IoT Open Architecture Ground Control System by Adaptive Fusion Intelligent Interfaces for Robot Vectors Applied to 5G Network Densification Era

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Abstract. The paper present IoT Open Architecture Ground Control System by adaptive fusion intelligent interfaces to the robot vectors communications applied to network densification in 5G Era. Intelligent interfaces for optimization and decision-making using neural networks, neutrosophic logic and deep learning convolutional are analyzed. The proposed solution providing efficient information management and decision grounding at a tactical and operative level in a wide array of applications.

Keywords: IoT · 5G access networks · Autonomous navigation · Software defined networking · Intelligent control interfaces · Robots vectors · Ground Control System · Aerial robots navigation systems · Wireless sensor networks

1 Introduction

The approach of the IoT Ground Control System (GCS) versus 5G densification network is of great importance and actuality in the current global context, in which unmanned aerial and terrestrial robotic systems [1–3] and the types of missions available to them have registered a significant evolution and growing interest [4–6]. The ever-increasing performance and miniaturization of available components places the field on the cusp of significant breakthroughs in theoretical research and practical applications alike [7–10].

IoT Open Architecture Ground Control System [3, 6, 9] by adaptive fusion intelligent interfaces for robot vectors communications presented in paper is intended for robot vectors with real-time control that involves, through the data volume of communications and quick response between system agents, the need for 5G network Densification Era communications. The system is made up of 3D (three-dimensional) - aerial, terrestrial and aquatic intelligence robot vectors, fulfilling the role of smart agents, the command and control center (CTC2), the Mission Management Center

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(CMM) and the SRA radio communication system. The GCS system has implemented artificial intelligence algorithms for optimization and decision-making.

2 3D VERO VIPRO Versatile, Intelligent, Portable Platform for Special Control Mission by 3D Robot Vectors

The VERO 3D platform integrated in the VIPRO platform has the role of the Mission Management Center CMM providing, by the way in which the VIPRO platform was designed, the ability to design, test and validate optimization and decision-making interfaces for the 3D robot vectors control - aerial, terrestrial, aquatic. In addition, the platform provides the e-learning and e-courses components for the dissemination of research results in the academic environment. Hardware configuration of the architecture 3D VERO VIPRO platform's architecture for special control mission by 3D robot vectors is presented in Fig. 1.

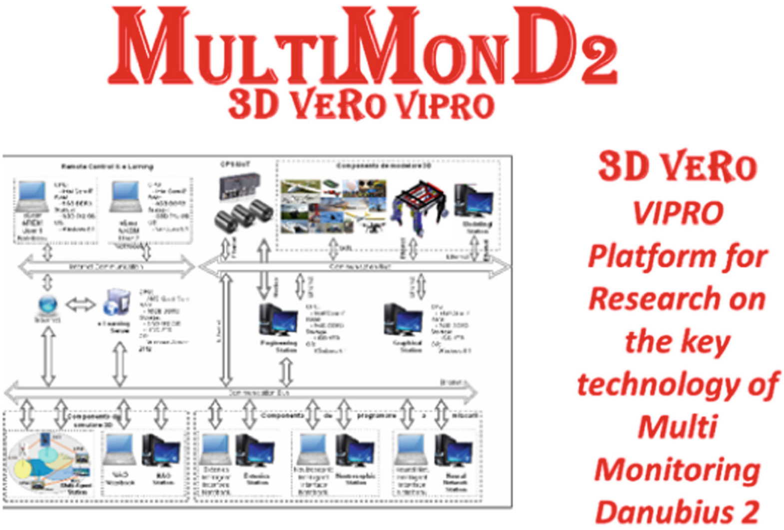


Fig. 1. Architecture 3D VERO VIPRO platform for special control mission by 3D robot vectors

The proposed 3D VERO VIPRO platform has a multi-agent real-time control system for robot vectors VRs, respectively aerial, terrestrial, aquatic robots, performance capabilities beyond the current state of the art and an open architecture design that allows greater flexibility further development and better customization of applications, with communication which require the 5G densification network in terms of speed and volume of data.

Aspects related to user needs and requirements as well as human-robot interaction have been considered to ensure the solutions' acceptance and usefulness.

3 Intelligent Optimization and Decision-Making Interfaces

By implementing a number of optimization and decision-making intelligent interfaces, the UAV command and control system (C2UAV) ensures high performances of the robot vectors VRs, and optimal decision-making support by sending in real time the coordinates of critical situations, determining the impact of decisions and designed actions, providing explanations for operations triggered.

C2UAV has the necessary features and capabilities to implement artificial intelligence algorithms that allow decentralized use of learning functions as tools for planning recognition operations and event mapping.

3.1 The VRs Optimization and Control Intelligent Interface in the Recognition/Monitoring Missions

The VRs optimization and control intelligent interface in mission performs optimization and control the position of the robot vector engaged in the recognition/monitoring missions. The optimization problem considers the existence of obstacles in the search space. The number of points modeled between two consecutive positions of the robot vectors VRs depends on the speed required by operator or the motion trajectory tracking algorithm.

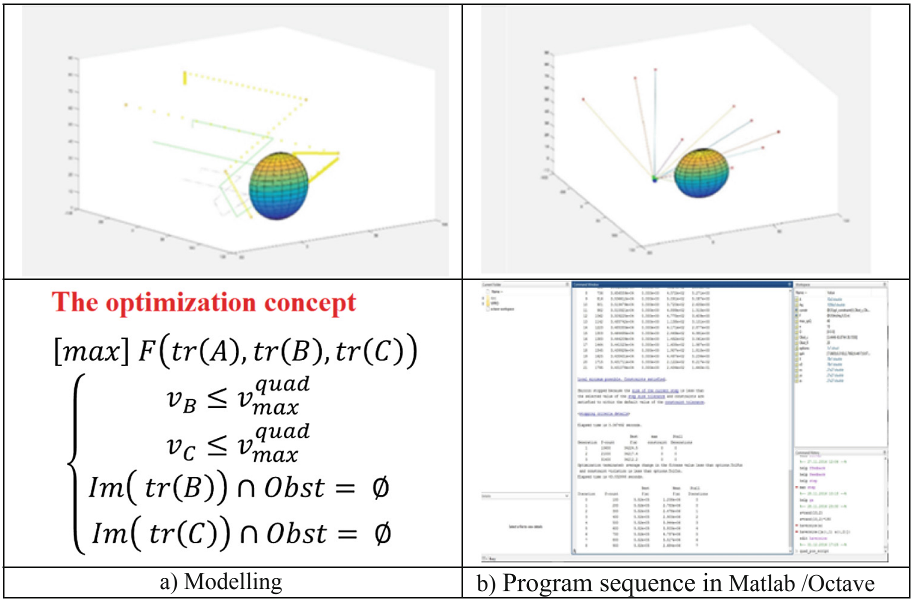


Fig. 2. Optimization and control intelligent interface of robot vectors in missions (Color figure online)

Running the optimization function script in Fig. 2 is presented sequentially following all the steps of the optimization problem [11, 12]. The intermediate results of each step are shown in the blue border. The optimization algorithm is written in the Maltab/Octave code, called by Python's main VRs control program.

3.2 Optimization and Decision-Making Intelligent Interfaces Using the Neutrosophic Logic

The intelligent interfaces for optimization and decision-making was developed using the neutrosophic logic algorithm, by applying the Desert-Smarandache DSmT theory. The robotic neutrosophic control (RNC) systems is known as the Vladareanu-Smarandache method. The proposed decision-making method developed by Gal and Vladareanu [9, 10] presented in Fig. 3 for real-time control of the 3D aerial, terrestrial and aquatic vector robots can be successfully applied.

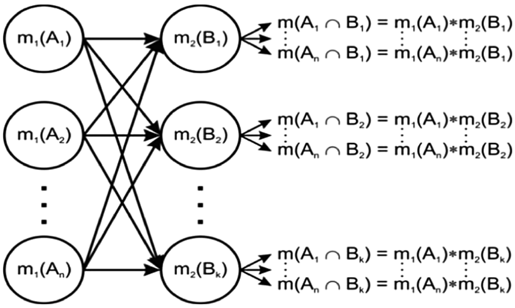
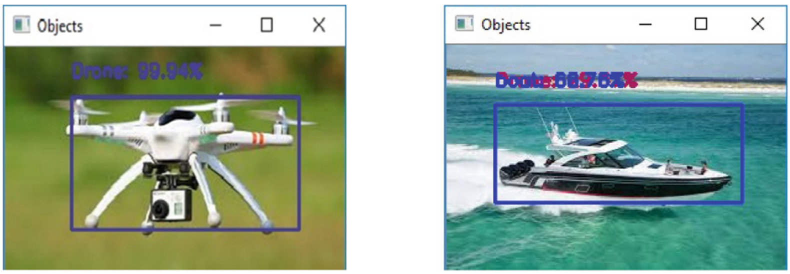


Fig. 3. Optimization and decision-making intelligent interfaces for robot vectors neutrosophic control (RNC) systems

3.3 Intelligent Deep Learning with Convolution NNs Interface

The intelligent interface performs image processing optimization by Deep Learning with Convolutional Neural Networks (NNs). In order to recognize the objects in images, the results obtained by using deep learning with convolutional NNs algorithms were investigated. These networks function like the human brain [11].



a) Drone recognition trust factor b) Boat recognition trust factor.

Fig. 4. Image processing intelligent interface through deep learning with convolutional NNs

OpenCV is an open-source image processing library and can be used along with other libraries and software platforms to develop deep learning and machine learning algorithms. For experiments performed in this work the OpenCV 3.4.3 library along with the NumPy library were used, the algorithm was developed in Python 3.7 and run on a Windows 10 operating system.

The experimental results and the trust factor in the recognition of the drones and the Naval Vehicles after modelling by the image processing intelligent interface using Deep Learning are shown in Fig. 4.

4 Results and Conclusions

The IoT Open Architecture Ground Control System using multi-agent systems is based on a network of modular aerial and terrestrial vectors of various concepts and architectures, equipped with an array of sensors, cooperative operation and control capabilities and portable ground-station integrated in 3D VERO VIPRO, which are not found in the state of the art, providing efficient information management and decision grounding at a tactical and operative level in a wide array of applications.

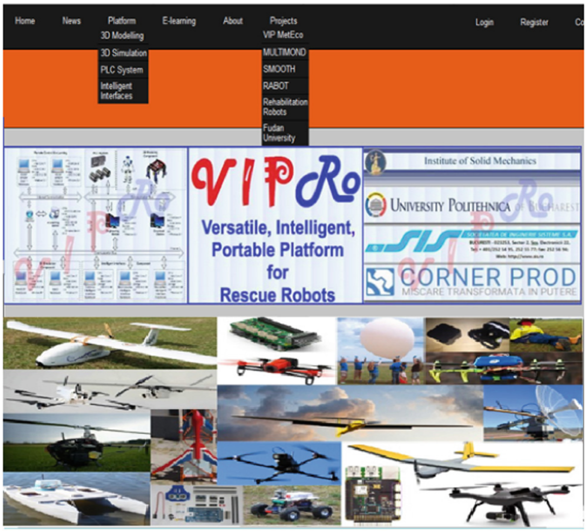


Fig. 5. 3D VERO VIPRO implementation and running on the VIPRO MULTIMOND platform

The proposed solution could have implications towards societal safety, security and privacy. Therefore, 3D VERO VIPRO implemented on the VIPRO MULTIMOND platform (Fig. 5) has an established risk management process to identify and assess risks towards an acceptable risk criterion, propose and develop mitigations, and to monitor the risk by analyzing the data from the IoT Open Architecture Ground Control System using 5G densification network.

The obtained results lead to missions of the robot vectors on surveillance in areas of interest in reducing environmental pollution and for rescue missions in areas where people's lives are at risk, such as natural disasters, terrorist acts or fires.

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