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Data Processing and Modeling for CEEPUS Academic Event Optimal Management in the IMA-NET Platform

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Abstract: The paper presents new features in the IMA-NET platform for e-management of academic networks. IMA-NET is implemented for the e-management of the Central European Exchange Program for University Studies (CEEPUS) network BG-1103 which has been functioning already for eight years. A mobility questionnaire was integrated into the platform to investigate the mobility interest of students from the 16 CEEPUS region countries to study or take part in the CEEPUS academic event with the grant and additional support offered by the partner country organizer and the home country. More than 150 responses were collected from students from different CEEPUS countries. The data collected are presented graphically and processed to study some correlations. A model of the potential student applicant for an event/study based on the Neural Network is developed to forecast the behavior and an algorithm is developed to prescribe recommendations to follow for organizing/managing a successful CEEPUS academic event in an arbitrary CEEPUS country. The goal is to integrate better all partners in the CEEPUS activities and avoid marginalization of countries offering lower grants.

Keywords: CEEPUS, Academic Network Management, Statistical Correlation, Neural Networks, Academic Event management, Optimal Grant Fulfillment

1. INTRODUCTION

University networks are partnerships or alliances established among many universities or higher education institutions spanning various areas or nations. The networks are designed to promote academic collaboration, enable student, and staff exchanges, conduct collaborative research initiatives, and share resources and best practices among member institutions. They frequently concentrate on certain areas like research, teaching, cultural exchange, or technology advancement, which helps in the globalization of higher education.

CEEPUS is an instance of a university network known as the Central European Exchange Program for University Studies. CEEPUS is an international exchange program that fosters regional collaboration in higher education throughout Central and Eastern European nations. The program facilitates exchange trips for students, professors, and researchers from member nations to enhance academic mobility and promote cultural and intellectual connections among countries in the area. The network facilitates semester exchanges for students, short-term teaching visits for faculty, and cooperative research initiatives across several academic disciplines, focusing on cooperation and information sharing.

According to the "CEEPUS project" (2024) on the project website, the CEEPUS Network CIII-BG-1103-04-1920 focuses on Modelling, Simulation, and Computer-aided Design in Engineering and Management. It has been active for 8 years and includes 40 partner Higher Education Institutions (HEIs) from 16 countries within the CEEPUS area "CEEPUS Home Page" (nd) on the CEEPUS website. This network represents a large-scale collaboration, necessitating the integration of advanced technology to manage the substantial data it generates effectively. The studies identified a gap in e-learning systems for network management, leading to the development of IMA-NET (Tola and Marinova, 2023), a web-based platform designed for managing summer schools or academic events. IMA-NET offers a scalable and user-friendly solution for coordinating international students and lecturers (Marinova and Tola, 2020). According to (Tola, 2023) and (Tola and Marinova,2023), this system integrates advanced data compression techniques to maintain application performance and data security, enhancing the educational experience. IMA-NET features a questionnaire to optimize student participation in various activities, collecting data on student mobilities and preferences. The research further discusses statistical methods for data analysis, the training of a forecasting model using the Neural Network's Multi-Layer Perceptron (MLP) classifier, and the development of an algorithm for generating organizational instructions. This approach aims to enhance the academic network's event management by improving partner integration and avoid marginalization of the countries that offer lower grants for their mobilities.

2. MOBILITY QUESTIONNAIRE AND DATA COLLECTION IN IMA-NET

The Mobility Questionnaire comes as a powerful feature helping the organizers increase student participation in the mobilities organized by them. This questionnaire is exclusive

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for students who can access it on their dashboard once they log in to the system.

Fig. 1 visualizes the look-alike of the questionnaire in the student's dashboard. The questions are formulated using this structure:

Would you go for mobility in these specific countries if you received this grant amount of money and had that condition?

Grant data are provided from the "CEEPUS Home Page" (nd) on the CEEPUS website for the amount of the CEEPUS grant for students, offered from the CEEPUS country: Country, Grant per month.

Country	Grant per month [EUR]	Would you go for mobility in one of the following countries if:					
		You don't have additional support				Host pays for the accommodation / offers free accommodation	Home country authorities support travel expenses
		The mobility includes conferences important for your thesis	You are attending summer school on topic that interests you andyou get certificate with ECTS	In the host institution you will follow courses which areimportant for your studies	You attend for long-term mobilities (3 - 4) months		
Albania	81	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No
Austria	1150	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No

Fig. 1: Mobility Questionnaire

Four types of CEEPUS mobilities/events, called from now on "the conditions", are defined which can be listed as follows:

- Mobility within the parallel conference.
- Summer School.
- Special courses.
- Long term.

Two additional conditions are added to the four previous conditions:

- The host country offers free accommodation (FA) for students in dormitories.
- The home country offers travel refunds (TR).

Each cell of the table represents a question that students need to answer by selecting Yes or No, referring if they would be interested in the mobility/event in the country, given the grant. There are 6 specific questions for 16 different countries for a total of 96 different questions.

All of the questions are obligatory, and a student is allowed to fill out this survey only once. The results gathered from this survey undergo a series of statistical processing to extract valuable information out of them and display it to the Administrators' dashboard using the charts and graphs mentioned above.

The number of positive responses is collected in the cells, then the percentage of answers Yes to the number of respondents is calculated. More than 150 students from CEEPUS countries filled the questionnaire.

3. DATA PROCESSING AND NN MODELING

The collected data undergoes a series of processing to find a way to optimize the student's participation in different events.

Table I: Grant Correlation Table

Condition	Correlation Value	The p-value
The mobility includes conferences important for your thesis	0.88	7.17×10^{-7}
You are attending a summer school on a topic that interests you and you get a certificate with ECTS	0.94	1.81×10^{-9}
In the host institution, you will follow courses that are important for your studies	0.89	5.18×10^{-7}
You attend for long-term mobilities (3 - 4) months	0.92	3.32×10^{-8}
Host pays for the accommodation / offers free accommodation	0.82	2.18×10^{-5}
Home country authorities support travel expenses	0.88	6.44×10^{-7}

First, a correlation analysis using Pearson correlation is conducted to assess the grant's influence on the overall outcome concerning other questionnaire conditions.
The Correlation results, displayed in Table 1 reveal a significant link between mobility conditions and grant amounts, highlighting the impact of financial incentives on students' educational mobility decisions.
A graph (Fig. 2) plotted from student responses shows this relationship, with countries (grants) on the x-axis in ascending order and response percentages on the y-axis; lines represent different conditions. There's a visible trend of increasing positive responses correlating with higher grants, illustrating the grant's influence on various conditions.
The graph's purple line, signifying long-term mobility preferences, is notably separated from others, indicating lesser student preference for such mobilities. Conversely, two lines closely follow each other, showing preferences for scenarios where the grant is supplemented by accommodation (sky-blue line) and transportation (orange line), suggesting these aspects significantly influence student preferences for educational mobility.

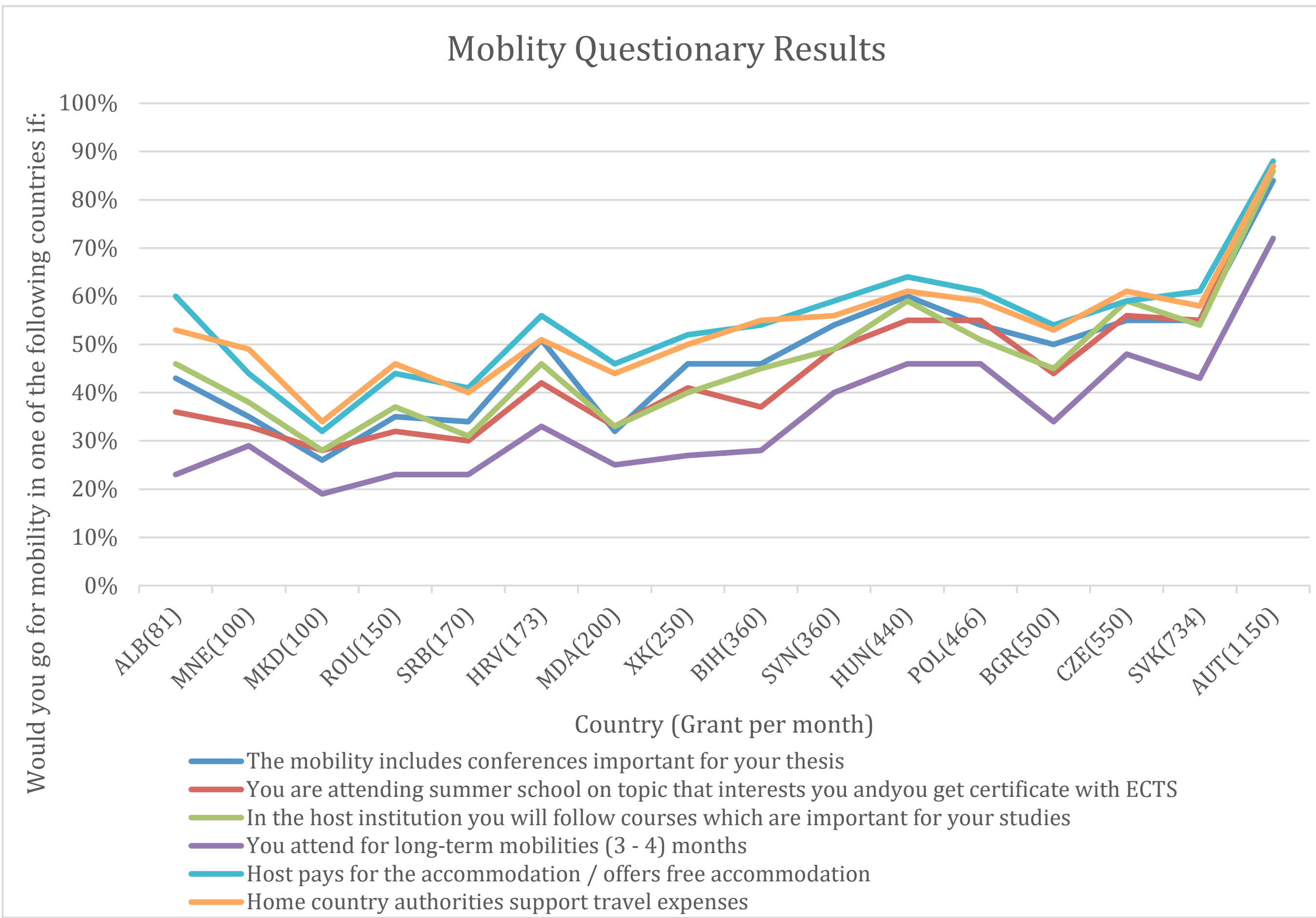

Fig. 2: Mobility Questionnaire Results

Upon closer examination of the chart, it is evident that the grant is not the only relevant component, but the host country itself.

Furthermore, the data collected are used to create the so-called “The Predictor”. This IMA-NET feature uses the Neural Networks MLP Classifier to create and train models based on the input given. This is because it is a method that supports the “online learning” process giving the possibility to update the trained models with new data without having to train the models from the beginning each time a new student fills out a survey. Another reason for using this method is that it is compatible with scenarios that contain strongly related conditions such as in this case.
Neural networks are a type of machine learning algorithms that are influenced by the neural architecture of the human brain and are created to identify patterns and address intricate issues. They are composed of linked nodes or neurons that can individually carry out basic calculations. Neural networks may represent intricate, non-linear patterns in data by linking nodes in different configurations and altering the weights of their connections. Neural networks are comprised of an Input Layer, Hidden Layers, and an Output Layer (Goodfellow et al., 2016).

The output layer generates the final output of the network. The output layer in classification tasks might depict the expected classes. Training neural networks requires fine-tuning the weights and biases to reduce the discrepancy between the real output and the anticipated results. This technique involves Forward Propagation and Loss Calculation.
Backpropagation is a method used to train neural networks, involving the backward propagation of the loss to calculate the gradient of the loss function for each weight (Haykin, 1999). This helps determine how changes in weights affect the overall error.
Optimization techniques like gradient descent are used to adjust weights and minimize the loss. Activation functions like Sigmoid, ReLU, and Tanh introduce non-linearity, allowing the network to learn complex patterns and affecting its training efficiency and performance (Goodfellow et al., 2016).

The Multi-Layer Perceptron (MLP) Classifier extends the basic perceptron by adding multiple layers, making it suitable for classification tasks. As a feedforward artificial neural network, the MLP consists of an input layer, several hidden layers, and an output layer. By incorporating multiple layers and non-linear activation functions, MLPs can model complex patterns and solve problems beyond the capability of single-layer perceptrons, handling non-linearly separable classification tasks effectively.

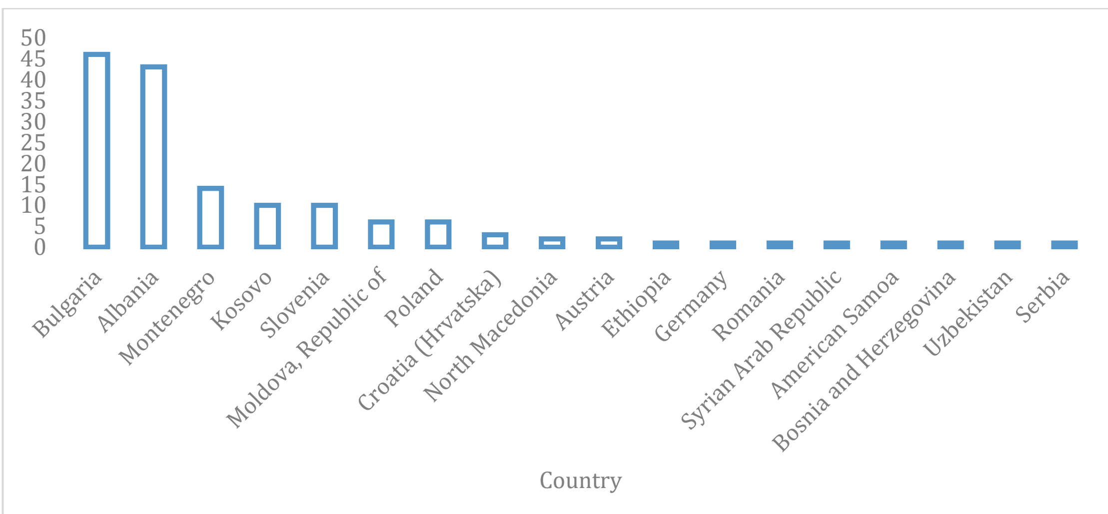

Fig. 3: Questionnaire Participants Demography

Activation Function**:** The result of the weighted sum is passed through an activation function $a_j^{(l)} = f(z_j^{(l)})$, introducing non-linearity into the model.

Backpropagation, combined with gradient descent, is key in neural network training, adjusting weights and biases to lower the loss function. Activation functions like ReLU and sigmoid introduce necessary non-linearity, aiding in complex pattern learning.

This process includes a forward pass, where input data moves through the network to produce outputs, and a backward pass, which calculates loss function gradients against weights and biases. These gradients inform parameter updates via optimization techniques like gradient descent, aiming to minimize error (Haykin, 1999).

In the forward pass, the input data is passed through the network, layer by layer. Then for each neuron, the input x is multiplied by the weights w, summed, and added to the bias b:

$$z = w * x + b$$

The result is passed through an activation function f to introduce non-linearity: $a = f(z)$.

The loss function L evaluates the discrepancy between the model's predictions and actual targets, with Mean Squared Error and Cross-Entropy Loss being typical for regression and classification tasks, respectively. Calculating the loss function's gradient involves using the chain rule to propagate errors backward:
For the output layer: $\frac{\partial L}{\partial w} = \frac{\partial L}{\partial a} * \frac{\partial a}{\partial z} * \frac{\partial z}{\partial w}$

For hidden layers, the gradient accounts for each neuron's effect on the loss, calculating gradients from the output back to the input layer.
Weights and biases are updated against the gradient direction, scaled by a learning rate α, iterating until the loss minimizes:

$$w = w - \propto \frac{\partial L}{\partial w}$$

$$b = b - \propto \frac{\partial L}{\partial b}$$

In the context of IMA-NET, this neural network approach, including the MLP Classifier, predicts student mobility based on country choice, grant amount, and conditions, trained on data from the Mobility Questionnaire. Integration of Python with PHP was employed to leverage Python's advanced statistical libraries absent in PHP, enhancing the model training and analysis process.

4. ALGORITHM DEFINING THE SET OF RECOMMENDATIONS FOR THE ORGANIZATION OF SUCCESSFUL ACADEMIC CEEPUS EVENT

The strong correlation between the grant amount and the interest of a student in a mobility/event in a country leads to the risk of organizing all or the majority of mobilities/events in countries with higher grants and marginalizing the countries with lower grants. To overcome this risk a goal function is defined: To organize/manage a successful CEEPUS event (with several student attendees superior to a threshold, ex.12) in an arbitrary CEEPUS country.

To achieve this goal, an algorithm is proposed to define a set of recommendations on how to organize/manage a successful event in an arbitrary CEEPUS country. Information about the travel refunds and free accommodation offered for students is taken from the "CEEPUS project" (2024) found on the project website. Travel refunds (TR) are offered by Austria, Bosnia and Herzegovina, Czech Republic, Croatia, Hungary, and Poland as home countries.

TR (country, home) = 0 – travel refund is not offered by the home country

TR (country, home) =1 –travel refund is offered by the home country.

Free accommodation in students' dormitories is offered to students by Albania, Croatia, North Macedonia, Serbia, and Slovenia as host countries.

FA (country, host) = 0 – Free accommodation is not offered by the host country.

FA (country, host) = 1 – Free accommodation is offered by the host country.

Let define:
%Yes (country, mobility/event, FA, TR) is the percentage of positive responses to a mobility/event in a country, with different values of FA and TR.

A promotion effort value (PAV) is defined for a CEEPUS mobility/event to be held in a CEEPUS country as:
PAV (country, mobility/event) = 1 / %Yes (country, mobility/event, FA, TR).

PAVs are calculated for each cell of the Mobility questionnaire table.

Additionally, each cell is considered data distribution per the home countries of the respondents. Let define:

%Yes (home country, host country, mobility/event, FA, TR)

The thresholds differentiating different approaches are defined *as 50% for %Yes, and 2 for PAV.*

The steps of the algorithm for optimizing the organization/management of CEEPUS mobility/event of concrete type in a selected CEEPUS country and making it successful are:

- Consider the values of *%Yes(country, mobility/event, FA=0,TR=0) and PAV(country .mobility/event, FA=0,TR=0)*;
- If *%Yes(country, mobility/event, FA=0,TR=0) ≥50%, PAV(country .mobility/event, FA=0,TR=0) ≤ 2*
  then the mobility/event can be promoted through a **Standard Call**, distributed through paper and social media advertisement, a certain time (1 month) before the application deadline.
- If *%Yes (home country, host country, mobility/event, FA≠0, TR≠0) > %Yes (home country, host country, mobility/event, FA=0, TR=0)+10%,* 2 options follow:

  * If the home country offers TR or the host country offers FA, then the Call should **Emphasize the Free accommodation and Travel refund options offered**.

  *If the home country doesn't offer TR or the host country doesn't offer FA, then additional **Co-sponsors can be searched** for these expenses to increase the interest in mobility.
- The approach can be refined by considering the values of the %Yes (home country, host country, mobility/event, 0, 0).

  * Let's define priority home countries PHC to be addressed for a mobility/event in a home CEEPUS country: PHC (home country, mobility/event) is a home country, for which *%Yes (home country, host country, mobility/event) ≥50%.*

  In these countries, the approach with the **Standard Call** is applied and most of the attendees are expected from these countries. These might be neighboring countries or others, depending on the data.

  * *For non-PHC, if %Yes (home country, host country, mobility/event) <50%, PAV (home country, host country, mobility/event, FA=0, TR=0) > 2* then **Stronger Promotion** to a larger community with possibilities for **Personal Contact** should be organized to motivate applicants.

  * *For non-PHC, if %Yes (home country, host country, mobility/event) =0*, an **Information Campaign** presenting the CEEPUS program, and the activities of the network should be organized before launching the Call for applicants.

In any concrete case, the subset of recommendations for the organization/management of a mobility/event in a concrete country should be selected from 7 instruments:

- **Standard Call**, distributed through paper and social media advertisement, a certain time (1 month) before the application deadline

- **Stronger/personalized promotion** to a larger community with possibilities for personal contact should be organized to motivate applicants.
- **Information campaign** presenting the CEEPUS program, and the activities of the network should be organized before launching the Call for applicants.
- **Emphasizing in the Call the Travel Refund** offered by the home country.
- **Emphasizing in the Call the Free Accommodation** offered by the host country.
- **Search for additional co-sponsors for Travel Refunds** by the home country.
- **Search for additional co-sponsors for Free Accommodation** by the host country.

Example 1. Organize a CEEPUS Summer School in Slovenia
Example 2. Organize a CEEPUS long-term mobility in Albania.

5. CONCLUSIONS AND FUTURE WORK

Programming this algorithm in IMA-NET will define for each mobility/event cell in the Mobility questionnaire the approach to follow for organizing a successful event considering different home countries. The recommendations allow for diversification of the host countries organizing and hosting the mobilities/events and diversify the home countries of the attendees. This optimal organization/management will lead to optimal fulfillment of the grants awarded in a network, no matter their amounts for different countries.

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