

SCIENTIFIC AND TECHNICAL REPORT

on the implementation of the project during February – December 2021 (stage 1)

A. STAGE SUMMARY

The research team who carried out research activities in the project “Data-driven fuzzy control with experimental validation”, project number 192 / 19.02.2021, registration code PN-III-P4-ID-PCE-2020-0269, is the one nominated in the funding application form: Prof.Dr.Eng. Radu-Emil Precup (project leader), Lect.Dr.Eng. Claudia-Adina Bojan-Dragoş, Lect.Dr.Eng. Adriana Albu, Lect.Dr.Eng. Alexandra-Iulia Szedlak-Stînean, Lect.Dr. Ciprian Hedrea, Assist.Lect.Dr. Raul-Cristian Roman, M.Sc.Eng. Ion-Cornel Mituleţu, Phd student, M.Sc.Eng. Elena-Lorena Hedrea, PhD student.

The main objective pursued in the project was fulfilled according to the funding application form and is described as follows:

- (1) The analysis of the theoretical research concerning the improvement of the existing control solutions and the design of new controllers aiming the performance improvement of control systems designed for nonlinear processes including processes with shape memory alloy (SMA) actuators. The activities carried out to achieve this objective are focused on:
 - 1.1. The analysis of the actual stage of theoretical research and experimental applications conducted on several laboratory equipments, which also include processes with shape memory alloy (SMA) actuators. The above mentioned analysis was carried out and the synthetic information related to this analysis along with the corresponding references is presented in Section B. The analyzed processes and equipments are: servo systems [C1], [C3], [C7], population and epidemic [C2], SMA [C4], monetary policy [C5], electromagnetic actuated clutch systems [C6], big data [C8], tower crane systems [C9], mobile robots [C10].
 - 1.2. The research of possibilities meant to improve the existent control solutions for nonlinear processes including processes with shape memory alloy (SMA) actuators and the design of new data-driven and fuzzy control solutions. New controllers such as fuzzy controllers [C1], [C6], [C10], Iterative Feedback Tuning-based controllers [C9], controllers based on artificial neural networks combined with reinforcement learning, and metaheuristic optimization algorithms [C3], with details presented in the papers [C1], [C3], [C6], [C9] and [C10], were proposed and analyzed.

The results expected to be obtained during this stage of the project according to the funding application form are:

- The publication of one paper in a high impact leading journal and the participation and presentation of two papers to important conferences.
- Preparing the reports for the documentation of the activities.

The main results obtained in this stage of the project exceed the expected results. These are:

- The research report.
- Ten published papers: [C1]-[C10].
- Details on the published papers: 2 papers [C1], [C2] published in journals indexed in Clarivate Analytics Web of Science (with one of the former names ISI Web of Knowledge) with impact factor, 2 papers [C3], [C4] accepted in journals indexed in Clarivate Analytics Web of Science (with one of the former names ISI Web of Knowledge) with impact factor, 1 paper [C5] published in conference proceedings indexed in Clarivate Analytics Web of Science (with one of the former names ISI Web of Knowledge or ISI Proceedings), 1 paper [C6] published in conference proceeding indexed in international databases (IEEE Xplore, INSPEC, Scopus, DBLP), 3 papers [C7], [C9], [C9] presented at conferences whose proceedings will be indexed in international databases (IEEE Xplore, INSPEC, Scopus, DBLP), 1 book chapter published in Springer.

- The cumulative impact factor of the published papers according to 2020 Journal Citation Reports (JCR) published by Clarivate Analytics in 2021 = 14.098.
- High impact leading journals in which the papers were published: Information Sciences (Elsevier), Scientific Reports (Nature), International Journal of Systems Science (Taylor and Francis).
- Important conferences in whose proceedings the papers were published: 4th IFAC Conference on Embedded Systems, Computational Intelligence and Telematics in Control CESCIT 2021, 30th International Symposium on Industrial Electronics ISIE 2021, 8th International Conference on Information Technology and Quantitative Management ITQM 2020 & 2021.

Remarks:

1. In this scientific report the texts, the figures and partially the equations were taken from the papers developed by the research team. This is the reason why the formulations are in English. For some of the equations the numbering from the research report will be kept.

2. All the published or currently being published papers which contain research results obtained in this project mentioned the support of UEFISCDI in the Acknowledgements section, along with specifying the project registration code from the funding application form.

B. SCIENTIFIC AND TECHNICAL DESCRIPTION

The description is focused on the synthetic presentation of the research carried out in the framework of the activity 1.1, namely the analysis of the actual stage of the theoretical research and experimental applications conducted on nonlinear processes including processes with shape memory alloy (SMA) actuators as [C4]. The derivation of Takagi-Sugeno evolving fuzzy models for a representative process built around SMA is proposed.

According to the remark 1 specified in Section A, the detailed description is continued in English in the research report posted at https://www.aut.upt.ro/~rprecup/RST_PCE_2021.pdf.

C. RESEARCH TEAM'S PUBLICATIONS

- [C1] R.-E. Precup, R.-C. David, R.-C. Roman, A.-I. Szedlak-Stînean and E. M. Petriu, Optimal tuning of interval type-2 fuzzy controllers for nonlinear servo systems using slime mould algorithm, International Journal of Systems Science (Taylor and Francis), DOI: 10.1080/00207721.2021.1927236, pp. 1-16, 2021, impact factor (IF) = 2.281, IF according to 2020 Journal Citation Reports (JCR) released by Clarivate Analytics in 2021 = 2.281.
- [C2] A. Topîrceanu and R.-E. Precup, A novel geo-hierarchical population mobility model for spatial spreading of resurgent epidemics, Scientific Reports (Nature), vol. 11, paper 14341, pp. 1-12, 2021, impact factor (IF) = 4.379, IF according to 2020 Journal Citation Reports (JCR) released by Clarivate Analytics in 2021 = 4.379.
- [C3] I. A. Zamfirache, R.-E. Precup, R.-C. Roman and E. M. Petriu, Reinforcement Learning-based Control Using Q-learning and Gravitational Search Algorithm with Experimental Validation on a Nonlinear Servo System, Information Sciences (Elsevier), accepted, impact factor (IF) = 6.795, IF according to 2020 Journal Citation Reports (JCR) released by Clarivate Analytics in 2021 = 6.795.
- [C4] R.-E. Precup, C.-A. Bojan-Dragoş, E.-L. Hedrea, R.-C. Roman and E. M. Petriu, Evolving Fuzzy Models of Shape Memory Alloy Wire Actuators, Romanian Journal of Information Science and Technology (Romanian Academy, Section for Information Science and Technology), accepted, to be published in vol. 24, no. 4, pp. 1-13, 2021, impact factor (IF) = 0.643, IF according to 2020 Journal Citation Reports (JCR) released by Clarivate Analytics in 2021 = 0.643.
- [C5] C.-V. Pop, R.-E. Precup and L. I. Cădariu-Brăiloiu, Analysis of Monetary Policy Decisions of the National Bank of Romania with Text Mining Techniques, Proceedings of 2021 IEEE 15th International Symposium on Applied Computational Intelligence and Informatics SACI 2021, Timisoara, Romania, pp. 21-26, 2021, indexed in Clarivate Analytics Web of Science.
- [C6] C.-A. Bojan-Dragoş, R.-E. Precup, S. Preitl, R.-C. Roman, E.-L. Hedrea and A.-I. Szedlak-

- Stînean, GWO-Based Optimal Tuning of Type-1 and Type-2 Fuzzy Controllers for Electromagnetic Actuated Clutch Systems, Proceedings of 4th IFAC Conference on Embedded Systems, Computational Intelligence and Telematics in Control CESCIT 2021, Valenciennes, France, 2021, IFAC-PapersOnLine, vol. 54, no. 4, pp. 189-194, 2021, indexed in Scopus.
- [C7] E.-L. Hedrea, R.-E. Precup, R.-C. Roman, E. M. Petriu, C.-A. Bojan-Dragoş and C. Hedrea, Tensor Product-Based Model Transformation Technique Applied to Servo Systems Modeling, Proceedings of 30th International Symposium on Industrial Electronics ISIE 2021, Kyoto, Japan, 2021, pp. 1-6, to be published in ieeexplore.
- [C8] I.-D. Borlea, R.-E. Precup and A.-B. Borlea, Improvement of K-means Cluster Quality by Post Processing Resulted Clusters, Proceedings of 8th International Conference on Information Technology and Quantitative Management ITQM 2020 & 2021, Chengu, China, pp. 1-8, 2021, to be published in Procedia Computer Science (Elsevier).
- [C9] R.-C. Roman, R.-E. Precup, E.-L. Hedrea, S. Preitl, I. A. Zamfirache, C.-A. Bojan-Dragoş and E. M. Petriu, Iterative Feedback Tuning Algorithm for Tower Crane Systems, Proceedings of 8th International Conference on Information Technology and Quantitative Management ITQM 2020 & 2021, Chengu, China, pp. 1-8, 2021, to be published in Procedia Computer Science (Elsevier).
- [C10] R.-E. Precup, E.-I. Voişan, R.-C. David, E.-L. Hedrea, E. M. Petriu, R.-C. Roman and A.-I. Szedlak-Stînean, Nature-inspired optimization algorithms for path planning and fuzzy tracking control of mobile robots, in: Applied Optimization and Swarm Intelligence, E. Osaba and X.-S. Yang, Eds., Springer Tracts in Nature-Inspired Computing, Springer, Singapore, pp. 129-148, 2021.

Project leader,

Prof.Dr.Eng. Radu-Emil Precup

