

FRAMEWORK PROGRAMME OF EARLY STAGE RESEARCHER TRAINING¹

1. BASIC DATA

Mentor's name and surname	Vili Podgorelec	Mentor's register number at <u>ARIS</u> (<u>SICRIS):</u>	16304
Mentor's e-mail:	vili.podgorelec@um.si	Mentor's tel. no.:	+386 2 220 7353
Research programme (RP) leader's name and surname:	Marjan Heričko	RP leader's register number at <u>ARIS</u> (<u>SICRIS)</u> :	11064
Title of research programme:	Information Systems	RP's Register number at <u>ARIS</u> <u>(SICRIS):</u>	P2-0057
Research organisation (RO) of University of Maribor, where training shall be conducted:	Faculty of Electrical Engineering and Computer Science	RO Register number at <u>ARIS</u> (SICRIS):	0796
Research field according to <u>ARIS classification</u> :	2.07	Research field according to Ortelius classification (EURAXESS)	9.0

2. DEFINITION OF RESEARCH PROBLEM AND GOALS OF DOCTORAL RESEARCH²

Starting point of research task of the early stage researcher and its position in the research programme, where the mentor is included, work hypothesis, research goals and foreseen result with emphasis on an original contribution to science:

The Background

Long-term forecasting with recurrent neural networks (RNNs) presents several challenges that need to be addressed to improve the effectiveness of predictive modelling. Key challenges include the high time complexity of training predictive models, low predictive performance of RNNs in long-term forecasting tasks, the complex structure of such models, and the need for proper preparation of time series data to achieve adequate forecasting accuracy. These issues stem from the inherent

¹ Term early stage researcher (ESR) is written in male form and used as neutral for women and men.

² Research and study programme of training have to harmonise with contents of the research programme, where the mentor is a member.

nature of RNNs, which struggle with long-range dependencies and require significant computational resources for training.

Several approaches have been proposed to overcome these challenges. One promising direction is knowledge distillation, which allows the creation of simpler predictive models that retain the essential information from more complex models while reducing computational overhead.

Additionally, the use of nature-inspired algorithms can help develop hybrid machine learning models with improved forecasting performance by leveraging evolutionary principles. Another possible solution is the application of various meta-heuristic optimization approaches, which can be used to reduce the training time of RNNs by efficiently searching the space of hyperparameters and model configurations.

The research area is directly related to the Intelligent Systems work package within the research program P2-0057 Information Systems and appropriately complements the goals of the research program, which are intended to analyse and develop methods and approaches for integrating complex data, their efficient processing, and building knowledge models of high predictive performance in an efficient manner.

Working Hypothesis and Research Methods

The central thesis of the research is based on the idea that through appropriate hybridization of machine learning algorithms and the use of both knowledge distillation and transfer learning, it is possible to improve the understandability of constructed knowledge models without significantly reducing predictive performance. The research will explore novel ways to address the challenges of long-term forecasting with RNNs, including transfer learning for pre-trained models, intelligent monitoring of the training process, and knowledge distillation for simpler models.

The research work will be a combination of both theoretical and empirical investigations, ensuring a balanced approach between conceptual understanding and practical application. This will include inductive and deductive connections between theoretical findings and empirical results. Research methods will include comprehensive literature review to understand existing solutions and identify gaps, experimental studies to evaluate different optimization and hybridization techniques, development and evaluation of new methodologies through computational experiments, comparative analysis of predictive performance and computational efficiency of developed models.

Goals and Expected Results

The research aims to achieve significant advancements in the field of machine learning for long-term time series forecasting. Expected results include:

• A comprehensive analysis of the limitations of existing RNN-based forecasting models and their training challenges.

• Development of novel intelligent training techniques to improve the efficiency of long-term forecasting models.

• Design and evaluation of hybrid machine learning algorithms incorporating nature-inspired optimization techniques for enhanced predictive performance.

• Implementation of knowledge distillation methods to produce more efficient and interpretable predictive models.

• Development of pre-trained transfer learning models that facilitate faster training and deployment of forecasting systems.

• A prototype implementation of optimized long-term forecasting models and a set of best practices for training recurrent models efficiently on large-scale time series data.

By addressing these research questions, the training program will contribute to advancing the stateof-the-art in machine learning and provide valuable insights into overcoming the challenges associated with long-term forecasting using RNNs.

3. STUDY PROGRAMME

Foreseen study programme, to which early stage researcher shall be enrolled in academic year 2025/2026:

Computer Science and Informatics

4. DESCRIPTION OF WORK AND TASKS

The main task is to perform research work in accordance with the research training program and the instructions of the mentor, which includes:

• study and analysis of scientific and professional literature,

• analysis, design, development and testing of research software,

- design, planning and implementation of appropriate research methods,
- analysis and evaluation of research results,

• publishing research results in the form of technical reports, conference papers, scientific and professional articles and possible other publications,

- independent search for solutions and a systematic and innovative approach to solving problems, and
- regular fulfillment of study obligations in the doctoral study.

Other tasks (from the UM systematization):

Implementation of scientific and research projects.

Participation in the design of research programs.

Professional cooperation with clients of research tasks.

Preparation of reports and studies on research.

Monitoring and coordinating research work in accordance with funding contracts.

Ensuring safe and healthy work.

Participation in working and standing committees of UM or other bodies and members.

Replacing colleagues and superiors in their absence (by authorization).

Participation in annual and other inventories.

Performing other related work as assigned by superiors.

5. REQUESTED LEVEL OF EDUCATION

Second cycle of higher and similar education/Second cycle of higher and similar education

6. REQUESTED FIELD OF EDUCATION

Education of appropriate level in the field of computer science and informatics.

7. KLASIUS SRV

170, Second cycle of higher and similar education/Second cycle of higher and similar education

8. KLASIUS P

4811, Computer science and informatics

9. REQUESTED KNOWLEDGE

In-depth knowledge of software development and data processing is required, as well as at least basic knowledge of machine learning.

10. REQUESTED SPECIAL REQUIREMENTS

There are no special requirements.

11. REQUESTED LANGUAGES

Knowledge of English and Slovenian language is required.

12. REQUESTED WORK EXPERIENCE

Work experience is not necessarily required.

13. FORESEEN POSTDOCTORAL TRAINING

Possible postdoctoral training will be prepared together with the selected candidate during this early stage researcher training. Given the topicality of the research field and the mentor's own focus on pursuing scientific excellence in research work, we anticipate the inclusion of the candidate in research and development projects at the national and international level and the continuation of the research path in the form of a postdoctoral research project.

Mentor's signature:

Research programme leader's signature:

Name and surname of Dean or authorised person³: Kliknite ali tapnite tukaj, če želite vnesti besedilo.

Signature of dean or authorised person:

Place and date:

³ The training program is signed by the dean of the member where the ESR's employment and training will take place.

Kliknite ali tapnite tukaj, če želite vnesti besedilo.

Kliknite ali tapnite tukaj, če želite vnesti datum.

Stamp: