in front and on both sides of the insect are used. When creating an air flow with a specific fan, the cockroach is trying to escape and deflects the platform in the opposite direction.



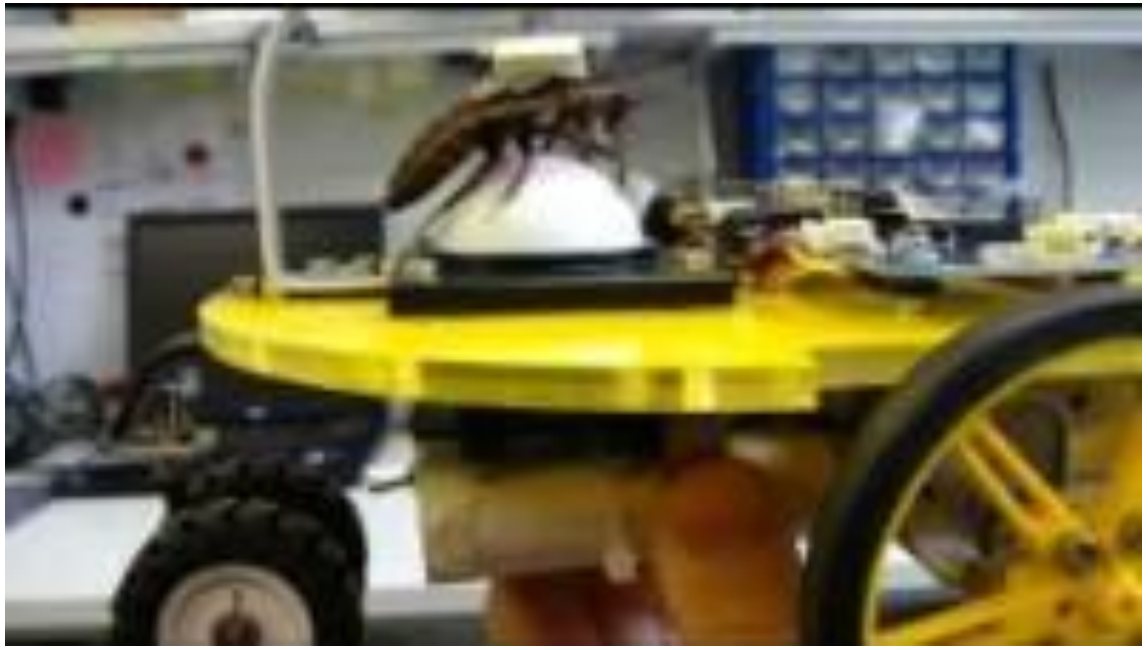
2. Developed prototype of a bio-robotic platform - CYROACH

- The fans are activated by the distance sensors mounted in the front of the mobile robot. When an obstacle is detected in front of one of the sensors, a corresponding fan is turned on.
- The airflow control is proportional and depends on the proximity to the obstacle. The closer the platform is to a potential collision, the faster the fans spin, and the intensity of the air flow increases. The used analog IR sensors measure the distance from the platform to an obstacle no further than 35 cm. The fans rotate at 100% at a distance of less than 10 cm. From 10 - 20 cm they are at 75%, and from 20-35 cm at 50%. Above 35 cm they do not rotate.



2. Developed prototype of a bio-robotic platform - CYROACH

- *CYROACH* v.1 – Part 1 video: https://www.youtube.com/watch?v=2XXbTM-DSCo
- *CYROACH* v.1 – Part 2 video: https://www.youtube.com/watch?v=3AGw1JQBvbs



3. Conclusion and future work

- **A prototype of a bio-robotic platform has been developed and built.**
- **Successful functional experiments have been conducted, confirming the operation of the mobile platform and the ability to bypass obstacles, controlled by a cockroach.**

Future work:

- The next stages of the project include the implementation of a software module for a PC, designed for storage and processing of information from the sensors and the reactions of the cockroach.
- In this way, algorithms for autonomous control of mobile robots can be generated, based on real behavioral models. Each change in the state of the system will be processed by a Machine Learning algorithm for generalization and generation of a control algorithm.
- A mobile robot with the same configuration will be added to the system and the new control function will be integrated into it to navigate and avoid obstacles.
- Different algorithms will be sought for better presentation and generalization of information.

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Thank you for your attention!