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FAAI:
The Future is in Applied Artificial Intelligence
Erasmus+ project 2022-1-PL01-KA220-HED-000088359

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# Research 3: Survey of scientific projects in applied AI:

## the state-of-the-art analysis for WP2


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**Date**
13.05.2023

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**Summary:** The questionnaires about 63 projects collected by partner organizations from the 5 countries were collected and analyzed, concerning artificial intelligence teaching. The project coordinators were from 19 countries. Among the more interesting results belongs the finding, that more than half of the projects concerned deep neural networks learning modules, and most machine learning tasks which were solved, were image processing, classification, regression, clusterization and natural language processing. Among the used AI libraries dominated TensorFlow, Keras, scikit-learn and CUDA. The programming languages were Python and C++.
Most of the answers were analyzed and visualized in a form of graphs.

**Keywords:** AI projects, questionnaire results, recommendations

## 1. Introduction

The questionnaire was a part of the research in connection with the objectives of project 2022-1-PL01-KA220-HED-000088359 "The Future is in Applied Artificial Intelligence" (FAAI) under the Erasmus + program. This project aims to join together Universities, and businesses and provide innovative solutions to develop AI experts. The questions in this study was aimed to research the needs and expectations of scientific projects to propose training specialists in the field of Applied AI. The respondents had to fill in the fields about their experience and opinions concerning Applied AI. Less than half of the fields were mandatory (eight of twenty one), which is shown by an asterisk following the question. However, respondents filled in practically most the non-mandatory fields as well. The project site is: http://faai.ath.edu.pl/

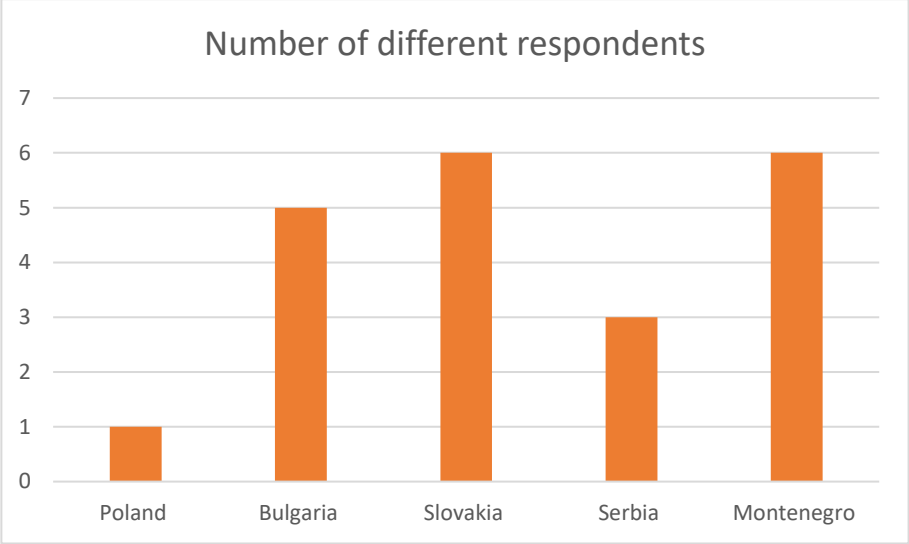
## 2. Collection and analysis of data

The data was acquired by five partner institutions academics and their colleagues from other institutions.
In total 63 questionnaires were collected. In research 11 (17.46%) questionnaires from Polish respondents (1 respondent), 21 (33.33%) questionnaires were obtained from Bulgarian respondents (5 different respondents), 10 (15.87%) from Slovak respondents (6 different respondents), 11 (17.46%) from Serbian respondents (3 different respondents), and 10 (15.87%) from the Montenegro (6 different respondents). In total the number of different respondents was 21.

## 3. Results

### 3.1. E-mail of the respondents

The first question of the survey asks the emails of the respondents. All five project participant countries were analyzed. The numbers of 63 questionnaires were filled in by 21 respondents distributed as follows: Poland 1 / 21 (4.76%), Bulgaria 5 / 21 (23.81%), Slovakia 6 / 21 (28.6%), Serbia 3 / 21 (14.28%), Montenegro 6 / 21 (28.6%). The results are presented below.




**Data description:**
According to the research data, respondents from Slovakia and Montenegro were most diversified.

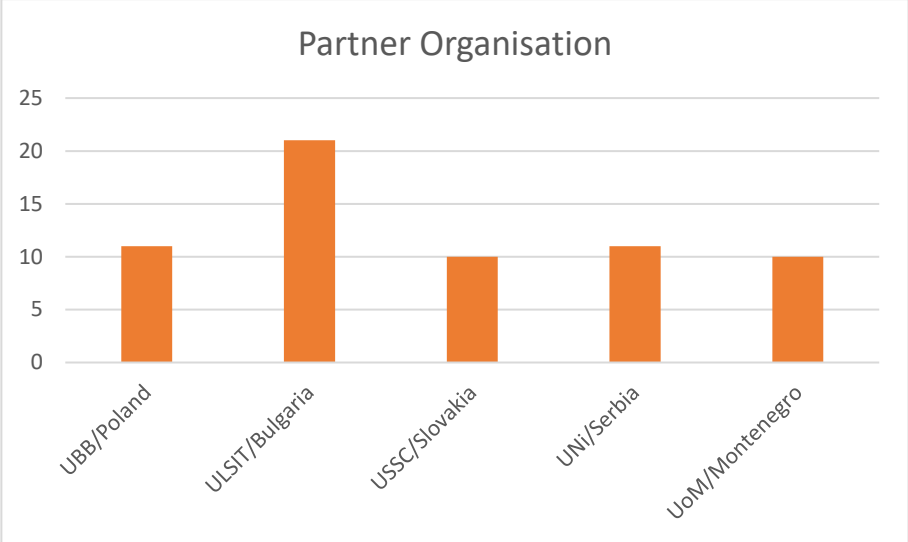
**Discussion:**
While it is preferable to have diverse respondents to ensure broad coverage of the area, it has also disadvantages, like when the answer to the question "What existing scientific program in the field of Artificial Intelligence …" was Yes in the questionnaire. A smaller number of dedicated respondents reduces the number of nonsensical answers to a minimum.

**Main conclusions:**

- Even though the Bulgaria got most answers (see the next graph), the questionnaires from Montenegro and Slovakia were of more diverse origins, therefore reduced bias in the research, which should increase the generalizability of the research findings.

### 3.2. Partner Organization

The second question of the survey asks where the respondents come from. All five project participants' countries were analyzed. The numbers of 63 questionnaires were distributed as follows: UBB/Poland 11 / 63 (17.46%), ULSIT/Bulgaria 21 / 63 (33.33%), UCM/Slovakia 10 / 63 (15.87%), UNi/Serbia 11 / 63 (17.46%), UoM/Montenegro 10 / 63 (15.87%). The results are presented below.




**Data description:**
According to the research data, Bulgaria provided twice as many respondents as the other partner organizations.

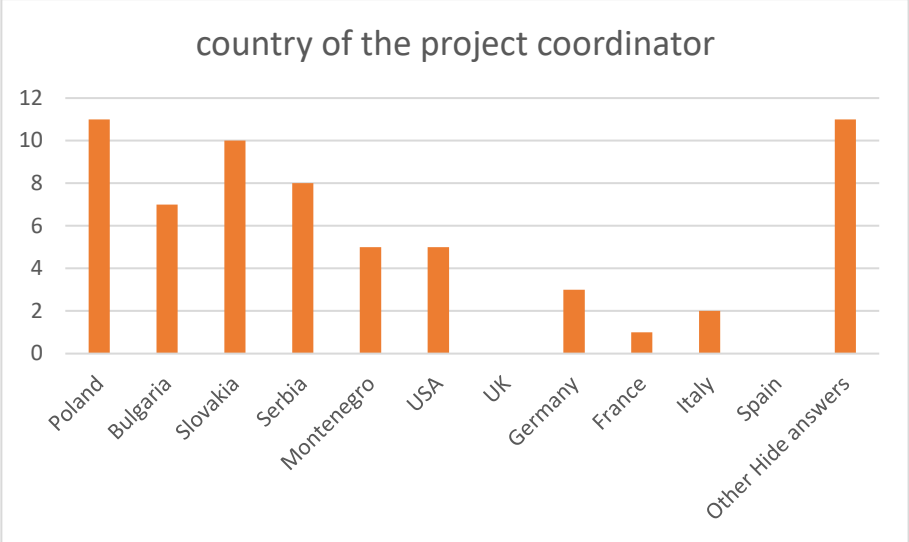
**Discussion:**
When the number of inhabitants is taken into account, the UoM/Montengro in relative terms provided most answers.

**Main conclusions:**

- Even though the Bulgaria got most answers, the Montenegro gets relatively most influence on inhabitant.

### 3.3. What is the country of the project coordinator?

The third question of the survey asks where the project coordinators come from. All countries were analyzed. The numbers of 63 questionnaires were distributed as follows: Poland 11 / 63 (17.46%), Bulgaria 7 / 63 (11.11%), Slovakia 10 / 63 (15.87%), Serbia 8 / 63 (12.7%), Montenegro 5 / 63 (7.94%), USA 5 / 63 (7.94%), UK 0 / 63 (0%), Germany 3 / 63 (4.76%), France 1 / 63 (1.59%), Italy 2/ 63 (3.17%), Spain 0 / 63 (0%), Other 11 / 63 (17.46%). The Other answer included countries Italy, Estonia, Ireland, Switzerland, Greece, Norway, Portugal, Greece, Ireland, India, - unspecified. The results are presented below.




**Data description:**
According to the research data, Poland provided most projects coordinators.

**Discussion:**
Again, when the number of inhabitants is taken into account, the Montengro in relative terms provided most of projects coordinators.

**Main conclusions:**

- Relatively many countries were included with just one project coordinator, the coverage across the globe was therefore relatively good, even though the participating countries provided most coordinators.

### 3.4. What existing scientific program in the field of Artificial Intelligence was found?

The fourth question of the survey asks the basis, where the project came from. Unfortunately, the question was not clear to many respondents, so the answers ranged from “yes”, “deep learning”, “NA”, email address, up to the name of the project. The actual source of support was mentioned only in 22 of 63 questionnaires, where most, 8 answers came from Polish NCN (National Science Centre), followed by 4 cases of Erasmus and 3 cases of Polish Smart Growth Operational Programme. Since most of the answers were not relevant, the answes were not analyzedt deeper.

### 3.5. Name of the project

The fifth question of the survey provided the following 63 answers:
Digital audio watermarking

Visual inspection of complex mechanical assemblies based on Siamese networks for 3D point clouds
Practical machine learning training
Audio-visual object classification and sound event recognition by unsupervised co-training
Smart Products and Services Engineering (SPaSE)
Advanced Data Analytics in Business – ADA,
Implementation of modern methods of Intelligent control within the study module Control Systems
ECVET Training for Operators of IoT-enabled Smart Buildings
AgAR - Universal agriculture autonomous robot
Development of new information and communication technologies using advanced mathematical technologies, with applications in medicine, energy, e-government, telecommunications and protection of national heritage
ATUVIS - Autonomous Trains Undercarriage Visual Inspection System
Curricula innovation in climate-smart urban development based on green and energy efficiency with the non-academic sector (SmartWB)
SMART-Smart Automation of Rail Transport
SMART2-Advanced integrated obstacle and track intrusion detection system for smart automation of rail transport
RoboShepherd - automated animal husbandry and grazing system
Improving license plate detection and recognition systems using deep learning.
Fake News Detector
Deep Learning for Image Classification in Python with CNN
Self-driving cars
Clearview AI
Platform for Situated Intelligence
Artificial Nose
CoModGAN: AI-Powered Image Completion
Efficient Face Recognition Using Regularized Adaptive Non-Local Sparse Coding
The Body Positioning System: A GPS for somatosensory space
AI4DI
ChemLife
ARISE
INSENSION
ChipAI
VIDEO CLASSIFICATION USING DEEP LEARNING TECHNIQUE
TRAFFIC ACCIDENT EVENT PREDICTION IN TRAFFIC VIDEO USING DEEP LEARNING
IMAGE CAPTION GENERATION USING DEEP LEARNING TECHNIQUE
SMARTFISH
HERON
Project No. BG05M2OP001-1.002-0023 - Competence Center "Intelligent mechatronic, eco- and energy-saving systems and technologies
"50. Project № 777720 of EC H2020 Cyber-Physical Systems for PEdagogical Rehabilitation in Special EDucation (CybSPEED)"
Predictive allocation of edge computing resources for autonomous driving
Advanced feature selection methods for high dimensional data

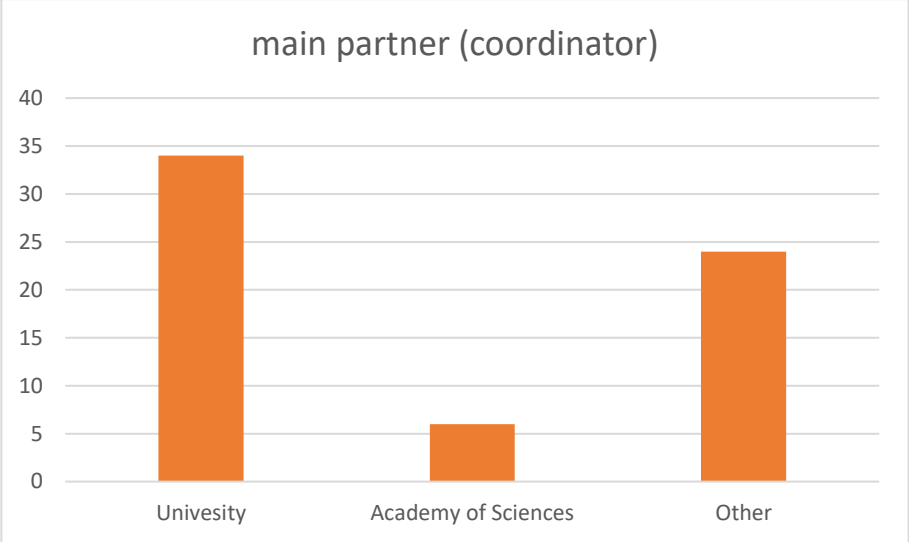
Intelligent Management of 5G Mobile Network based on the Comprehensive Learning with deep learning
INLINE EVALUATION OF LI-ION BATERY ELECTROD POROSITY USING MACHINE LEARNING ALGORITHMS
ANALYSIS OF ENVIRONMENTAL INFLUENCES ON POWER INDUSTRY EQUIPMENT BY THE METHODS OF ARTIFICIAL INTELLIGENCE AND CLOUD COMPUTING (ARIEN)
Agent based modeling of the spectrum distribution in the cognitive radio networks
INTELLIGENT CLOUD WORKFLOW MANAGEMENT FOR DYNAMIC METRIC- OPTIMIZED APPLICATION DEPLOYMENT (ICONTROL)
Intelligent Dynamic Spectrum Access Management for the Future Cognitive Communication Networks
DisAI: Improving scientific excellence of KInIT in AI and language technologies to fight disinformation
AI4Europe: The unified platform for boosting European AI academic and industrial research
CAPABLE
Nethone ATO - artificial intelligence, biometrics and advanced profiling for innovative protection of user accounts in electronic banking
Data Fund 1 - seed fund specialized in big data technology with main areas of interest: financial industry (fintech), IT security, technology, SaaS, Internet of Things, Artificial Intelligence
Artificial intelligence in podology research to improve patient treatment processes
Applications of deep and recurrent neural networks in acoustic modeling of speech
Deep extraction for robust speech recognition
Artificial Intelligence meets Asymmetric Catalysis: a new pathway for catalyst optimization and discovery
HOMER: Human Oriented autoMated machinE leaRning
Infinity in reasoning about data and knowledge
Hypernetworks methods in Meta-Learning
Deep Self-Organizing Neural Graphs
BonsAPPs
AI-on-Demand Platform
Robotics4EU - Robotics with and for Society – Boosting Widespread Adoption of Robotics in Europe
XMANAI - Explainable Manufacturing Artificial Intelligence
REGULAITE

**Main conclusions**
Their analysis provides the following answers:
***Most recurring topics are:***
Deep Learning: several projects focus on image and speech recognition, object classification, image completion, license plate detection and recognition, and traffic accident prediction using deep learning techniques.
Intelligent Systems: many projects aim to develop intelligent systems, such as autonomous robots for agriculture and animal husbandry, GPS for somatosensory space, smart products and services engineering, smart automation of rail transport,

cloud workflow management, and dynamic spectrum access management for cognitive communication networks.
Machine Learning: some projects are related to practical machine learning training, data analytics in business, and allocation of edge computing resources for autonomous driving.
Artificial Intelligence (AI): there are several projects focused on AI, such as artificial intelligence in podology research, AI for language technologies, and a unified platform for boosting European AI academic and industrial research. Unfortunately, no closer description of the actual AI methods was specified.
Computer Vision: projects related to computer vision include visual inspection of mechanical assemblies based on Siamese networks for 3D point clouds and video classification using deep learning techniques.
IoT and Smart Buildings: some projects are related to the development of IoT-enabled smart buildings, ECVET training for operators of IoT-enabled smart buildings, and competence center for intelligent mechatronic, eco- and energy-saving systems and technologies.
Speech Recognition: some projects focus on speech recognition, such as applications of deep and recurrent neural networks in acoustic modeling of speech, and deep extraction for robust speech recognition.
Agent-Based Modeling: one project uses agent-based modeling for the spectrum distribution in cognitive radio networks.
Cloud Computing: cloud computing is used in some projects for cloud workflow management and analysis of environmental influences on power industry equipment.

### 3.6. Who is the main partner (coordinator) in this scientific program? Name of company, community, state organisation or scientific organisation, University?

The sixth question of the survey asks about the name of the main coordinator. The numbers of 63 questionnaires were distributed as follows: Univesity 34, Academy of Sciences 6, Other 24. The results are presented below.




**Data description:**
According to the research data, universities or faculties provided most projects coordinators, followed by various institutes and companies.

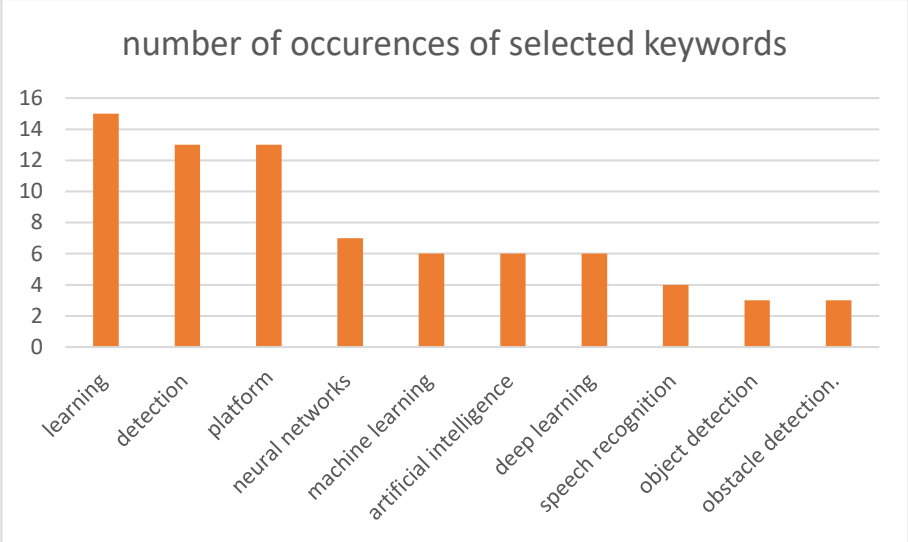
**Discussion:**
Since the respondents were from universities, it is logical, that main coordinator of most projects came from universities, the results might be different, when the companies would provide answers.

**Main conclusions:**

- The participating companies were quite diverse, only Microsoft was mentioned more times (3 times), other participating companies ranged from Massachusetts General Hospital to FBI.

### 3.7. Goal of the project

The seventh question of the survey asks about the goal of the project. The goals of 63 questionnaires provided mostly the following topics from the word count:
15 (1%) learning
13 (1%) detection
13 (1%) platform
7 (2%) neural networks
6 (2%) machine learning
6 (2%) artificial intelligence
6 (2%) deep learning
4 (1%) speech recognition
3 (1%) object detection
3 (1%) obstacle detection.




**Data description:**
From the detailed description of goals, the above keywords are most frequent.

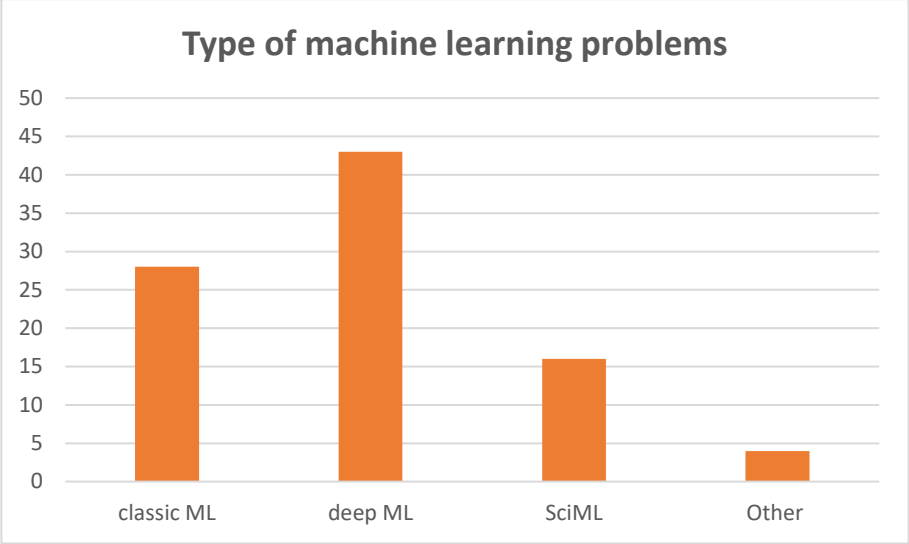
**Discussion:**
From the methods, deep learning is most frequent, popular goals include speech recognition, object detection and obstacle detection..

**Main conclusions:**

- Many projects are concerned about developing a platform for further use, but most direct applications involve machine learning, namely deep neural networks, mostly for problems concerning a visual processing and robotics problems.

### 3.8. Type of machine learning problems

The eighth question of the survey asks about type of machine learning problems. The numbers of 63 questionnaires were distributed as follows: classic ML 28/59 (47.46%), deep ML 43 / 59 (72.88%), SciML 16 / 59 (27.12%), Other 4 / 59 (6.78%). The Other answer included 2 n/a, 1 Explainable AI and 1 Artificial Neural Network (ANN). The results are presented below.




**Data description:**
According to the research data, 59 from 64 projects involve machine learning.

**Discussion:**
Nearly two thirds of the projects use deep machine learning. Since SciML can include also neural networks, the involvement of neural networks in the projects is even higher.

**Main conclusions:**

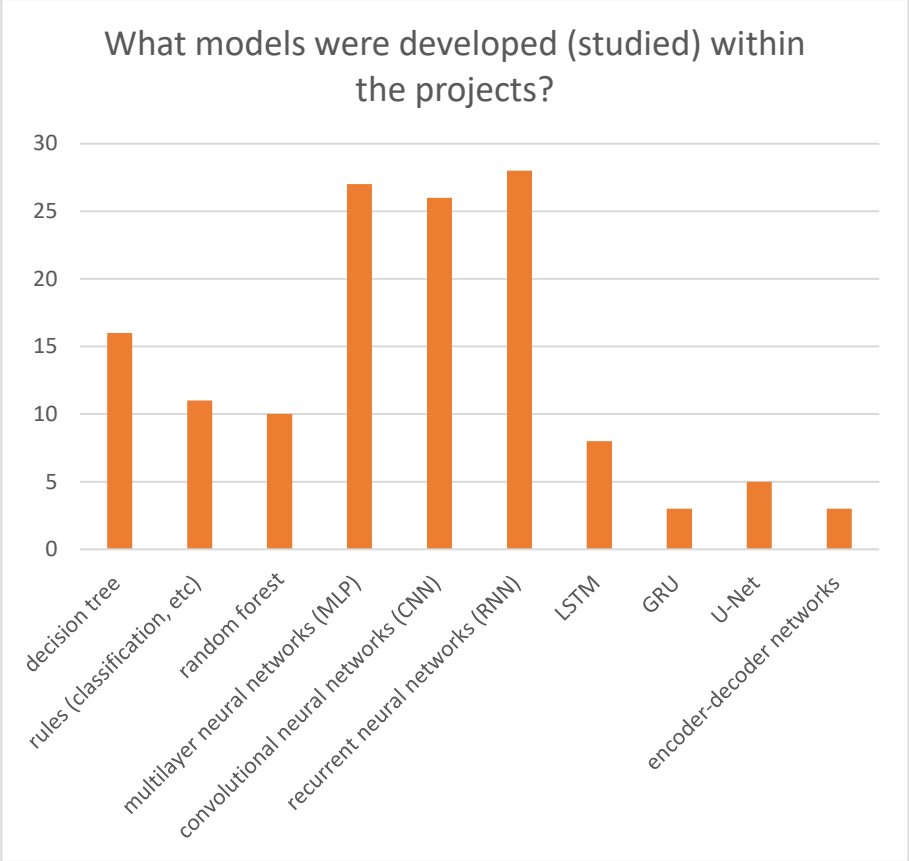
- Machine learning, namely deep neural networks, dominate the projects.

### 3.9. What models were developed (studied) within the projects?

The ninth question of the survey asks about the models. From the number of 63 questionnaires 53 contained the following machine learning methods:

1. decision tree 16 / 53 (30.19%)
2. rules (classification, associating, etc) 11 / 53 (20.75%)
3. random forest 10 / 53 (18.87%)
4. multilayer neural networks (MLP) 27 / 53 (50.94%)
5. convolutional neural networks (CNN) 26 / 53 (49.06%)
6. recurrent neural networks (RNN) 28 / 53 (52.83%)
7. LSTM 8 / 53 (15.09%)
8. GRU 3 / 53 (5.66%)
9. U-Net 5 / 53 (9.43%)
10. encoder-decoder networks 3 / 53 (5.66%)

The results are presented below.




**Data description:**
According to the research data, 53 from 64 projects involve one of the selected machine learning methods, where 37 contained rules and tree based decisions, while majority contained some kind of networks, mostly multilayer, convolutional and recurrent.

**Discussion:**
From the numbers is clear, that most of the projects used more than two methods.

**Main conclusions:**

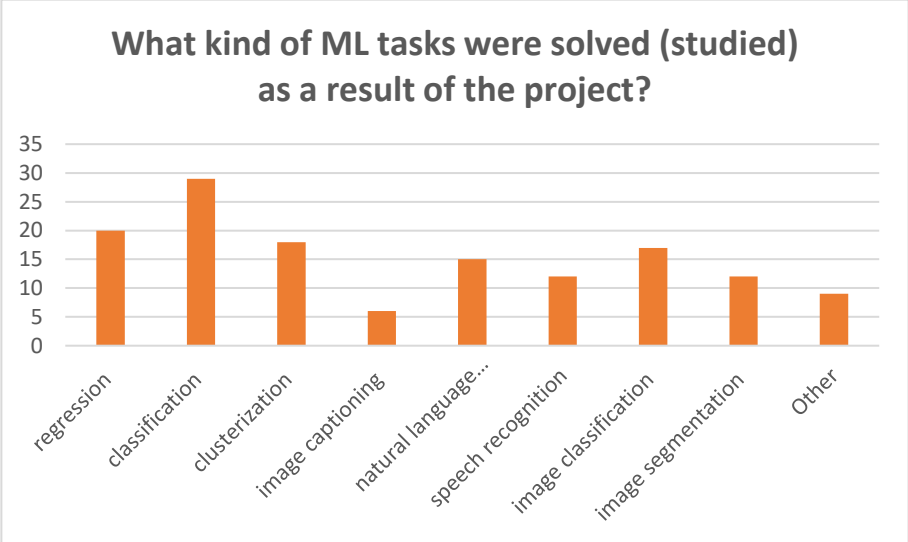
- Typically, projects do not use just one machine learning method.

### 3.10. What kind of ML tasks were solved (studied) as a result of the project?

The tenth question of the survey asks about the ML tasks. From the number of 63 questionnaires 55 were concerned with the following ML tasks:
1. regression 20 / 55 (36.36%)

2. classification 29 / 55 (52.73%)
3. clusterization 18 / 55 (32.73%)
4. image captioning 6 / 55 (10.91%)
5. natural language processing 15 / 55 (27.27%)
6. speech recognition 12 / 55 (21.82%)
7. image classification 17 / 55 (30.91%)
8. image segmentation 12 / 55 (21.82%)
9. Other 9 / 55 (16.36%)

The Other include object detection in images, AI-guided design and subsequent experimental validation, predicting the evolution trajectory of the user's behavioral profile over time, sensing interface installed both to the robotic platform and to the Road Infrastructures, Analog crossbar arrays enable power efficient synaptic signal processing with linear scaling on neural network size, Body Positioning System (BPS), 3D point cloud classification, and twice N/A.
The results are presented below.




**Data description:**
According to the research data, 55 from 64 projects involve one of the selected machine learning tasks, mostly more than two tasks were involved.

**Discussion:**
From the numbers is clear, that most of the projects used more than two methods.

**Main conclusions:**

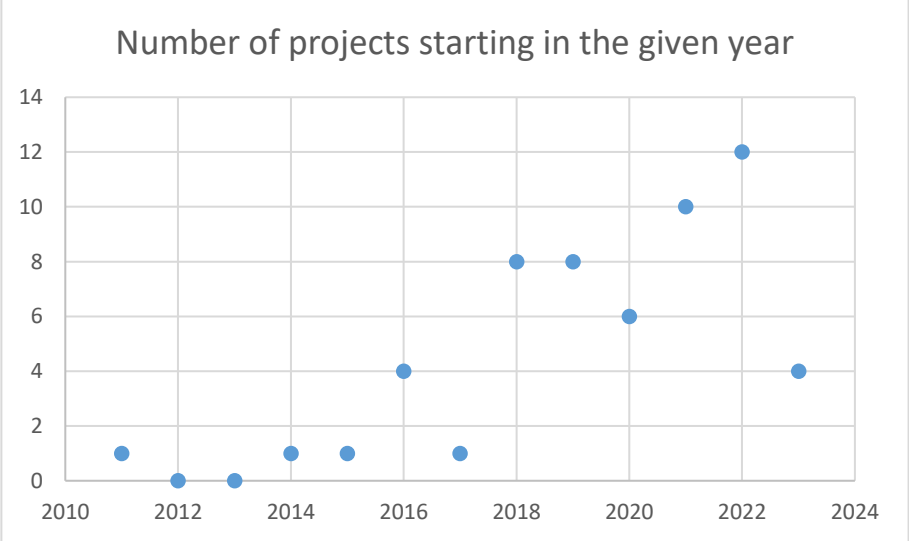
- Classification, regression, clustering, language and image tasks were solved.

### 3.11. Start of the project

The eleventh question of the survey asks about the start of the project. From the number of 63 questionnaires 56 provided these data:

| Year | Number of projects |
|---|---|
| 2023 | 4 |
| 2022 | 12 |
| 2021 | 10 |
| 2020 | 6 |
| 2019 | 8 |
| 2018 | 8 |
| 2017 | 1 |
| 2016 | 4 |
| 2015 | 1 |
| 2014 | 1 |
| 2013 | 0 |
| 2012 | 0 |
| 2011 | 1 |

The results are presented below.




**Data description:**
According to the research data, 46 from 56 projects started in the last 5 years.

**Discussion:**
The projects from questionnaires are fairly new.

**Main conclusions:**

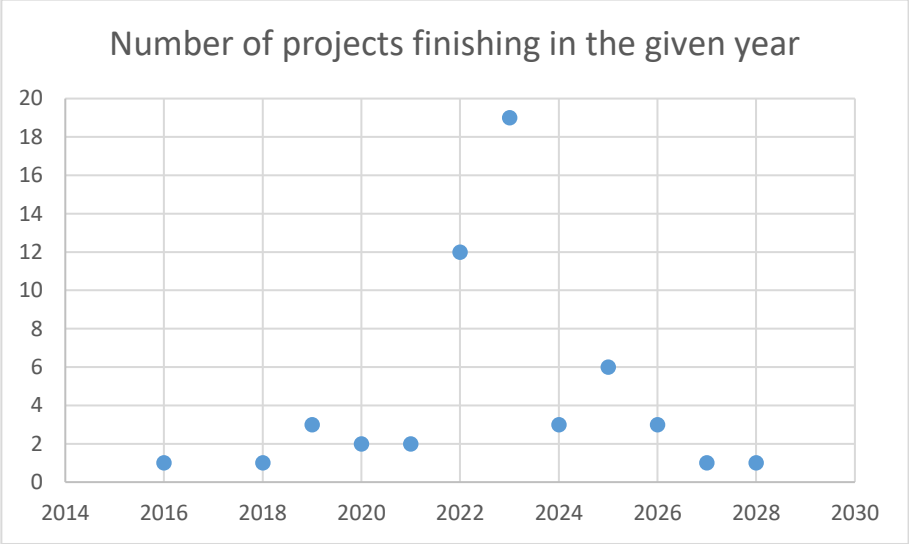
- The questionnaires were describing relevant new projects.

### 3.12. End of the project

The eleventh question of the survey asks about the end of the project. From the number of 63 questionnaires 56 provided these data:

| Year | Number of projects |
|---|---|
| 2016 | 1 |
| 2018 | 1 |
| 2019 | 3 |
| 2020 | 2 |
| 2021 | 2 |
| 2022 | 12 |
| 2023 | 19 |
| 2024 | 3 |
| 2025 | 6 |
| 2026 | 3 |
| 2027 | 1 |
| 2028 | 1 |

The results are presented below.




**Data description:**
According to the research data, 21 from 56 projects alredy ended.

**Discussion:**
The projects from questionnaires are mostly not yet finished.

**Main conclusions:**

- The questionnaires were describing mostly still running projects.

### 3.13. Hyperlink to the organization

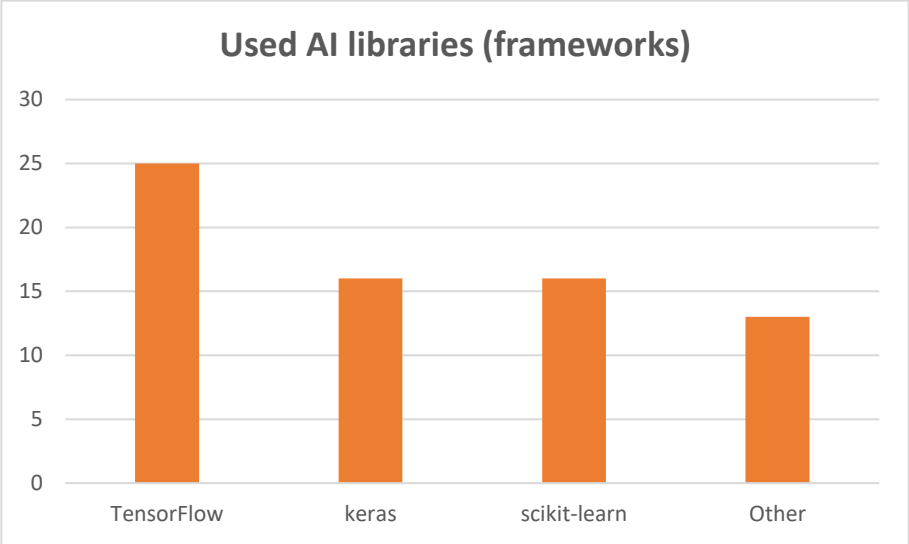
From the number of 63 questionnaires 51 provided the hyperlink to the organization.

**3. 14. Hyperlink to the project**
From the number of 63 questionnaires 54 provided the hyperlink to the project.

**3. 15. Achieved results of the project**
From the number of 63 questionnaires 52 provided descriptions of the achieved results. However, since most of the projects were not yet finished, the achieved results involved mostly published papers or descriptions of improvement. No patent or working solution on industrial level was mentioned.

**3.16. Used AI libraries (frameworks)**

The 16th question of the survey asks about the used AI libraries. From the number of 63 questionnaires 48 provided the answer: TensorFlow 25 / 48 (52.08%), keras 16/ 48 (33.33%), scikit-learn 16 / 48 (33.33%), Other 13 / 48 (27.08%). The Other involved 4x CUDA, once Pytorch, Open source Computer Vision (OpenCV) library, and open3D, and 6x N/A.
The results are presented below.



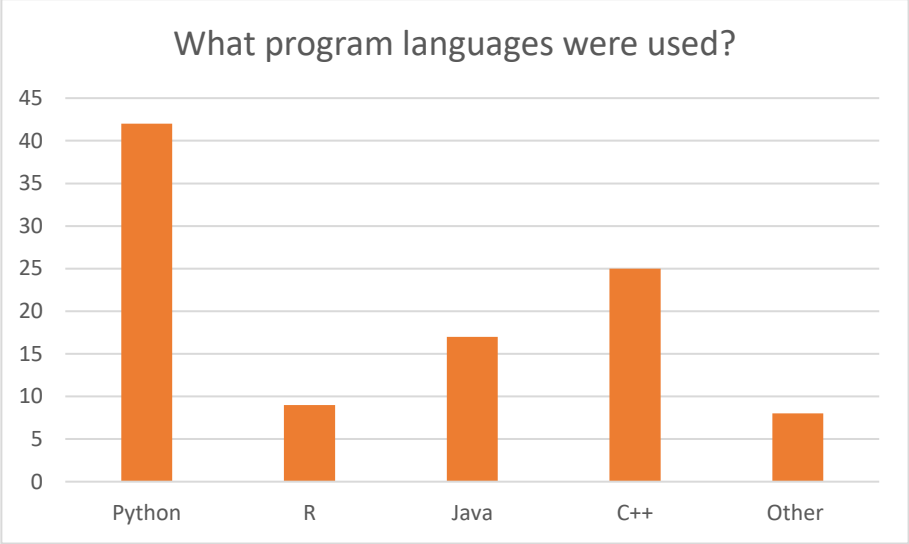

**Data description:**
According to the research data, TensorFlow is most popular.

**Discussion:**
From the 48 answers, 42 used open software, the remaining were not specified..

**Main conclusions:**
- Most of the cases use open software libraries.

**3.17. What program languages were used?**

The 17th question of the survey asks about the used programming languages. From the number of 63 questionnaires 52 provided the answer: Python 42 / 52 (80.77%), R 9 / 52 (17.31%), Java 17 / 52 (32.69%), C++ 25 / 52 (48.08%), Other 8 / 52 (15.38%). The Other involved JavaScript, JSON, C, LabView G, ROS, and 3 x N/A.
The results are presented below.




**Data description:**
According to the research data, Python is most popular, followed by C++.

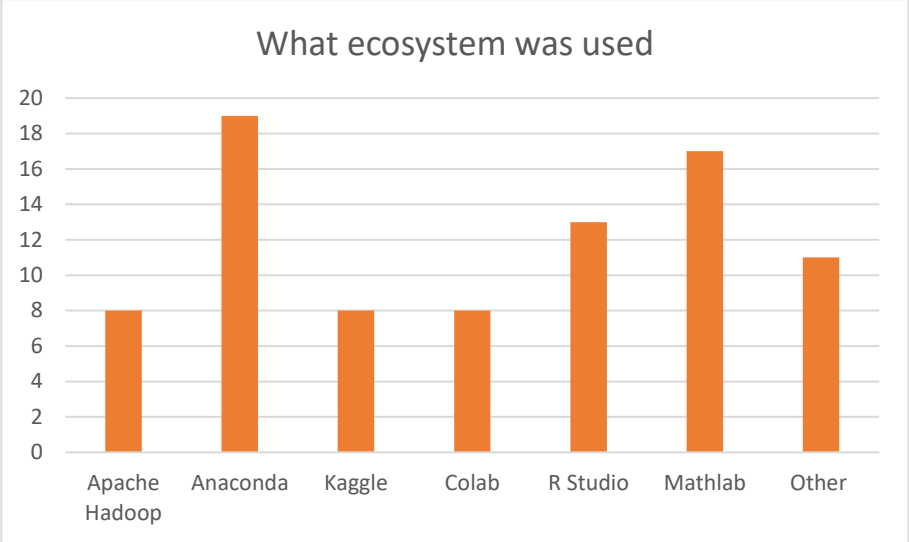
**Discussion:**
From the 52 answers, 42 used Python, however, many times more than one language was used.

**Main conclusions:**

- Python is most popular.

### 3.18. What ecosystem was used?

The 18th question of the survey asks about the used ecosystem. From the number of 63 questionnaires 49 provided the answer: Apache Hadoop 8 / 49 (16.33%), Anaconda 19 / 49 (38.78%), Kaggle 8 / 49 (16.33%), Colab 8 / 49 (16.33%), R Studio 13 / 49 (26.53%), Mathlab17 / 49 (34.69%), Other 11 / 49 (22.45%). The Other involved Node-RED, CUDA, OpenModelica, LabView, 2x ROS, 5 x N/A.
The results are presented below.



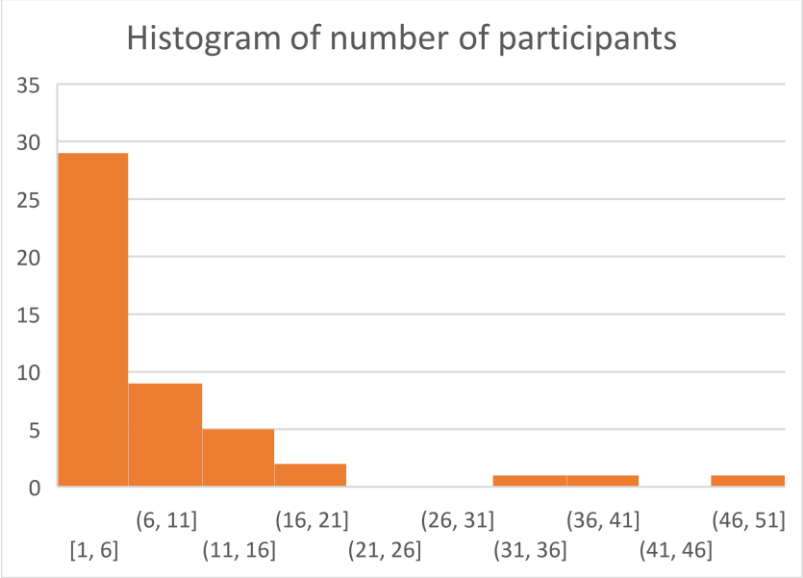

**Data description:**
According to the research data, Anaconda is most popular, followed by Matlab.

**Discussion:**
From the 49 answers, 19 used Anaconda, however, many times more than one ecosystem was used.

**Main conclusions:**
- Anaconda is most popular.

### 3.19. Number of participants in the project

The 19th question of the survey asks about the number of participants. From the number of 63 questionnaires 48 provided the answer. The histogram is presented below.




**Data description:**
According to the research data, most projects have 1-6 participants.

**Discussion:**
Small projects are most popular.

**Main conclusions:**

- 10 of the projects have just one participant, on the other hand, one project has 50 participants.

**20. Names and link for each partner in the project**
From the number of 63 questionnaires 46 provided the names and links of partners.

**21. GDPR: By completing and submitting this form, you confirm that you have reached the age of 18 and agree that the personal data (email) provided by you through the form will be processed in connection with the objectives of the project 2022-1-PL01-KA220-HED-000088359 "The Future is in Applied Artificial Intelligence" (FAAI) under the Erasmus + program. ***
From the number of 63 questionnaires, all aggreed.

## 4. Conclusions

In the field of artificial intelligence, it is crucial to analyze the competencies, hard skills, and soft skills that students should possess to succeed in this rapidly evolving industry. One important aspect of this analysis is the content of the learning modules, which should be designed to reflect the most prominent areas of machine learning that are currently in demand in the job market.

Based on the analysis of projects questionnaires that has been undertaken, it is evident that a significant proportion of the content of AI training should be devoted to deep neural network learning topics. Therefore, instructors should allocate around half of the course content to this area to ensure that students have a solid understanding of this critical aspect of machine learning.

Additionally, the projects were heavily focused on machine learning problems, particularly in image processing, classification, regression, clusterization, and natural language processing. As such, students should be oriented towards these areas to ensure they are equipped with the necessary skills to tackle real-world challenges in the industry.

It is also worth noting that knowledge representation and reasoning, planning and search strategies, expert systems, and fuzzy logic were not mentioned in the projects. Therefore, instructors should not devote much time to presenting these areas to students, and their applications should be minimized in the course content.

Furthermore, the AI libraries that were used in the projects were primarily open source, including TensorFlow, Keras, scikit-learn, and CUDA. Hence, students should not be encouraged to use business close-source solutions such as IBM in their projects or exercises. It is crucial to emphasize that open source solutions currently dominate the field of AI, and students should be trained to use them effectively.

Lastly, it is essential to choose the appropriate programming language for students' training, and Python stands out as the most suitable language for this purpose. Python is a highly versatile language with a wide range of libraries and tools that make it an ideal choice for developing AI applications. Therefore, instructors should prioritize teaching Python and ensure that students have a solid foundation in this language before proceeding to more advanced topics in AI.

In conclusion, the competencies, hard skills, and soft skills required for success in the AI industry are ever-evolving. It is the responsibility of educators to analyze the current trends and demands in the industry and design courses that provide students with the necessary skills to succeed in the field. By prioritizing deep neural network learning modules, machine learning problems, open source solutions, and Python programming language, students can be equipped with the skills to tackle real-world challenges in the AI industry.