



Fundamental field: Engineering Sciences
Specialisation: Mechanical Engineering

HABILITATION THESIS

- ABSTRACT -

**CONTRIBUTIONS REGARDING THE DEVELOPMENT OF ROBOTIC
SYSTEMS AND APPLICATIONS DEDICATED TO THEM USING
VIRTUAL REALITY TECHNOLOGIES AND ARTIFICIAL
INTELLIGENCE ALGORITHMS**

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This habilitation thesis, with the title "**Contributions regarding the development of robotic systems and applications dedicated to them using virtual reality technologies and artificial intelligence algorithms**" emphasizes a general picture about the evolution in the research and academic career of the candidate **Florin Alexandru COVACIU**, in order to obtain the habilitation thesis. The motivation to support this thesis is to obtain the qualification for the coordination of doctoral theses in the field of mechanical engineering within the Technical University of Cluj-Napoca, Romania. His research and academic career began with the beginning of his doctoral studies, which also meant integration into the collective of the Research Center for Simulation and Testing of Industrial Robots (CESTER), coordinated by Mrs. Prof. PhD. Ing. Doina Pisla. During the doctoral studies, CESTER center managed to attract significant research funds that contributed to obtaining special results in the doctoral thesis. Also, during this period, the candidate started his teaching career as an associate teacher teaching the subject "Computer Programming" at the Department of Mechanical Systems Engineering.

From 2016, the candidate entered through competition as the lector at the Design Engineering and Robotics Department, at the Technical University of Cluj-Napoca, where he evolved, becoming Associate professor from 2021. In this department the evolution of his research and academic career in general has been focused on the design, control, and actuation of robots; virtual reality; control and programming of numerically controlled machine tools. Through this he was able to publish articles, books, and patent applications. He was and is a member as a researcher on several national and international research projects. And by permanently combining his research and academic interests, he taught: Command and programming of Industrial Robots; Command and Programming of Machine Tools with Numerical Control; Machines, Robots and Equipment for Flexible Manufacturing Systems, at the undergraduate level.

This habilitation thesis is composed of 11 chapters, including the introduction, evolution plans and career development, references, list of figures and tables.

The thesis begins with a short chapter entitled "Abbreviations" and consists of a short list of abbreviations of terms most used in the thesis.

Chapter 2, "Introduction", briefly presents the current trends in the development of robotic systems used in industry and medicine, as well as the use of virtual reality for robotic systems used in medicine. The chapter presents the motivation of the author's work, and a brief presentation of the content of the thesis chapters.

Chapter 4, "Achievements in the field of robotics through Robot Design and Fabrication" features articles that describe the process of designing and fabricating of some robotic structures. The design process is carried out using dedicated programs for 3D CAD modelling of the robotic structure, and the manufacturing process is carried out using 3D printer technology and CNC machine technology.

Chapter 5, "Achievements in the field of robotics through robot's control and actuation" presents articles describing the control and actuation process for various robotic structures. For the control part, the Visual Studio development environment with the C# programming language, chipKIT Max32 with microcontroller development board, various sensors and PLC from the B&R Industrial Automation company are used. Stepper motors and servo motors were used for the actuation part. Block diagrams are also presented, which are

structured on three levels of control, namely: user level, command and control level, physical level.

Chapter 6, "Achievements in the field of Virtual Reality using elements of Artificial Intelligence" presents articles describing the development of simulators using specific virtual reality technologies that use artificial intelligence algorithms. For the development of simulators using virtual reality, dedicated programs are used for this purpose, such as the following: Unity, Blender and the avatar creation program called MakeHuman. In order to be able to control the objects from the virtual reality application, the C# (CSharp) programming language was used, and for an interaction between the virtual reality simulator and the user, the Visual Studio program was used to create a user interface. In some applications described in the habilitation thesis, the user interface connects with the virtual reality simulator via the TCP/IP protocol. For an interaction between a real person and the virtual reality simulator, the ESP32 microcontroller development board was used, which facilitates communication with the computer by using the Wi-Fi communication protocol, and to which different sensors were attached. The program used in programming the ESP32 microcontroller is Arduino. In some virtual reality applications, it has been necessary to use artificial intelligence algorithms to make decisions and actions independently.

Chapter 7 presents the conclusions regarding the scientific and professional achievements, also here an image of the candidate is presented about his future prospects for both research and academic ones.

Chapters: 8 "Evolution and Career Development Plans" follows three directions, namely: education and training, didactic activity, and research activity. Each direction being divided into two levels: current situation and career development proposal; 9, "References" of the thesis, 10 "List of Figures", and 11 presents the "List of Tables".