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Deliverable D.2.2 First Joint Research Report

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Contents

1. EXECUTIVE SUMMARY

This document describes the **First Joint Research Report** (D.2.2) of the GAIN project.

Document History			
Version	**Date**	**Contributors**	**Description**
1	03/03/2024	J. Alexandersson, P. Müller, B. E. Wirth – DFKI; F. Bremond– INRIA; G. Giorgobiani - MICM	First Joint Research Report
2	15/03/2024	J. Alexandersson, P. Müller, B. E. Wirth – DFKI; F. Bremond– INRIA; G. Giorgobiani - MICM	First Joint Research Report
Final version	29/03/2024	J. Alexandersson, P. Müller, B. E. Wirth – DFKI; F. Bremond– INRIA; G. Giorgobiani - MICM	First Joint Research Report

2. VERSIONS AND UPDATES

According to the DoA of the project, the Final Joint Research and Impact Evaluation Report (Deliverable 2.3) will be ready at the end of the project in 2025.

3. INTRODUCTION

The main goal of the GAIN project is to support Georgia, one of the widening countries, to integrate into the European Research Area (ERA) of Artificial Intelligence (AI). It will be achieved by adjusting the research profile of MICM and linking it to the European AI research and innovation community. To this end the GAIN project initiated joint research projects enabling long-term cooperation and partnership between Georgian and European researchers.

The basis for all research capacity building activities of the project is Work Package 2 - **Twinning Research and Innovation Programme (TRIP)**. The plan for future activities was agreed upon at the TRIP Steering Board meeting on December 27, 2022, and the corresponding deliverable *D 2.1 Framework parameters of the programme*, was submitted on the due date.

The final document was preceded by a series of webinars, which started in November 2022, and continue as weekly web-workshops and supervision meetings. They were organized by INRIA and DFKI and included 3 topics:

1. ***Topic 1.*** *AI Methods for Deep Speech Analysis in Health (Leader: DFKI);*
2. ***Topic 2****. AI Technologies for Human Behaviour Understanding (Leader: INRIA);*
3. ***Topic 3****. Pilot Research Project at MICM, based on (but not limited to) the bilateral (INRIA-DFKI) large-scale project MEPHESTO.*

Finally, 6 thematic research groups (sub-tasks), supervised by the researchers from DFKI and INRIA, were composed:

1. G1. EEG/EDA/ECG (Unimodal EEG/Multimodal [RGB+EDA+EEG]/Implicit Intent Recognition)
2. G2. Face (Emotion RGB or Multimodal [RGB+audio+Text])
3. G3. High-Level Behaviour Analysis (Personality)
4. G4. High-Level Behaviour Analysis (Behaviour disorders: Alzheimer, Schizophrenia, Bipolar, Depression)
5. G5. NLP[1]
6. G6. NLP-fMRI.

Taken together, 18 Georgian researchers are assigned to the specific research topics, sub-tasks (see Table 1 below and deliverable D.2.1).

Table 1.

Sub-Project Leader	Sub-Projet Title	Sub-tasks	Researchers from MICM	Group
DFKI	AI Methods for Deep Speech Analysis in Health	NLP	B.Mikaberidze, B.Tepnadze	5
		NLP-fMRI	T.Giorgobiani, G.Giorgobiani, S.Tsagareishvili	6
INRIA	AI Technologies for Human Behaviour Understanding	Action detection/recognition	T.Saghinadze, D.Datuashvili	3
		Emotions	I.Katchiasvhili, L.Tabagari (full body video)	2
			R.Kalandadze, N.Kukhilava, T.Tsmindashvili, D.Datuashvili, K.Kachiashvili, Z.Tabagari (face crop video, biosignals)	1
DFKI - INRIA	Pilot Research Project at MICM based on Mephesto Project	Clinical interviews with patients	K.Sulaberidze, E.Chkonia	4
		Clinical annotation	S.Tsagareishvili, T.Giorgobiani	
		ECSI annotation	E.Gaprindashvili	
Technical support at MICM	Technical support of all the Sub-Projects		L.Tabagari, B.Oikashvili, Z.Sanikidze, G. Ghlonti, I.Katchiashvili, V.Berikashvili, Ts.Javakhishvili	
Research Management and Coordination at MICM	Overall research management at MICM		G.Giorgobiani, V.Kvaratskhelia, M.Menteshashvili, Z.Sanikidze, V.Berikashvili	

[1] Natural Language Processing

Among 26 Georgian researchers of the GAIN-MICM team, 19 are young scientists, PhD, Master and Bachelor students mostly from MICM and GTU but also from I. Javakhishvili Tbilisi State University, International Black See University, Tbilisi State Medical University, Tbilisi Mental Health Centre, Caucasus University, AI start-ups "Helio.AI" and "Tbilisi AI Lab", the software company "EPAM Georgia" and a medical centre „Mrcheveli". Many other students, not yet affiliated with GAIN and MICM formally, use to attend our weekly seminars at MICM and are involved in the research process. The sub-tasks are supervised by the researchers from DFKI and INRIA, Francois Bremond, Michal Balazia, Laura Ferrari, Alexandra Konig, Philipp Muller and Benedikt Wirth. PhD students from DFKI and INRIA, Valeriya Strizhkova, Tanay Agrawal, Abid Ali, Hali Lindsay, and Mansi Sharma are involved in the joint research as well.

4. RESEARCH RESULTS

4.1. Abstracts of the presentations at the GAIN First Summer School

Results of 10 months of joint research were considered and evaluated at the GAIN workshop collocated with the First GAIN Summer School[2]. Five presentations[3] were delivered by the Georgian members of the Groups 1, 2, 3, 5 and 6. Group 4 will present their progress after the doctor-patient interviews are recorded in Georgia and analysed.

Sub-task 1: AI Technologies for Human Behaviour Understanding, Emotions (face crop video, biosignals)

Group 1: R. Kalandadze, N. Kukhilava, T. Tsmindashvili, S. Katamadze

Supervised by: F. Bremond, L. Ferrari (INRIA), P. Muller, B. Wirth (DFKI).

Title: Evaluation in EEG Emotion Recognition: State-of-the-Art Review and Unified Framework

Presented by R. Kalandadze and S. Katamadze

The biosignals group presented the main content of a nearly finalized paper cantered on Emotion Recognition derived from EEG signals. Delving into research conducted between 2018 and 2023 on EEG-driven emotion recognition, the team researched various studies, highlighting prevalent inconsistencies, which they elucidated using detailed statistics. It became apparent that the majority of inconsistencies stem from differing data pre-processing methods, types of data splits (like leave-one-trial-out or leave-one-subject-out), evaluation standards, dataset usage and label choices. Such discrepancies hinder accurate comparisons among various studies. Consequently, the team's paper advocates for a unified approach, established upon their comprehensive review, ensuring streamlined data pre-processing, data split techniques, metrics, and label choices. The group has developed a framework that connects a full model training cycle from pre-processing to evaluation. This intuitive

[2] Details of the First GAIN Summer School will be present in the GAIN Summer School Report (D.3.4)

[3] Full versions of the presentations are available at https://www.gain-twinning.eu/?page_id=302

pipeline supports the application of cutting-edge models to popular datasets, furnishing foundational results and encouraging the integration of unique models and datasets. All of the above mentioned topics are part of the paper and will be part of the presentation, too.

Sub-task 2: AI Technologies for Human Behaviour Understanding, Emotions (full body video)

Group 2: I. Katchiasvhili, L. Tabagari

Supervised by: P. Muller, B. Wirth (DFKI)

Title: The newest achievements of AI in Emotion Recognition from Human Body Movements

Presented by I. Kachashvili

The primary objective of the project is to utilize the MPIIEmo dataset for the creation of a novel method or the enhancement of an existing one, aimed at identifying human emotions through full-body recognition. The research team has conducted extensive investigations in this field, meticulously reviewing numerous publications and analysing the MPIIEmo dataset, known for its challenging perspectives and uniqueness. The team aspires to employ the "Multi-View Action Recognition using Contrastive Learning" method, which has demonstrated superior performance compared to the current state-of-the-art (SOTA) techniques for full-body action recognition. They will brainstorm potential contributions to the project, explore innovative approaches to the task in order to implement new methods and models that have not been previously explored.

Sub-task 3: Action detection/recognition (AI Technologies for Human Behaviour Understanding)

Group 3: T. Saghinadze

Supervised by: F. Bremond, T. Agraval (INRIA)

Title: Exploring Image Captioning with Parameter-Efficient Transfer Learning for Vision Transformers

Presented by T. Saghinadze

With the widespread adoption of transformer architecture, big new models emerged that could be repurposed for many downstream tasks using transfer learning. Full finetuning is the method of choice for achieving this goal. Due to the ever-increasing number of parameters, this approach requires a proportional increase in computational resources. That is why one can see significant developments in the research of parameter-efficient transfer learning. Most of these methods were developed with NLP tasks in mind. Adapter-based and similar methods show great promise; they significantly reduce the number of parameters that are needed to be retrained for downstream tasks while keeping the original parameters of the pre-trained model untouched.

The goal of the project is to apply parameter-efficient transfer learning to other tasks that are not necessarily bound to the paradigm of NLP. A pre-trained vision transformer seems like a good starting point. Image captioning was taken as a midway point between NLP and CV. A basic encoder-decoder architecture (ViT&GPT2) with prefixed and suffixed tunable prompts in conjunction with bitfit and adapters was explored using COCOCaptiions as the training dataset.

Sub-task 5: AI Methods for Deep Speech Analysis in Health, NLP

Group 5: B. Mikaberidze, B. Tepnadze

Supervised by: P. Muller, H. Lindsay (DFKI).

Title: Georgian Pretrained Language Understanding Model

Presented by B. Mikaberidze

Our primary goal is to develop the Pretrained Language Understanding Model for Georgian. In other words, we are focusing on Contextual Word-Embeddings, a crucial component for moving forward and advancing Natural Language Processing. This model can further be applied to almost all downstream Natural Language Understanding tasks, including Text Classification, Token Classification, Semantic Similarity, Relation Extraction, etc. Remarkably, such a Pretrained Language Model (PLM) can benefit the field of healthcare. If we fine-tune it on the Sentiment Analysis task, it can be utilized to process patient-doctor communications and detect the patient sentiment expressed in the interaction. As a training corpus, we intend to collect up to 0.5 billion tokens from sources like e-books, Wikipedia, and selective media platforms and 1.5 billion tokens of relatively noisier data from broader web scrapes.

Additionally, our team is currently developing a benchmark dataset specifically for evaluating the sentiment analysis performance of models trained on Georgian. Such benchmarks for different downstream tasks are the most reliable way to evaluate PLMs in general. We hope our research will significantly enhance Georgian NLP and benefit downstream applications, starting with healthcare.

Sub-task 6: AI Methods for Deep Speech Analysis in Health - NLP-fMRI

Group 6: T. Giorgobiani, S. Tsagareishvili

Supervised by: P. Muller, H. Lindsay, B. Wirth (DFKI)

Title: Studying neural correlates of speech production using fMRI and NLP

Presented by T. Giorgobiani

In this project we will attempt to apply natural language processing (NLP) methods to a functional Magnetic Resonance Imaging (fMRI) experiment currently being conducted to study functional reorganization patterns after the transient suppression of the Broca's area, a vital region for language production. In this, experiment participants will do a language production task in an fMRI scanner after real inhibitory and placebo stimulation of the Broca's region with Transcranial Magnetic Stimulation (TMS). For the elicitation of speech, picture stories depicting different everyday scenes will be used. The participants will be asked to describe them with simple and complete sentences in German. For the transcription of the narratives Google-Speech-to-Text will be used. Afterwards the results of the transcription will be checked manually. Our main question from the neuroimaging standpoint is to see how the brain adapts itself and how the language network will be reorganized to support the perturbated area and speech production processes. However, it is also of great importance to see how the stimulation affected the performance on the language production task. Broca's area is known to be engaged in lexical, grammatical as well as phonological processing. Since the offline TMS stimulation (also called virtual lesion approach) is usually not sufficient to cause any noticeable changes in speech production, NLP methods can potentially better delineate the subtle differences between the conditions. In our presentation we will discuss the possibilities of using mainly syntactic and semantic measures to answer our research questions.

Acknowledgments. *Aside from the GAIN project, research is supported by a scholarship of the Advanced Research Opportunities Program (AROP) at the RWTH-Aachen University. The experiment is conducted at the*

RWTH-Aachen University Clinic with the supervision of Univ.-Prof. Dr. med. Ferdinand C. Binkofski and his team of Clinical Cognitive Sciences.

The conducted work has been highly evaluated by the European partners.

4.2. Tenure-track Positions

Four Tenure-track Positions (D 2.1) were agreed upon by the TRIP steering board as follows:

1. PhD student Teimuraz Saghinadze (Sub-Task Action detection/recognition)
2. Master student Rapael Kalandadze (Sub-Task EEG-based emotion recognition)
3. Master student Natia Kuchilava (Sub-Task EEG-based emotion recognition)
4. PhD student Beso Mikaberidze (Sub-Task NLP).

MICM, aiming at recruiting young researchers has created 4 new employee positions within the research departments of the institute:

- Researcher – 1 competitive position at the department of „Computational Methods "
- Assistant Researcher – 3 positions at the „Computational Center".

Above mentioned 4 young researchers with the Tenure-track position, have applied to these positions. As a result, PhD student T. Saghinadze (who was an Assistant Researcher at MICM before) now holds the position of a researcher; three other students now hold the positions of assistant researchers. Note that two master students plan to start working on their PhD theses in 2024.

One of the important achievements of the project during the reporting period is the identification of talented young Georgian researchers with additional skills of leadership. As set out in the project, 3 groups are composed at MICM lead by 3 distinguished students:

1. PhD student Teimuraz Saghinadze (Sub-Task Action detection/recognition).
2. Master student Rapael Kalandadze (Sub-Task Emotions).
3. PhD student Beso Mikaberidze (Sub-Task NLP).

Teimuraz Saghinadze is working on his PhD thesis and plans to defend it in 2025. He has a broad knowledge in the field of Machine Learning (ML) but also a strong mathematical background, which is important to handle theoretical problems of AI as well as practical. Although he is assigned to the sub-task Action detection/ recognition, he willingly participates in the research of EEG and NLP groups. Rapael Kalandadze, though a master student yet, has vast experience and knowledge in AI technologies and is a co-author of several practical experiments and inventions. PhD student Beso Mikaberidze works on NLP problems for the Georgian language, which is regarded as low resourced making the task quite difficult and specific. Worthy to note that the research, conducted by all Georgian students during the reporting period is highly assessed by the European partners.

Two other Georgian PhD students, Master of psychology T. Giorgobiani and Master of psychiatry, clinician K. Sulaberidze are assigned to the Sub-project "Pilot Research Project at MICM based on the MEPHESTO Project".

Aside from the GAIN project, research of T. Giorgobiani is supported by a scholarship of the Advanced Research Opportunities Program (AROP) at the RWTH Aachen University, where an fMRI experiment currently being conducted to study functional reorganization patterns after the transient suppression of the Broca's area, a vital region for language production. In the GAIN project it is planned to apply NLP methods to this research. In this respect, the possibility of a joint project with RWTH is under consideration.

The possibility of double supervision (second supervisor from INRIA or DFKI) for Georgian students is being considered. GAIN will support this in the frames of the DoA of the project.

4.3. MICM AI Lab

Due to the support of the GAIN project, "MICM AI Lab" has started working in November 2022 and includes 26 researchers. The lab will be supported financially as well as scientifically by the project for 3 years. The MICM administration plans to maintain all created research capacities after the project ends with budgetary help of the Georgian government and/or by seeking other funding opportunities, like research grants, commercialization etc. MICM AI Lab will be a part of the "Joint Virtual Laboratory", which will be created in 2024 (see Task 2.4).

MICM AI Lab possesses 4 Microsoft Azure Kinect DK cameras (for the doctor-patient interviews' recording) and an EEG device, Unicorn Hybrid Black (for biosignals), which were purchased with the financial support of the GAIN project.

MICM AI Lab conducts the GAIN weekly workshops at MICM on various topics of ML and research problems posed by the project. The workshop series started in the beginning of the project in 2022 and continues.

4.4. Staff Exchange (mobility) Scheme

The Staff Exchange (mobility) Scheme is necessary to carry out collaborative research. In the GAIN project, the program enables task-specific trips with clearly identified purposes from one partner organization to another. They are linked to the 6 research Sub-tasks of the 3 Sub-Projects given above and the Tenure-track Positions defined by the TRIP.

After the evaluation of presentations of the Georgian students at the First Summer School, it was noted that the Georgian researchers have made tangible progress during the first stage of the collaboration with their European colleagues. Host organizations and research topics for visiting Georgian students were discussed. Finally, the Staff Exchange (mobility) Scheme (WP 2, TRIP) for the Georgian researchers was agreed upon by the TRIP steering board as follows:

1. Master student Rapael Kalandadze (Sub-Task Emotions, G1) – visit to INRIA in Paris.
2. Master student Natia Kuchilava (Sub-Task Emotions, G1) - visit to DFKI in Saarbrücken.
3. PhD student Teimuraz Saghinadze (Sub-Task Action detection/recognition, G3) – visit to INRIA in Sophia Antipolis.
4. PhD student Beso Mikaberidze (Sub-Task NLP, G5) – visit to DFKI in Saarbrücken.

The visits will start in Spring 2024, and the duration of each visit will be approximately 3 months.

4.5. Research papers and conference talks.

As a result of project planning and collaboration, in the reporting period, 5 research papers have been published in peer reviewed, open access journals, 1 paper is published in conference materials, 2 will appear in 2024, 1 is submitted and 3 papers are prepared. 17 conference talks have been delivered at international scientific conferences (see Appendix).

1.5.1. Research results in the thematic groups.

Due to the regular webinars organised by INRIA and DFKI and the permanent exchange between Georgian researchers and the partner institutions, progress in the research groups is subject to continuous change. Below we describe the state of research at the end of January 2024.

Group 1 (Sub-task 1: AI Technologies for Human Behaviour Understanding, Emotions (face crop video, biosignals) is working on 2 projects initiated and suggested by INRIA and DFKI researchers.

- **Project 1** (**participant**s: N. Kukhilava, T. Tsmindashvili, R. Kalandadze (master students, MICM), L. Ferrari (Post-doctoral researcher, INRIA), V. Strizhkova (PhD student, INRIA)) is focused on emotion recognition from video. Scale is the primary ingredient in attaining generalizable video representations. While scaling model capacity and data size for video masked autoencoders (VideoMAE) has been explored for large generic datasets of short videos, it is still unknown how to scale the VideoMAE pre-training for more specific cases such as small datasets of long face videos. Does increasing model size improve recognition performance when pre-training data is limited? Does VideoMAE scale as well for long videos as it does for short ones? Does pre-training on non-face videos improve performance on face-related tasks? The project addresses these questions by exploring VideoMAE scaling for the task of emotion recognition. The project uses the challenging AMIGOS and DEAP affective datasets with long face videos (1-2 minutes) and scale VideoMAE in both model and data, experimenting with transformer models ranging from 87 million to 305 million parameters and using datasets ranging from 600 to 300 thousand training videos. The project also shows the effect of progressive learning, which consists of self-supervised pre-training followed by supervised pre-training on datasets with mixed labels. This contribution is the first study on how to scale VideoMAE for the task of emotion recognition using small datasets with long face videos. The code is available at https://github.com/EmotionLab/EmotionVMAE . Regarding this project, a joint research paper is prepared, and a conference talk is given at an international conference (see Appendix, Publications, [10]; Conference talks [2]).
- **Project 2** (**participants**: N. Kukhilava, T. Tsmindashvili, R. Kalandadze (master students, MICM), S. Katamadze (PhD, MICM), L. Ferrari (post-doctoral researcher, INRIA), P. Müller, B. E. Wirth (senior

researchers, DFKI)) deals with the problem of emotion recognition from EEG signals, which has become a rapidly growing area of research in recent years. To fairly compare proposed approaches and to track the field's progress, commonly agreed-upon evaluation protocols are essential. In a comprehensive literature review of EEG-based emotion recognition articles published between 2018 and 2023, the authors uncover that the field lacks such protocols, making it impossible to reliably determine the state-of-the-art approach. Analyzing 231 papers, it is shown that inconsistencies between evaluation protocols of published approaches commonly arise from different choices of datasets, inconsistent ground truth discretisation, evaluation metrics, and data pre-processing. To overcome these challenges to the field's progress, recommendations for a unified evaluation protocol are given and EEGAIN, a novel open source software framework which allows researchers to efficiently evaluate their approaches with a unified protocol is presented. EEGAIN includes standardized methods for data pre-processing, data splitting, evaluation metrics, and the ability to load the 5 most relevant datasets in EEG emotion recognition with only a single line of code. In addition, EEGAIN offers a convenient way to execute recent state-of-the-art models, thereby providing baseline results and allowing comparison to novel user-defined models and datasets. EEGAIN is first used to evaluate recent state-of-the-art models on all the 5 most relevant EEG emotion datasets, namely Mahnob-HCI, DEAP, SEED, AMIGOS, and DREAMER. As such, this work is a significant step to make research on EEG emotion recognition more reproducible and comparable, thereby accelerating the overall progress of the field.

Within this project, a novel **Open Source Software Framework EEGain** is designed to improve the comparability and generalizability of EEG emotion recognition approaches. It enables to run 4 models - Tsception, EEGNet, DeepConvNet, ShallowConvNet, on 6 data – AMIGOS, DEAP, MAHNOB-HCI, SEED-IV, SEED, DREAMER.

EEGain link: https://github.com/EmotionLab/EEGain

The results of this project are reflected in the joint research paper, which is almost ready for publication, and 4 conference talks, given at international conferences (see Appendix, Publications, [11]; Conference talks [3, 4, 16, 17]).

In the context of sub-task 1, a GAIN Workshop entitled "EmoRec EEG: Generalizability of Emotion Recognition from EEG signals" will takes place in Glasgow, on 15 September 2024, at the International Conference on Affective Computing and Intelligent Interaction (ACII) 2024.
Workshop link: https://emotionlab.github.io/EmoRec-EEG/

Group 2, Sub-task 2: AI Technologies for Human Behaviour Understanding, Emotions (full body video).
Participants: I. Katchiashvili (master, MICM), L. Tabagari (master student, MICM), P. Müller, B. E. Wirth (senior researchers, DFKI), M. Balazia (Research scientist, INRIA).
Group 2 is currently in the process of developing new approaches to recognize emotions from body movements. More specifically, the group aims to recognize emotions from videos with partly challenging camera angles. The multi-object tracking computer vision model ByteTrack is used for tracking objects (humans) in videos, getting their bounding boxes, IDs and coordinates.
The primary issue identified was the inconsistent size of bounding boxes for each detected person, resulting in suboptimal cropped output videos. In this respect, the idea of obtaining the centre of each detected bounding box and applying padding was suggested. Following code modifications, the process now functions as follows:

- Specify the desired size of the bounding box.
- The code retrieves coordinates from the ByteTrack-generated txt file.

- Frame by frame, it detects the centre based on these coordinates and adds padding accordingly.

The final output video is regarded satisfactory, further improvements could be made to the bounding box cropping method.

For the aim of emotion recognition, Group 2 also delved into feature extraction methods with a focus on Dino V2, which is created by Meta AI with the assistance of INRIA researchers. Michal Balazia (INRIA) also recommended CLIP, developed by Open AI, suggesting the idea of initially implementing one and then the other in order to compare the results. This approach would enable showcasing two different results with Dino and Clip in the eventual paper.

In summary, the group outlined plans to refine the bounding box methodology, explore feature extraction methods, and tackle the challenges of server-based experiments. The next steps involve connecting to the server, setting up the environment, and testing code execution. The subsequent phase includes installing ByteTrack and DINOv2 on the server, acknowledging the anticipated challenges in this process. A related research paper and a conference talk will be ready by the second half of 2024.

Group 3, Sub-task 3: Action detection/recognition (AI Technologies for Human Behaviour Understanding).

Participants: T. Saghinadze (PhD student, MICM), D. Datuashvili (PhD, IBSU[4]), F. Bremond (Research Director DR1 at INRIA), T. Agraval (PhD student, INRIA).

The group has been investigating and implementing new methods for action recognition from video. French partners proposed the main components of the architecture. The backbone of the architecture is Dinov2 by Meta, with adapters used for fine-tuning. However, the first and last adapters serve a dual purpose in this model, as they also function as memory units, utilizing the absolute difference of attention maps as an additional input. The new variant, developed by the team in Georgia, incorporates TCN as a temporal comprehension mechanism. Said architecture has been implemented and is ready to be trained, which most likely will start soon. Since the model is on the larger side and multiple datasets ought to be checked, it will require a non-trivial amount of computation. In the meantime, the Georgian side has been developing a couple of possible fine-tuning schemes that have Dinov2 as its backbone as a possible next step.

Collaboration with the team working on EEGain (Group 1) resulted in the first model being ready to be trained with CNN adapters (Rebuffi and Chapter adapters) and bitfit. TSception is the first CNN-based model that is intended to check. Preliminary experiments show relatively good results for the bitfit technique, but a proper hyperparameter search would be preferable since the smaller size of the model and lesser number of epochs allow to run it on a local machine.

Paper [2] is inspired by research carried out in the GAIN project. It deals with a well-known fact that the convolutional layer has the property of translational equivariance. However, it's non-obvious how to expand the symmetry group associated with the said layer. Employing key definitions adopted in deep geometric learning (see e.g. *[Bronstein, M. M., Bruna, J., Cohen, T., & Veličković, P. (2021). Geometric deep learning: Grids, groups, graphs, geodesics, and gauges. arXiv preprint arXiv:2104.13478]*, the set of filters that induce 90-degree rotational equivariance without modifying the convolutional operator is constructed. This work is primarily intended as a

[4] International Black Sea University

theoretical exercise, beginning with a predefined symmetric group in mind and producing a convolutional layer with the desired equivariance.

Group 5, Sub-task 5: AI Methods for Deep Speech Analysis in Health, NLP.

Participants: B. Mikaberidze, T. Saghinadze (PhD students, MICM), H. Lindsay (PhD student, DFKI), P. Müller (senior researcher, DFKI).

The group has developed a benchmark dataset specifically for evaluating the sentiment analysis performance of models trained on the Georgian language. A Georgian sentence tokenizer based on NLTK by compiling a list of nearly 1,000 abbreviations and enhancing the base tokenizer with several additional rules is developed as well. The Initial stage of pre-processing is completed and construction of pipelines for the training and fine-tuning of Georgian language models is in process. It should be noted that the group actively collaborates with Dr. Lonneke van der Plas from Idiap Research Institute, Switzerland. Modification of the method of investigation of the low-resourced Maltese language is used for Georgian language within the GAIN project. A related research paper and a conference talk will be ready in 2024.

Group 6 (Sub-task 6: AI Methods for Deep Speech Analysis in Health - NLP-fMRI).

Participants: T. Giorgobiani (PhD student, TSU[5]), S. Tsagareishvili (master, TSU), P. Müller (senior researcher, DFKI).

An fMRI experiment is currently conducted at the RWTH - Aachen, Germany, to study functional reorganization patterns after transient suppression of Broca's area, a vital region for language production. Within the GAIN project it is planned to apply NLP methods to this research. For this purpose, RWTH – Aachen University shared research data with DFKI. Joint research is in progress. A related research paper and a conference talk will be ready in the second half of 2024.

1.5.2. Research at European Partner Institutions supported by GAIN.

Automatic analysis of human behaviour is a fundamental prerequisite for the creation of machines that can effectively interact with and support humans in social interactions. In MultiMediate '23, researchers from INRIA and DFKI address two key human social behaviour analysis tasks for the first time in a controlled challenge: engagement estimation and bodily behaviour recognition in social interactions. For the challenge, the researchers introduced novel sets of annotations for both tasks. For engagement estimation, novel annotations on the NOvice eXpert Interaction (NOXI) database were collected. For bodily behaviour recognition, test recordings of the MPIIGroupInteraction corpus were annotated with the BBSI annotation scheme. In addition, the researchers provided baseline results for both challenge tasks. The corresponding challenge paper [1], co-authored by senior scientists from DFKI and INRIA, is supported by the GAIN project.

PhD student Tanay Agrawal from INRIA, supervised by Professor Francois Bremond, together with other students at INRIA, works on parameter efficient transfer learning techniques, which plays a pivotal role in advancing the fields of artificial intelligence and multimodal learning. Traditional machine learning models often require extensive amounts of data for training, which can be impractical or even infeasible in many real-world

[5] I. Javakhishvili Tbilisi State university

scenarios. Parameter efficient transfer learning mitigates this issue by allowing models to leverage pre-trained knowledge from related tasks or domains, enabling them to adapt to new tasks with limited data. This not only significantly reduces the data requirements for training, but also accelerates the development of sophisticated AI systems. Moreover, in the context of multimodal learning, where information is integrated from diverse sources such as text, images, and audio, parameter efficient transfer learning facilitates the effective fusion of these modalities by providing a framework to leverage knowledge gained from one modality to enhance performance in others. This promotes the creation of more robust and versatile AI systems capable of handling complex, real-world tasks across multiple input modalities. Therefore, the development and refinement of parameter efficient transfer learning techniques represent a critical area of research with far-reaching implications for the advancement of artificial intelligence and multimodal learning.

In paper [9] a new model agnostic architecture for cross-learning, called CM3T, applicable to transformer-based models is presented. Challenges in cross-learning involve inhomogeneous or even inadequate amounts of training data, and lack of resources for retraining large pretrained models. Inspired from transfer learning techniques in NLP (adapters and prefix tuning), the authors introduce a plugin architecture that makes the model robust towards new or missing information. It is also shown that the backbone and other plugins do not have to be finetuned with these additions which makes training more efficient, requiring less resources and training data. Two adapter blocks called multi-head vision adapters and cross-attention adapters for transfer learning and multimodal learning respectively are introduced. Through experiments and ablation studies on three diverse datasets - Epic-Kitchen-100, MPIIGroupInteraction and UDIVA v0.5 - with different recording settings and tasks, the efficacy of this framework is shown. With only 12.8% trainable parameters as compared to the backbone for video input and 22.3% trainable parameters for two additional modalities, comparable or even better results as compared to the state-of-the-art are achieved. Compared to similar methods, this result is achieved without any specific requirements for pretraining/training and is a step towards bridging the gap between research and practical applications for the field of video classification.

Future work would involve extending adapters and other parameter efficient techniques to optimize the finetuning and even transferring pretrained models across different fields of AI. It would also be interesting to explore their efficacy in the field of explainable AI owing to their property of decoupling different aspects to be learnt in a task. For example, adapters can be used to separate spatial and temporal reasoning in the field of video understanding.

PhD student Mansi Sharma from DFKI is working on her PhD thesis “Adapters for Calibration of EEG Classifiers”[6]. The adapter modules are inserted between pre-trained network layers. This involves copying parameters from pre-training, keeping them fixed, and adding a few task-specific parameters for each new task without impacting previous ones. The adapter module's design strategy achieves parameter efficiency in a single model without compromising performance. In contrast to traditional fine-tuning, which adds and co-trains a new layer, the adapter tuning strategy introduces new layers (randomly initialized) into the original network, supporting parameter sharing between tasks while keeping the original network's parameters frozen. This adapter-based tuning architecture introduces a minimal number of parameters, aiming to preserve the original

[6] Research is performed in collaboration with the “Adapter Group of GAIN” composed of researchers from DFKI, INRIA and MICM

network and maintain training stability. The approach initializes adapters close to an identity function, influencing activation distribution during training (which can be optionally excluded). Adapter-based tuning is applied to Transformers, known for achieving state-of-the-art performance in various NLP tasks like machine translation and text classification. There are very few research works that have used adapter-based tuning for cross-subject analysis in EEG. Our idea is to use the data from the target subject in the most efficient way to predict the target subjects' unlabeled samples. Adapter Networks *[Houlsby, N., Giurgiu, A., Jastrzebski, S., Morrone, B., De Laroussilhe, Q., Gesmundo, A., ... & Gelly, S. (2019, May). Parameter-efficient transfer learning for NLP. In International Conference on Machine Learning (pp. 2790-2799). PMLR.]* can be investigated in both the scenario where we have ground truth, and the scenario where we don't.

1. Supervised Calibration. We have ground truth: use the standard Adapter formulation.
2. Unsupervised Calibration. We don't have ground truth: use a meta-network to predict the adapter weights based on unlabeled EEG input (as discussed e.g. in *[Sung, Y. L., Cho, J., & Bansal, M. (2022). Vl-adapter: Parameter-efficient transfer learning for vision-and-language tasks. In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (pp. 5227-5237)]*).

Adapters are expected to be especially helpful in this scenario, because we only have very few samples for the calibration. Recent work in NLP indicates that adapters have advantages especially in data-scarce situations *[He, R., Liu, L., Ye, H., Tan, Q., Ding, B., Cheng, L., ... & Si, L. (2021). On the effectiveness of adapter-based tuning for pretrained language model adaptation. arXiv preprint arXiv:2106.03164]*.

As a baseline model, BENDR would be fitting as adapters were introduced in the context of transformers previously. The principle can be applied to other networks as well. The project makes use of the common publicly available EEG emotion recognition datasets like SEED and DEAP.

1.5.3. Research at MICM supported by GAIN.

Traditionally, research at MICM comprise various fields of applied mathematics, such as probability and statistics, mathematical modelling, computational methods, optimization etc.

One of the main goals of the GAIN project is to adjust the research profiles of MICM to AI problems. GAIN has elicited an interest of scientists at MICM to the field of Machine Learning. Conference talk [1] is about the various mathematical methods applied in this field and research problems posed in the frames of the project.

Professor K. Katchiashvili, a member of the GAIN-MICM team, is the author of 2 textbooks „The methods and algorithms of machine learning (2021)" and "Machine learning (2023)". Within the GAIN project, aside from the consultations of young researchers in ML topics, Professor K. Katchiashvili is investigating the problem of automatization of diagnosis of lung diseases (pneumonia, cancer) based on an X-Ray image of patients by use of statistical and ML methods. The research group includes 2 young members of the GAIN-MICM team. On these topics, one paper [8] is submitted and 3 conference talks are delivered [8 – 10].

The problems related with permutations (rearrangements) in different settings has been investigated by the group of mathematicians at MICM for a long time. It occurs that permutations are the object of interest in many ML problems as well. Note that some of our recent papers are cited by several authors working in this field (see e.g. *[Yucheng Lu, Wentacited byristopher De Sa. GraB: Finding Provably Better Data Permutations than Random Reshuffling. 36th Conference on Neural Information Processing Systems (NeurIPS 2022)], [Harvey N., Samadi S. Near Optimal Herding. JMLR: Workshop and Conference Proceedings. 35, 1-18, 2014]*). In 2023 two papers were devoted to this topic. In [3], a polynomial algorithm for finding the near-optimal rearrangement in the Steinitz

functional for the vectors in the finite dimensional normed space is established. Maximum inequality and a Transference theorem, obtained by the authors, as well as a Monte-Carlo method are applied. This algorithm can be useful in ML problems as well as for some longstanding classical mathematical problems. The GAIN-MICM team intends to design a software for this algorithm. Another paper [7] (to appear in 2024) deals with trigonometric Fourier series. The so called „permutation sign convergence" condition is considered, which may be interesting in applications. In the conference talk [11], rearrangements of a famous Dirichlet type series are considered, which are related to the Laplacian eigen values of the Heat Equation and corresponding spectral zeta function. Aside from the pure mathematical problems, the mentioned objects are applied to the Shape Recognition problems (see e.g. *[Mohamed Ben Haj Rhouma, Mohamed Ali Khabou, Lotfi Hermi. Shape Recognition Based on Eigenvalues of the Laplacian. Advances in Imaging and Electron Physics, V. 167, 2011, pp. 185–254]*). The corresponding paper is in preparation and will be submitted for publication in 2024.

Paper [4] aims to develop methods for increasing knowledge and model tracing capabilities of intelligent tutoring systems (ITS) designed for teaching mathematics and informatics. From different areas of mathematics and computer science, based on the strategy of self-explanation, the authors consider the cases where the solution of a problem can be achieved as a result of generalization of results found at previous stages. By using a holistic approach and appropriate methods of ontology engineering this can become the basis for building an e-learning environment, where students naturally move through the subject based on effective feedback from the ITS.

Paper [9] describes the process of constructing a solution to the Initial Value Problem for a quasi-linear non-strictly hyperbolic equation. AI approaches are not new in pure mathematics, these are e.g. multi-agent learning of numerical methods for hyperbolic partial differential equations, physics-informed neural networks (PINNs), etc. Motivated by this, the authors of the paper plan to use AI methods in their research.

As noted above, probability and statistics as well as computational methods are the traditional research fields at MICM. The GAIN project supported the research in these fields as well. The moment of a random variable is an essential statistical concept in data science and is important in statistical machine learning. Conference talk [7], which deals with the connections between the moments of random variables, was delivered at CSIT 2023 (Computer Science and Information Technologies). A corresponding extended journal publication is in preparation and will be ready in 2024 (see also paper [5], conference talks [12, 14]). The conference talks [5, 6] deal with numerical calculations of engineering constructions and of electrostatic fields. A paper [12] *(to appear in Pattern Recognition and Image Analysis, 2024)* and a conference talk [13] is about the sub-Gaussian random variables.

1.5.4. Data Sets.

In the Gain project the generation of various research datasets is planned. GAIN follows Open Science and FAIR data principles as given in the Grant Agreement and DoA of the project. Digital research data generated in the project, according to the Data management plan (DMP) (deliverable _D 6.3), is handled in line with these principles.

During the reporting period, the GAIN researchers worked on generating the following datasets:

1. **EEG dataset**: Two types of experiments are conducted at MICM, which involve the recording of Event Related Potentials (ERP) with a commercial Unicorn Hybrid Black EEG device purchased by the GAIN project. The device has 8 active electrodes and a recording frequency of 250 Hz, covering 10-20 system positions FZ, C3, CZ, C4, PZ, PO7, OZ and PO8. Both experiments recorded

auditory evoked potentials (AEP), which measure the electrical activity of the brain responding to sound stimuli, and both involve target/oddball tasks. In the second experiment subjects were required to make a certain response depending on the type of stimulus. As planned, the dataset and its analyses will be ready for publication after 20 recordings (each including 2 sessions per participant). Up to this day, 5 records have been conducted and the experiment is still in progress. The research material and the dataset will be uploaded to the Zenodo platform as well as the website of the project and will be open access.

Remark: The experiments will continue after the mentioned 20 sessions. Participants are mainly the volunteers from the GAIN-MICM team, but also other citizens, not related to the project. Up to now, we have consent of about 10 volunteer citizens, who are interested in the results of research, are collecting data for the project, providing practical support, testing & experimenting with innovative R&I solutions. Note also that we plan to conduct other EEG experiments as well.

2. **Georgian language corpus**: it is planned to use the GTU library's electronic documents to create Georgian language corpus. The work is in progress. The dataset will be uploaded to the Zenodo platform as well as the GTU and the project's websites and will be open access.
3. **Records of doctor – patient interviews**: in the reporting period, 5 interviews with 3 patients have been recorded at the Tbilisi Mental Health Centre. This data, containing medical and personal information, is subject to the Ethics Requirements and, consequently, is restricted. Data is encrypted and stored at the GAIN-MICM server. The work is in progress.

1.5.5. Open source software.

Open source software framework EEGain.

Within the project GAIN, a novel open source software framework EEGain is designed to improve the comparability and generalizability of EEG emotion recognition approaches. The framework will be presented at the first workshop on Generalizability of Emotion Recognition from EEG Signals (EmoRec EEG) at ACII'24. It enables the participants to run 4 models - Tsception, EEGNet, DeepConvNet, ShallowConvNet, on 6 data – AMIGOS, DEAP, MAHNOB-HCI, SEED-IV, SEED, DREAMER.

Workshop link: https://emotionlab.github.io/EmoRec-EEG/

Framework link: https://github.com/EmotionLab/EEGain

Open source software VideoMAE.

For the problem of emotion recognition from video, scale is the primary ingredient in attaining generalizable video representations. While scaling model capacity and data size for video masked autoencoders, VideoMAE has been explored for large generic datasets of short videos, adapting these models for longer video sequences remains a challenge which we aimed to address. Open source software VideoMAE was used as a feature extractor model, and with an added classifier layer on top, it was fine-tuned on specific emotion recognition datasets to enhance its performance in identifying and categorizing emotions from video data.

The code is available at https://github.com/EmotionLab/EmotionVMAE

1.5.6. Recording doctor-patient interviews at Tbilisi Mental Health Centre.

Azure Kinect Cameras were installed at the Tbilisi Mental Health Centre to make audio-video recordings of the doctor-patient interviews according to the MEPHESTO study protocol. "Empatica" wristbands are used to collect the biosignals. (https://www.gain-twinning.eu/?p=814). Up to now, 5 interviews with 3 patients have been recorded (see Datasets).

During the preparation for the doctor-patient recordings, medical and support personnel of the End-user entity Tbilisi Mental Health Centre (in addition to 2 psychiatrists from the GAIN team) was actively involved in providing the space/facilities and in patient data collection. Furthermore, the staff was involved in co-creating R&I visions, policies and frameworks, in testing and debating R&I findings, etc. Medical research staff will contribute to scientific publications as part of the GAIN project. MICM and the representatives of the Centre intend to submit a joint research proposal to the Shota Rustaveli National Science Foundation (SRNSF) grant contest in 2024. Furthermore, other opportunities for future joint research are discussed.

1.5.7. Computing Centre at MICM

A high-performance computing server is launched at MICM with the support of the GAIN project[7].

Specifications of the computer:

- Model: HPE Proliant dl385 Gen10 Plus
- CPU: 2 x AMD EPYC 7713
- RAM: 256 GB DDR4
- HD: 7.2 TB
- GPU: 2 x Nvidia A100 40GB.

Currently, the server is primarily used for the machine learning problems of the GAIN project. Aiming at upgrading the computer, MICM has submitted a proposal to SRNSF contest for infrastructural grants in 2024. As the demand for computing is growing[8] in Georgian research community, the server will be used in other areas of science, societal challenges, in healthcare, etc.

5. MEETINGS, WORKSHOPS AND TRAINING

During the reporting period, 6 research and training events have been organized. Below we describe the research component of these events.

5. 1. Kick Off Meeting

The Kick-Off Meeting of the GAIN project (WP 6, Task 6.3: Coordination, communication and administration infrastructure) was held at MICM on October 18 – 19, 2022. The meeting was attended

[7] Partially supported by the Shota Rustaveli National Science Foundation grant.

[8] Presentation of the GAIN-MICM server, March 2024, was attended by the representatives of several universities and research institutions https://www.gain-twinning.eu/?p=895

by representatives of all partner organizations and other guests (approximately 70 participants in total). Among the special guests were Dr. Silvia Bozhinova (Senior Policy Officer and ENP Team leader at the European Commission DG R&I), and Nino Inasaridze, the head of the Horizon Europe Georgia office. All partner organizations gave presentations about their institutions including the research carried out. The joint DFKI - INRIA large-scale project "MEPHESTO", which deals with the use of artificial intelligence methods in psychiatry was presented as well:

- Dr Alexandra König (INRIA) - MEPHESTO Digital Phenotyping 4 Psychiatric Disorders from Social Interaction
- Professor Francois Bremond (INRIA, STARS team, Nice University Hospital CoBTeK) - Video Understanding for Human Behavior Analysis.

Similar studies within the GAIN project are planned in Georgia.
In order to provide a first insight about the research potential of the Georgian scientists, 2 presentations were given by the young researchers, the members of the newly created laboratory of artificial intelligence (MICM AI Lab). In the first presentation, existing MICM computing server specifications and the corresponding plan of its upgrade with the support of the GAIN project were introduced. Another dealt with the practical implementation of Machine Learning methods for one specific medical problem.
Doctor of Medicine from Tbilisi State Medical University Professor Eka Chkonia was invited to present her current research “The electrophysiology and genetics of visual backward masking". Research is carried out at “Tbilisi State Medical University” in cooperation with Swiss scientists from “Ecole Polytechnique Federale de Lausanne”. It deals with the Endophenotype concept in psychiatry, namely in the study of schizophrenia. Professor Eka Chkonia and her doctoral student are members of the GAIN team and are involved in the project activities related to collecting medical data at the Tbilisi Mental Health Centre.
See more details at https://www.gain-twinning.eu/?p=520

5. 2. MEPHESTO & GAIN meeting at INRIA.

The meeting (Task 3.1 GAIN workshop series) was held in January 2023, at INRIA, Sophia Antipolis, France, and was attended by the MEPHESTO project team and the representatives of the GAIN partner organizations. MICM was represented by 9 young researchers and a coordinator of the project.
The MEPHESTO clinical team presented an overview of the data corpus. Use cases/research questions, annotations, and events of interest were discussed. The Use-case demonstrators & infrastructures section included presentations about “SEMLA a Secure Machine Learning Architecture” and “F2F and telemedical solutions”. Synergies of the projects MEPHESTO and GAIN as a continuation of MEPHESTO were discussed.
The GAIN technical team had meetings at INRIA with different research teams, where prospective data analysis plan, annotations etc. were discussed. The clinical team had meetings with different teams

at the "Institute Claude Pompidou", Nice. Prospective data analysis plans, annotations, protocol issues/improvements, future studies, and the implementation of study in Georgia, etc. were discussed.
The GAIN team visited the "Institut Pasteur" in Nice, department of psychiatry, where the doctor-patient interviews for the MEPHESTO project are recorded and analysed.
See more details at https://www.gain-twinning.eu/?p=581

5.3. First GAIN Summer School

The First GAIN Summer School (WP 3, Task 3.4) was collocated with the 3rd INRIA-DFKI EUROPEAN SUMMER SCHOOL ON ARTIFICIAL INTELLIGENCE, IDESSAI 23. It took place at INRIA, Sophia Antipolis, France on 4 – 8 September 2023. The summer school was attended by 10 young Georgian researchers.
The programme was divided into 2 tracks, Track A: Simulation & AI and Track B: AI for Agriculture and the Environment (see entire programme at https://idessai.eu/files/2023/09/Booklet-rev.pdf).
Young Georgian researchers were present at INRIA every day during the summer school and attended numerous presentations, mostly of Track A.
The GAIN workshop was scheduled in parallel to the two main tracks, at the Euler Violet room on 5 September. The workshop included presentations by the young Georgian researchers and the GAIN steering board meeting.
The topics and titles of the presentations have been elaborated and coordinated with the partners from INRIA and DFKI during the joint weakly webinars in different research groups defined by the TRIP. Five presentations were delivered by members of the Groups 1,2,3,5,6 (see the abstracts of the presentations in the Appendix, Section 4.3). Group 4 will present their progress after the doctor-patient interviews have been recorded and analysed.
The presentations (see section 4.1) were followed by discussions, questions, comments, and recommendations by the audience. Taken together, the presentations and research achievements of all the groups were assessed positively. Remarkably, it was noted that the Georgian researchers had made tangible progress during the first stage of the collaboration with their European colleagues. Consequently, the Staff Exchange (mobility) Scheme for the Georgian researchers was agreed upon (see Section 4.4, Task 2.3). Specific methods and means to solve the research problems posed within the thematic groups were outlined.
The First GAIN Summer School succeeded in dissemination and networking. It provided a platform for young researchers from MICM and the consortium as a whole to build their research capacity and networking skills in an international environment.
The achieved goals of the First Summer School were (a) transferred organizational experiences to MICM and development of the blueprint for the organization of future summer schools (b) experience gained by the young researchers in presenting their research in front of an international audience.
Corresponding deliverable D.3.4 GAIN Summer Schools' Report, will be submitted in 2025.

5.4. On-the-job training for Research Administrators and Managers

The training workshop (WP 4, Task 4.3), organized by the project partner EXOLAUNCH was held at Technical University of Berlin, 21 – 25 August 2023. The training was attended by 11 representatives of MICM, the members of EXO and other guests.

The training allowed Georgian researchers to improve awareness about the financial aspects of spinning-off (including management of IP), personnel management, balancing technology maturation and commercial activities, managing relations with external stakeholders, etc. as well as to ensure the improvement of skills in different areas of information technologies with applications in earth observation, space technologies, including methods of application of the present space observations to examples of the best European practices.

See more details at https://www.gain-twinning.eu/?p=676

5.5. Web-based training on European innovation tools

The training (WP 4, Task 4.2) was organized online by EXOLAUNCH on January 21, 2023. The webinar was attended by 21 persons, including tenure-trackers, young researchers and the management from MICM and GTU. The title of presentation was "Stay ahead in R&D – IPR issues within HEP[9] projects". Technology transfer and IPR topics relevant to HEP projects were described and their importance in research was stressed. Several examples of successful European start-up projects were given.

5.6. The first innovation training workshop for researchers and managers

The training (WP 4, Task 4.1) was organized by EXOLAUNCH at MICM, Tbilisi, Georgia, January 16, 2024. The topic of the workshop was "Competitive RTD proposal writing" and the workshop was aimed at building research fundraising capacity at MICM. The workshop was attended by 24 persons, including tenure-trackers, young researchers and the management of MICM and GTU.

A complete report of the training workshops and webinars of WP 4 will be given in deliverable D 4. 1 at the end of March 2024.

5.7. GAIN Workshop at ACII 2024

In the context of sub-task 1 (EEG-based emotion recognition), young Georgian researchers (N. Kukhilava, T. Tsmindashvili) as well as researchers from DFKI (P. Müller, B. E. Wirth) and INRIA (L. Ferrari, F. Bremond) have submitted a GAIN Workshop proposal entitled "EmoRec EEG: Generalizability of Emotion Recognition from EEG signals" to the International Conference on Affective Computing and Intelligent Interaction (ACII) 2024.

The proposal was accepted. The workshop, which will take place on 15 September 2024, announced a challenge with the goal to maximise emotion recognition accuracy across the six most used datasets in

[9] Horizon Europe Programme.

the field in order to foster comparability and generalizability of EEG-based emotion recognition approaches.

6. INSTITUTIONAL KPIs OF MICM

According the DoA of the project, Institutional Key Performance Indicators (KPI) are set out to monitor the evolution of MICM capacities.

6.1. International project proposals

MICM was invited to be a member of the EDU AI consortium. Researchers Proposal # 101120027, Call: HORIZON-CL4-2022-HUMAN-02, was submitted on November 15, 2022, but was not accepted for funding. In this project, MICM would have played the role of a quality assurance provider (internal).

6.2. Conferences and workshops organized at MICM

During the reporting period, 1 scientific conference and 6 research seminars with invited speakers have been organized at MICM (see Appendix). Additionally, at 4 departments of MICM local weekly seminars take place.

The summary of the research results achieved at MICM during the reporting period (2023) is given in Table 1, Appendix. Table 2 in the Appendix reflects the progress of research, which is supported directly by the GAIN project. Diagram 1 in the Appendix shows the dynamics of growth of research performance indicators of MICM in 2023 with respect to 2022.

7. APPENDIX.

All publications, conference talks and presentations contain references to the European Union and the GAIN project and all relevant acknowledgements[10].

7.1. Publications

1. **Philipp Müller, Michal Balazia** et. Al. MultiMediate'23: Engagement Estimation and Bodily Behaviour Recognition in Social Interactions. 10.1145/3581783.3613851, https://arxiv.org/pdf/2308.08256.pdf
2. **T. Saghinadze**. Constructing Convolutional Neural Networks with 90 Degree Rotational Equivariance and Invariance. Georgian Electronic Scientific Journal: Computer Science and Telecommunications 2023|No.1(63), p. 39 – 43. ISSN 1512-1232. https://gesj.internet-academy.org.ge/en/list_artic_en.php?b_sec=comp

[10] The authors with bold letters are GAIN consortium members.

3. S. Chobanyan, L. Chobanyan, Z. Gorgadze and **G. Ghlonti**. An Algorithm for Finding a Near-Optimal Rearrangement in the Steinitz Functional. Bulletin of TICMI. Vol. 27, No. 1, 2023, 21–27. http://www.viam.science.tsu.ge/others/ticmi/blt/vol27_1/3.pdf
4. N. Abzianidze, N. Dogonadze, **G. Ghlonti**, Z. Kipshidze. About knowledge delivery strategies for intelligent tutoring systems in mathematics and computer science. Bulletin of TICMI. Vol. 27, No. 1, 2023, 29–37, ISSN 1512-0082 http://www.viam.science.tsu.ge/others/ticmi/blt/vol27_1/4.pdf
5. **V. Kvaratskhelia, G. Giorgobiani, M. Menteshashvili.** On one connection between the moments of random variables. Computer Science and Information Technologies CSIT 2023, September 25 - 30, 2023, Yerevan, Armenia. Book of abstracts https://csit.am/2023/proceedings/DMCA/DMCA_5.pdf
6. G. Baghaturia, **M. Menteshashvili**. Application of general integral of quasi-linear equation to solving of non-linear Cauchy problem. Bulletin of TICMI. Vol. 27, No. 2, 2023, 59–65. ISSN 1512-0082. https://www.emis.de/journals/TICMI/vol27_2/2%20Bagaturia_Menteshashvili_23_TICMI.pdf
7. G. Chelidze, S. Chobanyan, **G. Giorgobiani**, V. Tarieladze. Trigonometric series and the permutation sign convergence condition. *Accepted for publication in Analysis Mathematica*.
8. **Kachiashvili K.J., Kachiashvili J.K., Kalandadze R. M., Kvaratskhelia V.V**. Automatic diagnosis of lung diseases (pneumonia, cancer) with given reliabilities on the basis of an irradiation images of patients. *Submitted to the journal "Cancer Investigation".*
9. **T. Agrawal.** Robust and Efficient Multimodal Multi-dataset Multitask Learning. Submitted to AAAI (Association for the Advancement of Artificial Intelligence), 2023.
10. **N. Kukhilava, T. Tsmindashvili, R. Kalandadze, L. Ferrari, V. Strizhkova**. Multimodal emotion recognition with physiological signals and video. *Prepared to submit*.
11. **T. Tsmindashvili, N. Kukhilava, S. Katamadze, R. Kalandadze, L. M. Ferrari, P. Müller, B. E. Wirth** Evaluation in EEG Emotion Recognition: State-of-the-Art Review and Unified Framework. *Prepared to submit*.
12. **G. Giorgobiani, V. Kvaratskheliaa, and M. Menteshashvili**. Unconditional Convergence of Sub-Gaussian Random Series. Pattern Recognition and Image Analysis, 2024, Vol. 34, No. 1, pp. 92–101.

7.2 Conference Talks

The conference talks are supported by the GAIN project. Presentations contain the logos of the EU and the GAIN project and all relevant acknowledgements.

1. **G. Giorgobiani, V. Kvaratskhelia, T. Saghinadze.** Mathematics of Artificial Intelligence. 2nd Int. Conf.: Science, Education, Innovations and Chemical Technologies – From Idea to Implementation. Tbilisi, Georgia, 23 – 24 November 2023. https://conference23iice.ge/
2. **N. Kukhilava, T. Tsmindashvili, R. Kalandadze, L. Ferrari, V. Strizhkova**. VideoMAE for Emotion Recognition. Second CERN-GTU collaboration meeting PMBC2023, 6 – 10 November 2023, GTU, Tbilisi, Georgia. https://indico.cern.ch/event/1334518/timetable/
3. **T. Tsmindashvili, N. Kukhilava, S. Katamadze, R. Kalandadze, L. M. Ferrari, P. Müller, B. E. Wirth**. Evaluation in EEG Emotion Recognition: State-of-the-Art Review and Unified Framework. Second CERN-GTU collaboration meeting PMBC2023, 6 – 10 November 2023, GTU, Tbilisi, Georgia. https://indico.cern.ch/event/1334518/timetable/

4. **S. Katamadze , T. Tsmindashvili, N. Kukhilava, R. Kalandadze, L. M. Ferrari, P. Müller, B. E. Wirth**. Enhancing Emotion Recognition: EEG Evaluation and AI Models. DataFest Tbilisi 2023. 9 – 11 November 2023, Tbilisi, Georgia. www.datafest.ge
5. M. Kublashvili, **Z. Sanikidze, T. Saghinadze**, M. Kublashvili. On the Mathematical Aspects of the Numerical Calculation of Engineering Constructions Weakened by Cracks. Second CERN-GTU collaboration meeting PMBC2023, 6 – 10 November 2023, GTU, Tbilisi, Georgia. https://indico.cern.ch/event/1334518/timetable/
6. M. Zakradze, **Z. Tabagari**. Numerical analysis of some problems related to the calculation of electrostatic fields. Second CERN-GTU collaboration meeting PMBC2023, 6 – 10 November 2023, GTU, Tbilisi, Georgia. https://indico.cern.ch/event/1334518/timetable/
7. **V. Kvaratskhelia, G. Giorgobiani, M. Menteshashvili.** On One Connection Between the Moments of Random Variables. Computer Science and Information Technologies CSIT 2023, September 25 - 30, 2023, Yerevan, Armenia. https://www.csit.am/2023/schedule.php
8. **Kachiashvili K., Kachiashvili J., Kalandadze R., Kvaratskhelia V**. Automatic Diagnosis of Lung Disease on the Basis of an X-Ray Images of a Patient with Given Reliability. XIII International Conference of the Georgian Mathematical Union, Batumi, September 4-9, 2023. p. 140. http://gmu.gtu.ge/conferences/wp-content/uploads/2023/09/Conference_GMU_2023_01.09.pdf
9. **Kachiashvili K., Kachiashvili J., Kalandadze R., Kvaratskhelia V**. Automatic Diagnosis of Diseases on the Basis of an Irradiation Images of a Patient with Restrictions Both Type of Errors. The 4th International Conference on Modern Management based on Big Data (MMBD2023), August 1-4, 2023, Seoul, South Korea. p. 19 http://www.mmbdconf.org/
10. **Kachiashvili K., Kachiashvili J., Kalandadze R., Kvaratskhelia V**. The automatization of the medical diagnosis on the basis of an X-ray image of a patient with the restrictions of both possible errors on the desired levels. The International Conference "Distributed Computing and Grid Technologies in Science and Education", 3-7 July, 2023, Dubna, Russia. JINR Meshcheryakov Laboratory of Information Technologies. https://indico.jinr.ru/event/3505/attachments/16120/27954/program_GRID2023.pdf
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12. **V. Kvaratskhelia, G. Giorgobiani, M. Menteshashvili.** On One Connection Between the Moments of Random Variables. Int. Conf. Applications of Stochastic Processes and Mathematical Statistics to Financial Economics and Social Sciences. November 15 –16, 2023, Tbilisi, Georgia
13. **V. Kvaratskhelia, G. Giorgobiani,** V. Tarieladze. Subgaussian Random Elements in Infinite Dimensional Spaces. XIII International Conference of the Georgian Mathematical Union. September 4 – 9, 2023, Batumi, Georgia. Book of Abstracts, p. 116. http://gmu.gtu.ge/conferences/wp-content/uploads/2023/10/Conference_GMU_2023_7.10_last.pdf
14. **V. Kvaratskhelia, G. Giorgobiani, M. Menteshashvili.** On One Connection Between the Moments of Random Variables. Ninth International Conference on Statistics for Twenty-first Century - 2023 (ICSTC-2023). 15-18 December 2023, Kerala University, India. https://sites.google.com/view/icstc2023/home

15. **V. Kvaratskhelia, G. Giorgobiani,** V. Tarieladze. Subgaussian Random Elements in Infinite Dimensional Spaces. The Fourth International Conference "Modern Problems in Applied Mathematics" dedicated to the 105th Anniversary of I. Javakhishvili Tbilisi State University (TSU) & 55th Anniversary of I. Vekua Institute of Applied Mathematics (VIAM). September 13-15, 2023, Tbilisi, Georgia.
16. **S. Katamadze, T. Tsmindashvili, N. Kukhilava, R. Kalandadze, L. M. Ferrari, P. Müller, B. E. Wirth**. Enhancing Emotion Recognition: EEG Evaluation and AI Models. Online I En, Data Zen Community. December 20, 2023, Tbilisi, Georgia. https://wearecommunity.io/events/enhancing-emotion-recognition-eeg-evaluation-and-ai-models
17. **S. Katamadze, T. Tsmindashvili, N. Kukhilava, R. Kalandadze, L. M. Ferrari, P. Müller, B. E. Wirth**. Enhancing Emotion Recognition: EEG Evaluation and AI Models. Online I Georgian language. March 22th, 2024, Tbilisi, Georgia. https://wearecommunity.io/events/enhancing-emotion-recognition-eeg-evaluation-and-ai-models-ge?utm_source=facebook&utm_medium=social&utm_campaign=ta?fbclid=IwAR0-mmpPbgQOhrvfV1T3y6awSz3Z9xFadOpKyYg0dS1k0M-rBYFcGai7cAM

7.3 Presentations at the First Summer School

1. Evaluation in EEG Emotion Recognition: State-of-the-Art Review and Unified Framework.
   Sub-task 1: AI Technologies for Human Behaviour Understanding, Emotions (face crop video, biosignals). Group 1: R. Kalandadze, N. Kukhilava, T. Tsmindashvili, S. Katamadze. Supervised by: F. Bremond, L. Ferrari (INRIA), P. Muller, B. Wirth (DFKI). Presented by R. Kalandadze and S. Katamadze.
2. The newest achievements of AI in Emotion Recognition from Human Body Movements. *Sub-task 2: AI Technologies for Human Behaviour Understanding, Emotions (full body video)*
   Group 2: I. Katchiasvhili, L. Tabagari. Supervised by: P. Muller, B. Wirth (DFKI). Presented by I. Kachashvili.
3. Exploring Image Captioning with Parameter-Efficient Transfer Learning for Vision Transformers. *Sub-task 3: Action detection/recognition (AI Technologies for Human Behaviour Understanding). Group 3: T. Saghinadze. Supervised by: F. Bremond, T. Agraval (INRIA). Presented by T. Saghinadze.*
4. Georgian Pretrained Language Understanding Model. *Sub-task 5: AI Methods for Deep Speech Analysis in Health, NLP. Group: B. Mikaberidze, B. Tepnadze. Supervised by: P. Muller, H. Lindsay (DFKI). Presented by B. Mikaberidze.*
5. Studying neural correlates of speech production using fMRI and NLP. *Sub-task 6: AI Methods for Deep Speech Analysis in Health - NLP-fMRI. Group 6: T. Giorgobiani, S. Tsagareishvili. Supervised by: P. Muller, H. Lindsay, B. Wirth (DFKI). Presented by T. Giorgobiani.*

7.4. List of conferences and seminars organized at MICM

1. *2022, December 21 – Scientific conference dedicated to the academician N. Vakhania.*
2. *2023, 14 February – Seminar "About Lothar Collatz (3n+1) problem". Speaker Dr. T. Jaoshvili.*
3. *2023, 21 February – Seminar "Universality of Rademacher series". Speaker Prof. S. Tetunashvili (GTU).*
4. *2023, 21 March – Seminar "Convergence and divergence of Fourier series with respect to the systems of compact group characters". Speaker Prof. G. Oniani (Kutaisi State University).*

5. *2023, 28 March – Seminar "Necessary and sufficient conditions of existence of a singular integral with Cauchy kernel. Speaker Dr. I. Machavariani.*
6. *2023, June 27 – Seminar "Real-time decision support with distributed contextual intelligence". Speaker Professor of Distributed Systems & Security at Deakin University, Melbourne, Australia, A. Zaslavky.*
7. *2023, December 5 – Seminar "The Set Ordering Method for Scoring the Outcomes of Testing in Computerized Adaptive Testing". Speaker Dr. S. Razmadze.*

7.5. Tables for the KPIs

Table 1. Institutional KPIs to monitor the evolution of MICM research capacities, 2023.

Number	Key Performance Indicators	Target for the end of project	Current
Scientific performance			
1	Number of peer-reviewed publications	25	31[11]
2	Number of peer-viewed publications per researcher	1	1.1[12]
3	Number of presentations at scientific conferences	30	45
4	Number of publications/presentations co-authored by young researchers	40	12
5	Number of scientific conferences, workshops, symposia organized	10	7
6	Number of MSc and PhD dissertations defended	5/3	N/A yet
7	Number of researchers affiliated with the Joint Virtual Laboratory	25	N/A yet
8	Number of international project proposals submitted/accepted	10/3	1/0
9	Combined h-index of MICM researchers (sum)	40	h=80 Scopus, h=148 google sch.

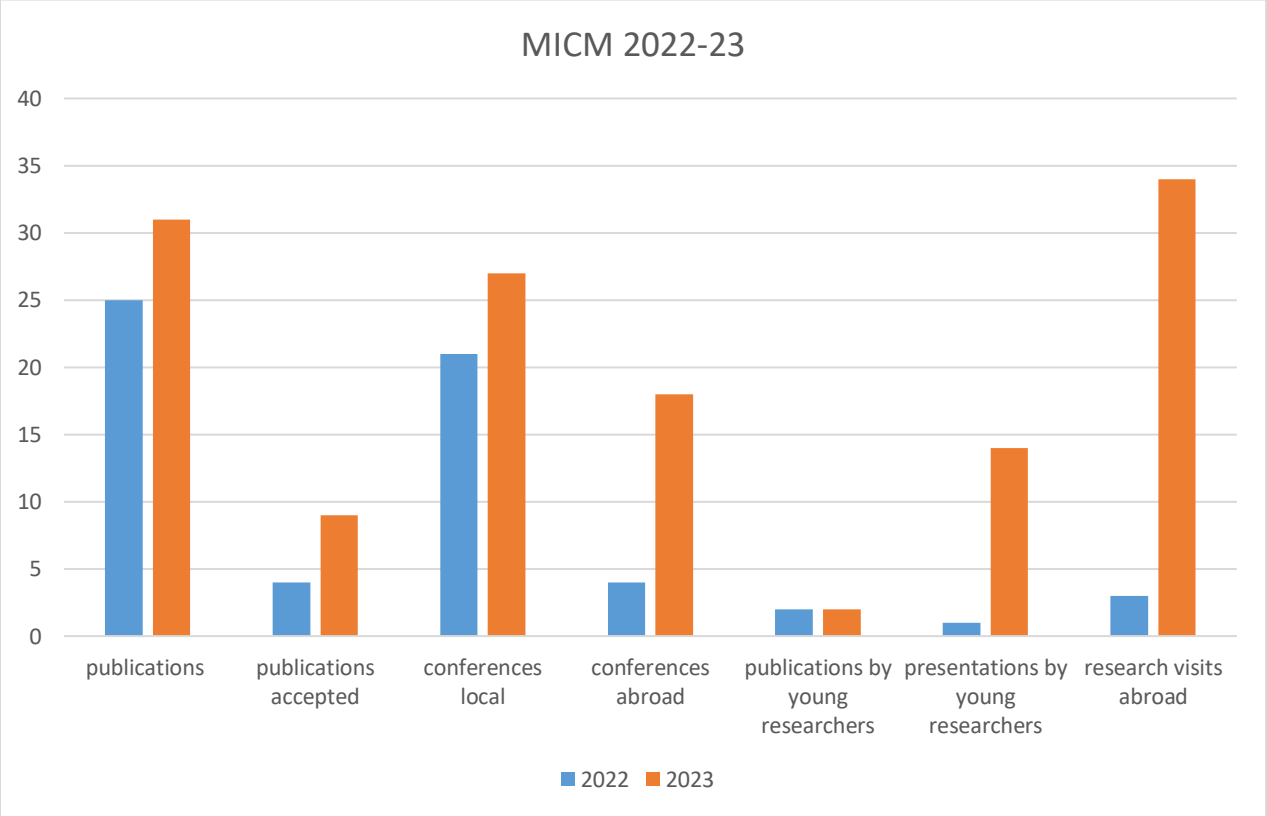
Table 2. KPIs (GAIN consortium), 2023.

No.	**Key Performance Indicator**	Target value	Current
1	Number of consortium staff members participated in the research mobility	60	38
2	Number of established contacts (research leads) with potential collaborators outside of the GAIN consortium	100	18
3	Number of committed strategic supporters (local and international)	10	N/A yet
4	Number of European organizations expressed interest to cooperate (LoI)	20	7
5	Number of research proposals where MICM is invited to participate	10	1

[11] In addition, 9 papers were accepted.
[12] There are 28 researchers at MICM.

6	Number of research events organized by the project	11	6
7	Number of research papers (non peer-reviewed/peer-viewed) published on the basis of results received through the TRIP implementation	45/25	1/5[13]
8	Number of PhD candidates submitted their theses under double supervision	3	N/A yet
9	Number of young researchers participated in the project activities and trained through the project	15	19
10	Number of presentations at scientific conferences	30	17

Diagram 1. Dynamics of growth of research performance indicators of MICM.



[13] In addition, 2 papers were accepted, 1 – submitted, 3 prepared for submission.