Versatile, intelligent, portable robot platform with adaptive network control systems for rescue robots

Project Code: PN-II-PT-PCCA-2013-4-2009; Contract UEFISCDI nr. 009/2014

Realisation of functional model, experimentation, solution validation and demonstration of functionality for the virtual 3D modelling and simulation platform for mobile robots

Stage 3/2016

SYNTHESIS REPORT

The main objective of our project consists of developing experimental research with the aim of accomplishing the experimental model of a VIPRO platform: versatile, intelligent and portable for robots, by applying an original method known as the virtual projection method.

The main characteristics of the VIPRO platform are:
- Representation of modern mobile robots in a 3D virtual environment through a powerful robotic simulator with the aim of designing and improving their performance in navigation, search and urban rescue
- Modelling the mechanical structure of the state-of-the-art Nao robot and the rescue robot RABOT from the FP7 European project, in which IMSAR is a main partner, with the aim of controlling the movement in virtual projection.
- Constructing an open architecture system and adaptive networks enclosing the classical robot control system
- Developing intelligent control interfaces using advanced control strategies adapted to the robot environment, such as extended control (extenics), neutrosophic control, human adaptive mechatronics, etc., implemented through fast processing techniques and real time communication
- Developing the VIPRO platform with e-learning characteristics which will allow the development of and inter-academic network with the aim of furthering research and developing new intelligent robots such as Nao, Rabot, etc.
The main activities of the project consist of developing the experimental model of a versatile, intelligent, portable platform VIPRO for the design, testing and experimentation of intelligent control methods and improving robot performance using advances in artificial intelligence and remote control adaptive network, demonstrated on the Nao robots and on robots used in search and rescue type operations such as RABOT.

Stage 3 has as its main objective the development of a functional model, experimentation, solution validation and functionality demonstration of the 3D virtual platform for modelling and simulating mobile robots. The activity results allow the realisation of the VIPRO platform prototype and establishing testing procedures for the software components.

The activities of stage 3, the obtained results and the deliverables for each activity are presented below:

- **Activity A3.1.** Experimental and functional model of the 3D virtual platform for modelling and simulation of mobile robots
- **Activity A3.2** Experimentation and solution validation for the experimental model, part I: software
- **Activity A3.3.** Technical feasibility study of the VIPRO platform
- **Activity A3.4.** Protecting intellectual property rights
- **Activity A3.5.** Referential of the VIPRO platform
- **Activity A3.6.** Prototype design for the VIPRO platform, part I (software)
- **Activity A3.7.** Experimentation and solution validation for the experimental model, part II: hardware
- **Activity A3.8.** Demonstration of functionality and utility of the experimental model

The functionality and utility of the experimental model was undertaken by developing 7 applications for the control of rescue robots with the aid of the VIPRO virtual robot platform, respectively a robot for navigation and environment exploration through image processing, robot for navigation and exploration through RFID/QR – Codes, intelligent interface for extended robot control, intelligent interface for neutrosophic robot control, robot walking interface with resistive loads and mobile rescue robot with six differential wheels. There were developed support applications in demonstrating the functionality and utility of the experimental model: local 3d platform for modelling and simulation of mobile robots, data communication between the PC Engineering and the PLC System in the VIPRO platform network, VIPRO PC Engineering – PLC System interface, remote control of the VIPRO platform resources, e-learning and e-courses for specialist training in real time control in robotics. The main directions in demonstrating the functionality and utility of the experimental model are presented as follows.

**Organizing a workshop and special session**

Within the SISOM 2016 conference, scientifically sponsored by the Romanian Academy, the Commission for Acoustics of the Romanian Academy and the General Association of Romanian Engineers (AGIR), a special session was held on Robotics and the First Workshop in 2016 of the VIPRO project. The special session was moderated by Prof. Luige Vlădăreanu, Prof. Mihaielea Iliescu and Dr. Yongfei Feng (Yanshan University). 15 papers were presented, authored by members of the project team, in which were presented applications of the VIPRO platform or research that is yet to be implemented in the platform.
The first workshop for 2016, organized for the project PN-II-PT-PCCA-2013-4-2009, Contract 009/2014, has led to open discourse, applied experimentation and demonstrations on the VIPRO platform with local or remote users, using the portal www.vipro.edu.ro. The workshop was attended by specialist from national universities and research institutes: Prof. T. Sireteanu, Corresponding Member of the Romanian Academy, Prof. Polidor Bratu, General Director at ICECON, a potential beneficiary of the VIPRO platform, Prof. I. Magheti, Prof. Inge Gavat and Dumitru Stanomir – UPB, members of the research teams from UPB, SIS, CORNER and IMSAR. Foreign visitors included Dr. Yongfei Feng. The program of the special session and workshop are shown in Annex A 8.1.1.


The meeting was organized at the project partner CORNER SRL, which has contributed with the necessary infrastructure for presentation, logistics and financing the workshop. The meeting was attended by Prof. Florentin Smarandache, University of New Mexico, USA, founder of neutrosophic logic, member in the IMSAR team, interested in collaborating and promoting the VIPRO Platform on the website of the University of Albuquerque and in the academic environment in the USA, General Director,
Dr. Eng. Teodor Necșoiu, Optoelectronica 2010, potential beneficiary, members of the research teams from CORNER, UPB and the project coordinator.

The second Workshop - VIPRO Platform Project

Participation in European Projects and International Collaborations

The results of the activities in the VIPRO project were integrated and developed in European projects / project proposals in the H2020 FLAG-ERA JTC 2016 project, NEO_VIPP project, Marie Curie Program - RISE, SMOOTH project, or international cooperation projects.

FLAG-ERA JTC 2016, NEO-VIPP, H2020

Project Title: “Versatile Intelligent Portable Platform for Modelling Complex Bio-Medical Data for Early Diagnosis of Neoplasia Progression and Management Towards Personalised Medicine”, acronym NEO-VIPP, H2020 Project - FLAG-ERA JTC 2016, partners: Romanian Academy, Institute of Virology, Université Catholique de Louvain, Brussels, de Duve Institute (DDUV), FRS-FNRS, Belgium, Ege University, Department of Infectious Diseases and Clinical Microbiology, Turkey, Riga Technical
NEO-VIPP is an innovative platform which makes the difference from existing ones in that it is the only one which ensures real-time testing and experimentation on its own real time control system and adaptive networked control for remote users through e-learning & remote communication in addition to the design, modelling and simulation facilitated by scientific research platforms such as ICGC Data Portal, TCGA Data Portal, NCI Genomic Data Commons (GDC), being integrated into the DMC platforms using the ITfoM concepts.

The nucleus, extended first with Romanian Academy/Institute of Solid Mechanics/ Department of Robotics and Mechatronics (RA-ISM) as a partner able to develop their existent VIPRO platform to the new extendable NEO-VIPP for integration, testing and experimenting clinical research on modelling complex bio-medical data for neoplasia early diagnosis of progression and management towards personalised medicine. Prof. Luige Vlădăreanu’s team will provide expertise in different fields of IT&C on advanced intelligent control, dynamic systems’ control, computational intelligence, multi-microprocessor systems along with Prof. R. I. Munteanu, Conf. M. Iliescu, Dr. A. Gal and Dr. O. Melinte, cyber-physical systems and adaptive networked, Conf. M. Moisescu, Conf. I. Sacală, Dr. V. Vlădăreanu and Dr. O. Melinte, was extended with experts in Information Science and Technology on advanced research work in the field of smart systems, Prof. T Sireteanu and cyber physical systems, Prof. Ioan Dumitrache.

The VIPP architecture for humanoid and cooperative robots, based on the virtual projection method, patented by IMSAR [30], is extendable for integration, testing and experimenting clinical research on neoplasia progression through building an open architecture system and adaptive networks over the classic control system. The virtual platform to be developed and extended, NEO-VIPP, is the tool for transforming data in knowledge on oncogenesis and use it in personalized/precision medicine. The need to manage all behaviours and interactions is solved by developing a new interface for intelligent control based on advanced control strategies, such as extended control (Extenics), neutrosophic control, human adaptive mechatronics, implemented by high speed processing IT&C techniques in real time communication for a high amount of data processing, including a remote control & e-learning component and an adaptive networked control.

H2020, SMOOTH Project,

*Grant Agreement number: 734875 — SMOOTH — H2020-MSCA-RISE-2016*  

*Call: H2020-MSCA-RISE-2016, Research and Innovation Staff Exchange (RISE), Marie Skłodowska-Curie Actions.*

The SMOOTH project will go beyond the current state-of-art in a number of ways. It is clear that development of a unique and universal robot that can operate under harsh firefighting environments with wide and dexterous tasks to meet the aforementioned needs is not a simple task. The innovative platform VIP-FiTRo, developed as open architecture system and adaptive networks integrates Future Internet Systems vision enabling: cyber-physical systems by adaptive networks, intelligent network control systems, human in the loop principles, data mining, big data, intelligent control interfaces, network quality of service, shared resources and distributed server network - remote control and e-learning users by interconnected global clouds.

For moving of the firefighting robots in uncertain environments, allowing actuation in crisis situations or natural disaster, in which human life is in danger, SMOOTH will develop haptic interfaces that provides the robot spatial orientation and navigation based on that the robot feels the land on which it moves by changing the stiffness of the robot paw joints and of the segments robot joints, using the stiffness associated of the paw joints position $X_c$ on the robot environment map if uneven ground is detected.

The main innovations of SMOOTH are the development and evaluation of a cognitive firefighting robots swarm and 3D human-robot interfaces. Data mining and predictive capabilities will allow vital patterns of behaviours to be evaluated at the robots as well as the firefighting team (ICs and firefighters). Data mining of the on-the-spot firefighting information across EU and China will gather the “wisdom of the crowd” to produce a predictive platform of smart actions in firefighting operations and services.
FP7, RABOT Project

FP7-PEOPLE-2012-IRSES-no.318902 “Real-time adaptive networked control of rescue robots” (RABOT), 2012-2016, coordinator: Bournemouth University, UK, UK, main partners: Institute of Solid Mechanics of Romania Academy; Staffordshire University, Shanghai Jiao Tong University, CN, Institute of Automation Chinese Academy of Sciences, CN, Yanshan University

Collaboration with Institute of Automation, Chinese Academy of Science, Beijing, China, project RABOT, FFP7-PEOPLE-2012-IRSES-no.318902.

Presentation of the VIPRO platform to the specialists, teachers and students of CASIA-Institute of Automation, Chinese Academy of Science

Scientific collaboration agreement
IMSAR – Yanshan University

Presentation of rehabilitation robots

Meeting on the signing of the collaboration agreement
IMSAR – Yanshan University

We have met with remarkable interest from the audience – researchers, university professors and businessmen, for the possibility of academic collaboration in the development of the VIPRO platform and the to-market transfer, after the project implementation period.
Demonstrations for specialists and potential beneficiaries.

*Salon International for Inventions in Geneva-SWITZERLAND (13-17 Aprilie 2016)*

Participation at the Salon International for Inventions in Geneva-SWITZERLAND with the invention „Method and device for the development of control interfaces for mechatronic systems in virtual environments”, RO A2016/00174 din 10.03.2016, authors: Luige Vlădăreanu, Radu I. Munteanu, Tudor Sireteanu, Eugen Albu, Victor Vlădăreanu, Radu A. Munteanu, Boris S., Cononovici, Mihaiela Iliescu, Octavian Melinte, Ionel A. Gal, Daniel M. Mitroi, Oana Chenaru.

The invention, authored by IMSAR, was accomplished in the project PN-II-PT-PCCA-2013-4, ID2009, VIPRO, no. 009 / 2014-2017, with the majority of the authors being members in the research team.

Demonstrations were made for specialists and potential beneficiaries, respectively participants in the exposition, of which: Prof. Lina Hao, Hongtai Cheng from North-eastern University, C. Ranea – ANCSI, OSIM, RI Munteanu – UTCN, M. Costoiu, A. Hader – UPB and others.

The invention, as a result of the project, was presented to the Exposition jury, formed of renowned specialists in the fields of research and innovation. The Gold Medal was awarded after evaluation by a group of 12 specialists out of the 47 specialists in the Exposition jury.


Indian Institute of Technology Delhi and Asia Pacific Institute of Information Technology

At the invitation of Prof. Shashi MATHUR, Dean and Professor in the Department of Civil Engineering, Indian Institute of Technology Delhi, and of Prof. Ramesh Kumar CHOUDHARY, President and Director APIIT SD India(International Engineering College), a working visit was made
with the aim of dissemination information on the functionality and utility of the experimental model and of the results of research and design undertaken within the VIPRO project.

At the “Indian Institute of Technology Delhi”, India (IITD), there were held meetings with representatives of the institute management, as well as directors of the engineering departments:
- Shashi Mathur – Dean, Alumni Affairs @ International Programmes, Professor, Department of Civil Engineering;
- Ranjan Bose – Professor, Head of Department of Electrical Engineering;
- Subir Kumar Saha – Professor, Head of Department of Mechanical Engineering.

The discussions broached the themes of the VIPRO project, current activities and associated deliverables, as well as risk-generating situations for accomplishing the objectives undertaken in the project. The functionality was demonstrated for Remote Control, E-learning and e-Courses in the VIPRO platform. The resulting discussions and demonstrations contributed to the development of the experimental model.

Discussions included the opportunities for using the final results obtained in the project, especially through continually developing research through international projects within the HORIZON 2020 program.

A future collaboration between IMSAR and IITD, especially through academic exchange and co-tutelage of doctoral theses, was discussed. A proposal was received for a “Memorandum of Understanding for Academic Cooperation”.

Indian Institute of Technology Delhi

“Asia Pacific Institute of Information Technology”, Panipat, India (APIIT), meeting with institute director Prof. Ramesh Kumar Choudhary and representative from the departments of electro-mechanical engineering, management and applied mechanics. The visit was aimed at discussions of the VIPRO project and demonstrations for specialists and potential beneficiaries of the VIPRO platform. The functionalities for Remote Control, E-learning and e-Courses were demonstrated for the VIPRO platform.
Discussions were held referring to the research undertaken in the VIPRO project and the problems met when designing and developing the components for the prototype stand and platform, using the obtained results as background for further development and finding future funding opportunities. Prof. Luige Vlădăreanu presented the course “Real time control in solid mechanics applied on the VIPRO Platform”, and Prof. Mihaiela Iliescu held the course “Applications of the VIPRO Multi-Axes Mechatronic Systems”.

Inventions developed and registered in Stage 3 of the VIPRO Project:


2. “Method and device for hybrid force-position control applied in intelligent control platforms”, RO A/00821 din 14.11.2016, Authors: L. Vlădăreanu, R.I. Munteanu, T. Sireteanu (MC AR). I. Dumitracche (MC AR), M. Iliescu, S. Cononovici, V. Vlădăreanu, RA Munteanu, O. Melinte, A. Gal, V. Barbu, MS Munteanu, D. Mitroi, M. Moisescu, O. Chenaru, I. Mihai, I. Sacală, Gh. Florea. All authors, except Mr RI Munteanu and Mr Sireteanu, are members in the PNII VIPRO project.

Papers published in international databases.


VIPRO innovative platform is conceptually competitive with other similar platforms for virtual applications CDA, CAM, CAE, Solid Works or MatLab, Simulink, COMSOL, Lab View, etc., but rapport with them enable the design, testing and experimentation of the intelligent control methods, in real-time control, by integrating physical control system, in modeling and simulation robot. In this project we intend to achieve the embryo development, that will allow entry VIPRO of the platform on the IT market as a new component between the existing IT platform.