Aeris - robots laboratory with dynamic environment

Michal Chovanec, Lukáš Čechovič and Lukáš Mandák

University of Žilina, Faculty of Management, Science and Informatics, Department of Technical Cybernetics, Univerzitná 8215/1, 010 26 Žilina, Slovakia

Abstract. Is it possible to create an ant robot which can leave "scents" behind? Is it possible to create robotic football on the same platform? What about mouse maze, line follower or sumo robot? And what about possibility to have dynamically scalable environment which can interact with robots? Everything mentioned and more can be done on the same platform called Aeris.
In this paper unique robot platform called Aeris is presented. Department of Technical Cybernetics has long years experience with implementing different robots into education. The logic step was trying to integrate existing robots experiment scenarios into one platform but the result went over borders of common "robot" discipline. Universal and interactive robot "playground" is presented, with potential to be easily usable on teaching purposes from simplest robotics to technical cybernetics, embedded systems or artificial intelligence. This platform has potential to be also powerful equipment for researchers, for example in dynamic learning systems, swarm systems or other learning algorithms. Actual state of Aeris is presented with overview of future work.

Keywords: robots in education, robot laboratory, dynamic map on LCD, robot simulations

1 Introduction

It is said that if we want to see best of ourself we should let ourself play.

1.1 History of Robots on DTC

Department of Technical Cybernetics implements robots into education since 2002 when AT90S1200 [1] microcontoroller was released. Our first two wheel drive robot with stepper motors and ultrasound sensors was build on this device. As this was introduced into education, the interest from the students side was enormous. Next step was to bring some challenges into process. ISTROBOT [2] competition on Slovak Technical University became arena for the students to measure technical and software parts of their robots. Every year since then, students were guided to build their own or use existing wheel drive robots with various microcontrollers and sensors prepared specially for competition categories as line follower, mouse maze or sumo[2].

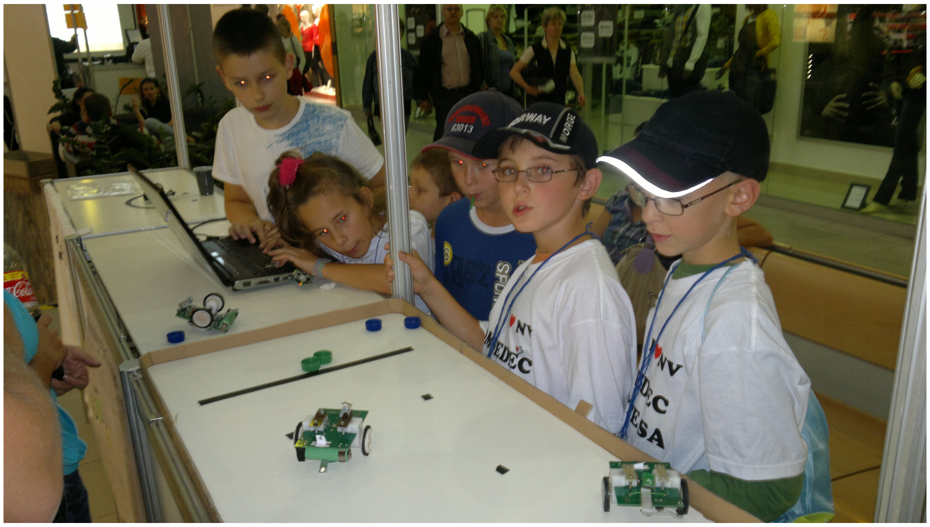

Fig. 1. Presentation of robot called George on European Researchers' Night in Bratislava, Slovakia, 2011. It was predecessor of YROBOT.

These activities were focused on University students and their study process. Then there come interest from high schools for education platform and as there was importance for better preparation for potential students, platform YROBOT [5],[6] was created in 2012. Parallel with developing YROBOT, faculty became the host of First Lego League [4] regional competition from 2012. This competition is primary focused on primary and secondary school students.

Since then DTC helps to bring whole scale of students at different school levels to robotic education.

In late 2014 research need brings idea of an ant robot which can leave mark - scent behind, as a part of ant colony optimization problem. Standard robot approach with static track was not sufficient so it become clear that there is need to bring a kind of interaction upgrade to the existing approach. This effort resulted into system called Aeris.

1.2 Standard robot playground

In standard robot scenario there is defined static playground (track). Usually this track is for one robot goal, painted on floor, created with tape, build from wooden board or Lego parts. Doing changes into track needs to manually reassemble track parts.

1.3 Dynamic robot playground

In dynamic robot playground, map is changeable at any moment. This fact brings many new possibilities and applicability of such a system. This system can handle

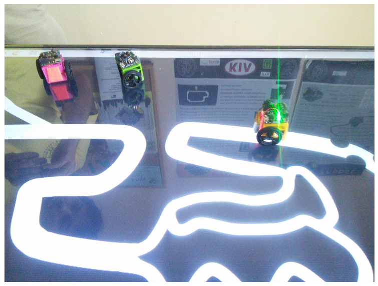

Fig. 2. Aeris robot version 1 as line follower

Fig. 3. Early version of Aeris system

all standard static robot scenario maps as line follower, sumo or mouse maze. It is possible to extend these standard scenarios for example in way such as a line follower track could dynamically change while robot is following, or maze could have dynamic parts. It is easy to imagine many new parameters in standard static robot scenarios.

2 Aeris system

Aeris is dynamic robot playground system with Supervising Control and Simulating centre. Map and robots are able of interaction through control centre. System control centre knows position of the robot and is able to communicate with robot. Control centre controls scenario which is displayed on the map. Map is represented by horizontally placed LCD display. Robot is reading map and executing given tasks by given program.

2.1 Aeris parts

- Universal robot.
  - RGB sensors
  - 3D gyroscope
  - 3D accelerometer
  - 3D compass
  - Microcontroller
  - Drives with controllers
  - Wi-Fi communication module
  - Slots for expansion boards
- Playground physically created with horizontally placed LCD display.
  - LCD Display
  - Protective layer
  - Touch layer (optional)
- Supervising Control and Simulating Centre
  - LCD display controlling (graphical input to LCD panel)
  - LCD display External state reading (Camera reading the activity of physical robots on the map)
  - Physical robot communication (Wifi module)

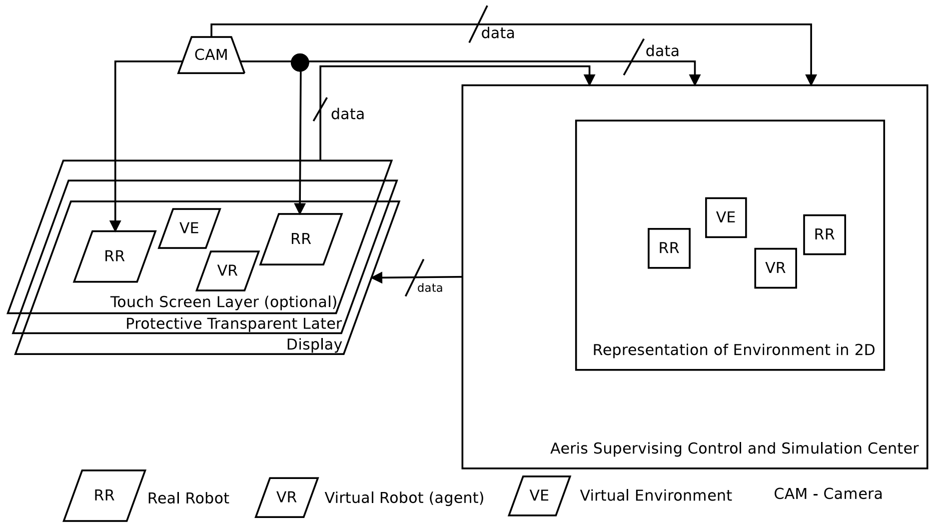

Fig. 4. Aeris simplified system functional diagram

- Environment processing
  - ∗ Virtual robots processing
  - ∗ Real robots processing
  - ∗ Virtual environment processing
  - ∗ Real environment processing
  - ∗ Algorithms

2.2 Platform for new dynamic playground - RGB sensors and LCD Display

The basic goal for transition from static playground to dynamic playground was to find the platform for dynamic playground which can be readable with sensors in similar way as standard static robot playground. For this purpose, LCD LED display was used. In horizontal position it is "easy to get" equipment with sufficient dynamic parameters dependant from display type (frame rate).

Next step was to find and test sensors, applicable on robot, able to read informations from common LCD displays. RGB sensor APDS9950 was chosen and tested as it is Digital Proximity, RGB and Ambient Light Sensor. This device is capable of up to 390 readings per second. It is characterized by easily applicable I2C communication interface. Practical tests showed that it is able to read surface of LCD display from needed range, approximately 1.5 centimetre in our scenario.

At the beginning, obtained values showed noise in intensity of colour components, Fig. 5, which was partly degrading information from sensors. This did

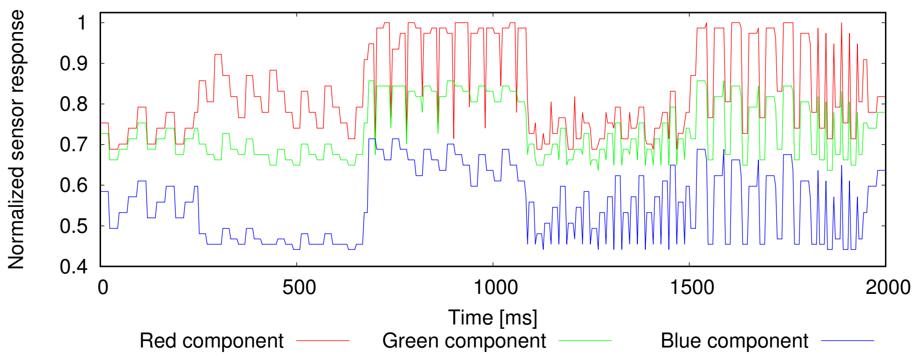

Fig. 5. Sensors response on white light with LCD LED brightness setting on 50%, 250Hz sensor sampling

not prevent the colour identification as the ratio between colour channels stayed in sufficient range to distinguish basic colours.

It was found out that sensors were affected by noise in intensity of colour components while displayed brightness value was under 100%. With display brightness level on 100%, intensity noise disappeared (Fig. 6). It is supposed to be result of display back light controlling.

Next thing to deal with was frame rate of display. To minimize this possible effect, sensors were setted to 250 readings per second, which was over 4 times higher than 60Hz frame rate of used display. In measuring, as is seen in Fig. 6, random spikes in colour components were present, which is supposed to be frame rate artefacts. These were filtered out with median filter.

- Parameters of Aeris dynamic playground
  - LCD LED Display Dell E5515H
    - Diagonal Viewing Size 54.6" (1386.84 mm)
    - Resolution 1920 x 1080 pixels
    - 60Hz Frame Rate
  - RGB sensor APDS 9950
    - Up to 390 readings of color per second
    - I2C communication interface
    - Small Package Dimensions (3.94x2.36x1.35 mm)

2.3 Aeris Supervising Control and Simulation Center

In proposed solution, it was necessary to split system parts into independent blocks to maximize universality and variance of experiments.

- environment
- map

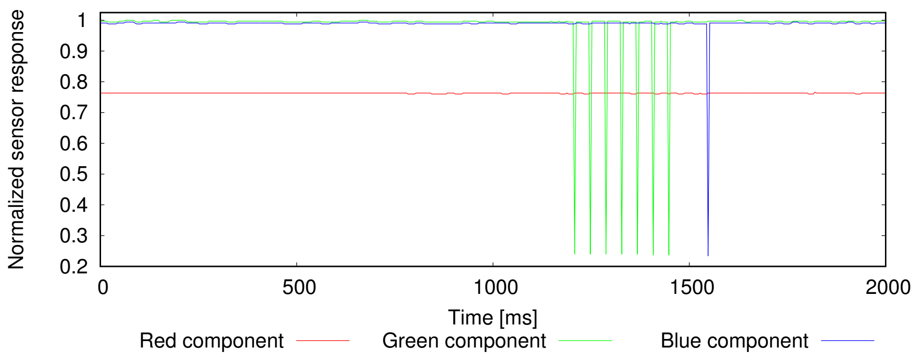

Fig. 6. Sensors response on white light with LCD LED brightness setting on 100%, 250hz sensor sampling

- server
- robots
- visualization

Main part of the system is running environment, which is handling incoming agents (robots) requests Fig.7. Environment is processing all interactions including physics, communication, and rewards for agents. Environment is loading map, which can be designed manually or randomly (to simulate real world). All these parts are connected using common TCP server, which has open connections for robots and visualization. Each robot can be calculated on it's own computer as this is necessary for complex AI algorithms like huge neural networks real time calculations. More than one visualization computer can be also used, so the experiment can be visualized on any machine connected to the server via internet. It is planed to do visualization on html5 currently, so no other application will be necessary.

2.4 Possibilities and limitations

Aeris system is able to handle static and dynamic scenarios. Size of scenario is limited by used display. Dynamic scenarios are limited by frame rate of used display and reading rate of used sensors for display reading.

From its nature, the system is able to create 2 dimensional scenarios or 2 dimensional version of specific 3 dimensional scenarios. As example, in mouse maze its possible to represent near presence of wall by increasing intensity of colour near wall, to use a camera on robot pointed on the surface or use system camera and give the information to the robot that the wall is near.

Aeris Supervising Control and Simulation Centre is being constantly developed to become map editor, map generator, centre for handling various simulations of virtual robots behaviour or maps behaviour centre to create "living" maps.

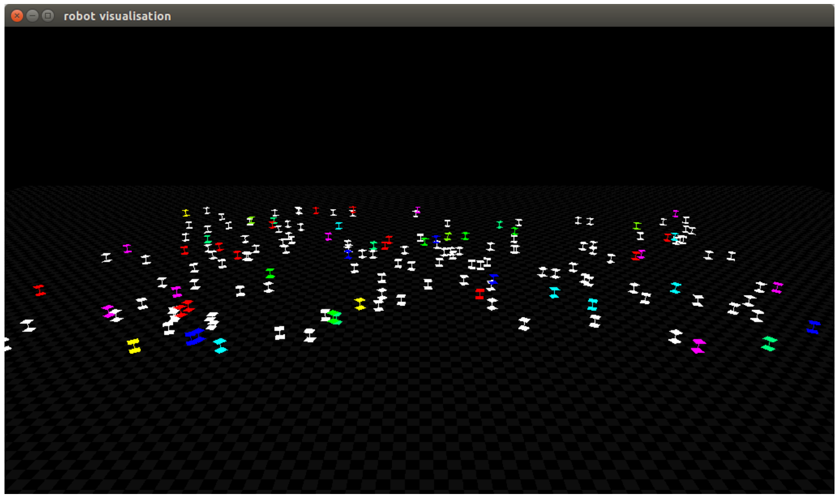

Fig. 7. Visualization of virtual robots in Aeris system in 3D

2.5 Actual State and Future Work

- Actual state and work in progress
  - Robot version 2 - done Fig. 8 and 9
  - Robot programs for specific scenarios - done/development
  - Supervising Control and Simulation Centre - done/development
  - Camera detection of robot position - development
  - Optical monitoring of robot communication - development
  - Optical robot-to-camera communication - development
  - Expansion board to enhance robot functions - development
- Future work
  - Charging stations for robots
  - Touch screen addition

Recently, second version of robot with diameters of base 5x5cm was created. This robot replaced first unreliable but smaller version with base 3x3cm. Aeris robot was created with aim on universality, where the goal was that robot will be able to handle all tasks what the system could bring.

Project web page is being developed [7] including informations about project. Also some video links demonstrating basic parameters of project can be shown in [8], [9].

3 Conclusion

Aeris system is aiming to become powerful robotic laboratory equipment by its unprecedented variability, ability to change on fly different scenario maps and robots behaviour programs. With Aeris, there is a possibility to bring till now simulation only experiments closer to real world, closer to audience. Evacuation problems, multi-agent problems, robotic challenge scenarios with totally new possibilities to create interactive maps by new and fresh way, all together on the same platform. Real robot interacting with simulated robots on "living map". Implementing simplest robot scenarios as line follower, trough robotic football to ant colony. Limits of playing with robots are pushed forward with Aeris system.

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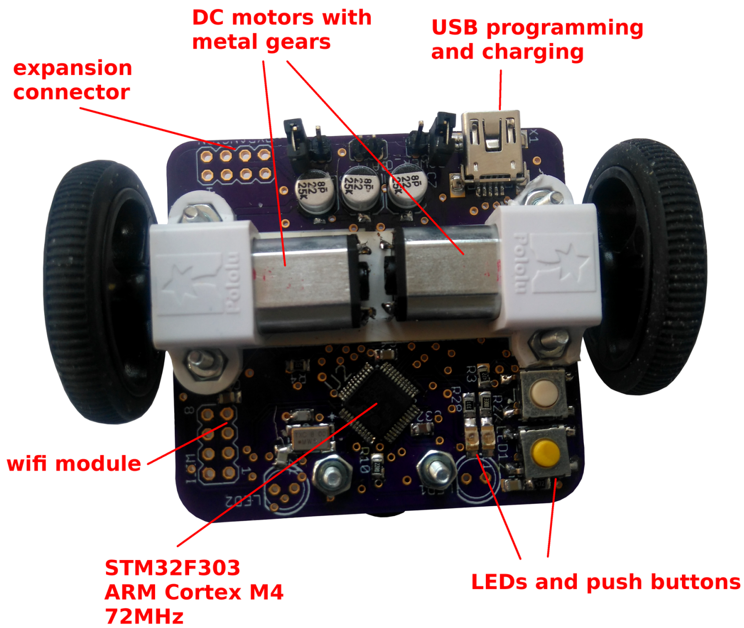

Fig. 8. Aeris robot version 2, top view, 5x5cm base dimensions without wheels

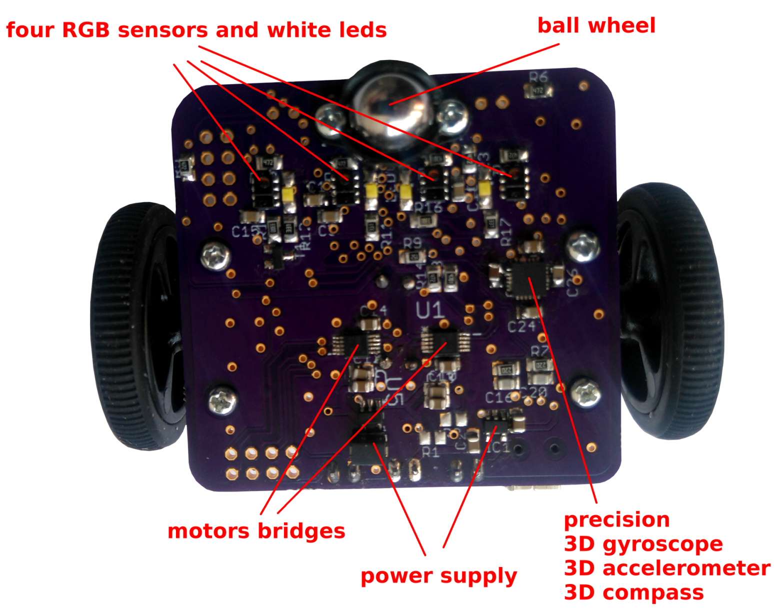

Fig. 9. Aeris robot version 2, bottom view,5x5cm base dimensions without wheels