International Journal of Mechatronics and Applied **Mechanics - IJOMAM** Issue 22, Volume II

CEFIN Publishing House, Bucharest, Romania E-ISSN: 2559 – 6497 | DOI: 10.17683/ijomam

Indexed in SCOPUS, EBSCO, Ei Compendex and PROQUEST International Databases

Editor-In-Chief: Daniela-Doina CIOBOATĂ Co-Editor-in-

Chief:

Professor Ion STIHARU

Professor Iosé MACHADO – coordinator of the field of MECHATRONICS Co-Editors-In-

Chief:

Professor Alexandru SOVER - coordinator of the field of APPLIED MECHANICS Professor Sarfaraz Hashemkhani ZOLFANI- coordinator of the field of AI

Octavia Căruntu - Senior Editor **Editors:** Ligia Petrescu - Senior Editor Florentina Badea - Editor

Andreea Stanciu - Managing Editor

Phone: +4021.252.30.69/240, 241; +4021.252.20.96

Contact Fax: +4021.252.34.37

> E-mail: ijomam@incdmtm.ro Website: www.ijomam.com

 Published by Cefin Publishing House, under the framework of the National Institute of Research and Development in Mechatronics and Measurement Technique - INCDMTM.

in this industrial field, in Romania.

The main research and development activities that the institute develops include:

- Mechatronic integrated control systems;

- 2. Biomedical and Robotic Mechatronics:

- Rapid Prototyping;
- 3. Micro and Mechatronic Nanotechnologies:

- Preparation of metallographic samples;

Cefin Publishing House was established in the National Institute of Research and Development in Mechatronics and Measurement Technique in 1991, with the main purpose of promoting and publishing of the most important results of research.

Cefin Publishing House's main product, with international visibility, is the International Journal of Mechatronics and Applied Mechanics, a publication dedicated to the global advancements of mechatronics and applied mechanics research, development and innovation, providing researchers and practitioners with the occasion to publish high quality papers, mainly dedicated to applied research and underpinned by a solid theoretical base

 This publication is edited with support from the Ministry of Education and Research in Romania, via the National Research Authority. •

EDITORIAL BOARD

of the International Journal of Mechatronics and Applied Mechanics - IJOMAM

Editor-in-Chief: Daniela Doina CIOBOATĂ, PhD, Eng. (Romania) Honorary Editor-in-chief: Prof. Ion STIHARU, PhD, Eng. (Canada)

Field of MECHATRONICS - Prof. José MACHADO, PhD, Eng., Co-Editor-in-chief (Portugal)

♥ Robotics and Automation:

Prof. Pierluigi REA, PhD, Eng., Associate Editor (Italy)

Prof. Adrian OLARU, PhD, Eng., Associate Editor (Romania)

Alexander SKVORCHEVSKY, PhD, Eng., Associate Editor (Ireland)

Mihai Gabriel MATACHE, PhD, Eng., Associate Editor (Romania)

Measurement Systems and Image Processing:

Prof. Sahin YILDIRIM, PhD, Eng., Associate Editor (Turkey)

Prof. Luciana CRISTEA, PhD, Eng., Associate Editor (Romania)

Modelling and Simulation of Mechatronic Systems and Manufacturing Processes:

Prof. Yevheniia BASOVA, PhD, Eng., Associate Editor (Ukraine)

Prof. Maohua XIAO, PhD, Eng., Associate Editor (China)

Prof. Umidjon MARDONOV, PhD, Eng., Associate Editor (Uzbekistan)

Prof. Yevgen TSEGELNYK, PhD, Eng., Associate Editor (Ukraine)

Prof. Paulo MYIAGI, PhD, Eng., Associate Editor (Brazil)

Prof. Dacian ROMAN, PhD, Eng., Associate Editor (Canada)

Prof. Patrick HENDRICK, PhD, Eng., Associate Editor (Belgium)

Prof. Chi Hieu LE, PhD, Eng., Associate Editor (UK)

Prof. Adam EKIELSKI, PhD, Eng., Associate Editor (Poland)

Prof. Tomasz ŻELAZINSKI, PhD, Eng., Associate Editor (Poland)

Prof. Lukas PRASOL, PhD, Eng., Associate Editor (Germany)

Prof. Milan EDL, PhD, Eng., Associate Editor (Czech Republic)

Prof. Vijaya Kumar MANUPATI, PhD, Eng., Associate Editor (India)

Prof. Stefan VÖTH, PhD, Eng., Associate Editor (Germany)

Prof. Cătălin ALEXANDRU, PhD, Eng., Associate Editor (Romania)

Prof. Adriano A. SANTOS, PhD, Eng., Associate Editor (Portugal)

Dănuţ-Iulian STANCIU, PhD, Eng., Associate Editor (Romania)

Vladimir KOTEV, PhD, Eng., Associate Editor, (Bulgaria)

Natalia SMETANKINA, PhD, Eng., Associate Editor (Ukraine)

Prof. Vitalii IVANOV, Ph.D, Eng., Associate Editor (Ukraine)

\\$ Electronics and Cyber-Physical Systems:

Filipe Alexandre de SOUSA PEREIRA, PhD, Eng., Associate Editor (Portugal)

Prof. Géza HUSI, PhD, Eng., Associate Editor (Hungary)

Nicolae TĂNASE, PhD, Eng., Associate Editor (Romania)

Prof. Carlos FELGUEIRAS, PhD, Eng., Associate Editor (Portugal)

Field of **APPLIED MECHANICS - Prof. ALEXANDRU SOVER, PhD, Eng.,** Co-Editor-in-chief (Germany)

Materials Science:

Prof. Adinel GAVRUS, PhD, Eng., Associate Editor (France)

Prof. Vasile BRATU, PhD, Eng., Associate Editor (Romania)

Prof. Georgeta IONAȘCU, PhD, Eng., Associate Editor (Romania)

Phys. Liliana-Laura BĂDIŢĂ-VOICU, PhD, Eng., Associate Editor (Romania)

Prof. Mărioara ABRUDEANU, PhD, Eng., Associate Editor (Romania)

Prof. Valeriia SUBBOTINA, PhD, Eng., Associate Editor (Ukraine)

Prof. Paweł ZAWADZKI, PhD, Eng., Associate Editor (Poland)

♦ Structural Mechanics:

Prof. Laurențiu Adrian CARTAL, PhD, Eng., Associate Editor (Romania)

Prof. Salwan Obaid Waheed KHAFAJI, PhD, Eng., Associate Editor (Iraq)

Prof. Ioan Mihail SAVANIU, PhD, Eng., Associate Editor (Romania)

Prof. Fawaz Al-Bakri, , PhD, Eng., Associate Editor (Iraq)

♦ Fluid Mechanics:

Prof. Antonio Riveiro RODRIGUEZ, PhD, Eng., Associate Editor (Spain) Gabriela MATACHE, PhD, Eng., Associate Editor (Romania)

Technology of Measurement and Instrumentation:

Prof. Jan HOŠEK, PhD, Eng., Associate Editor (Czech Republic)

Prof. Aurel - Mihail ŢĨŢU, PhD, Eng., Associate Editor (Romania)

Prof. Mihai DRAGOMIR, PhD, Eng., Associate Editor (Romania)

Field of ARTIFICIAL INTELLIGENCE - Prof. Sarfaraz Hashemkhani ZOLFANI, PhD, Eng., Co-Editor-in-chief (Chile)

Prof. Vlad MURESAN, PhD, Eng., Associate Editor (Romania)

Prof. Vladyslav PLIUHIN, PhD, Eng., Associate Editor (Ukraine)

Scientific Researcher II, Vasile PĂIŞ, PhD, Eng., Associate Editor (Romania)

Prof. Andrei PĂUN, PhD, Eng., Associate Editor (Romania)

Prof. Florentin SMARANDACHE, PhD, Eng., Associate Editor, (USA)

Prof. Maya Rumenova LAMBOVSKA, PhD, Eng., Associate Editor, (Bulgaria)

Prof. Dragan PAMUCAR, PhD, Eng., Associate Editor, (Serbia)

Professor Hasan Hamad ALI, PhD, Eng., Associate Editor (Iraq)

Scientific Researcher III, Ioana PETCU, Ph.D.Ec., Associate Editor (Romania)