

### INTRODUCTION

- Echo state networks (ESNs) - specific type of recurrent neural networks (RNNs)
- Much less computationally demanding adaptation - only small part of ESN parameters is trained
- Ability to achieve state-of-the-art performance on prediction tasks on some artificial time series
- Many interesting theoretical results - often approximating recurrent dynamics with linear transformations

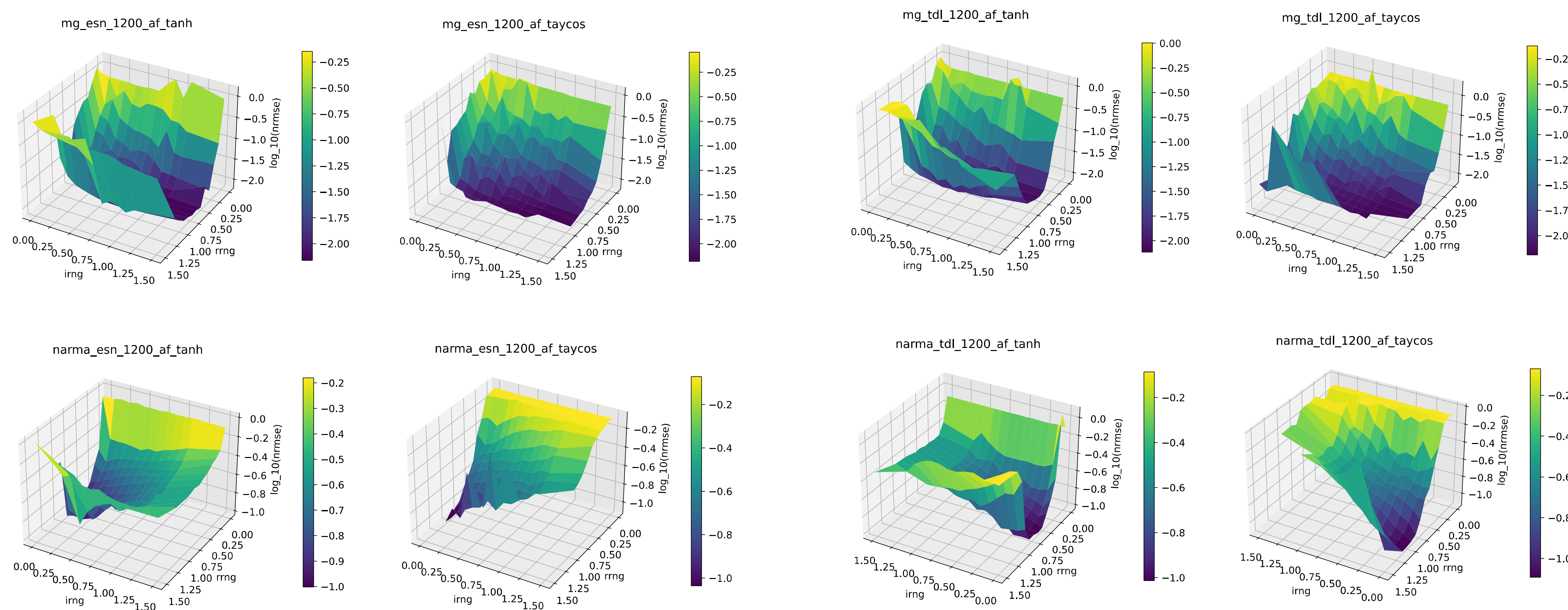
### MATERIALS AND METHODS

- Models:
  - ESN - special type of RNN with huge randomly interconnected recurrent layer called reservoir
  - ESN - TDL - simplified ESN with reservoir formed of unites connected in a cycle
  - Reservoir model with activities explicitly induced by various polynomials
- Artificial time series:
  - Chaotic Mackey Glass (MG)
  - Nonlinear Autoregressive Moving-average (NARMA)

### AIM

- Study performance of classic ESN model and simplified ESN-TDL with reservoirs of different sizes
- Test different nonlinear activation functions
- Approximate activation functions with simple polynomials resulting from Taylor series expansion
- Evaluate performance of models using polynomials for reservoir

### RESULTS



### CONCLUSIONS

- Simplified ESN-TDL can achieve similar resulting performance as classic ESN
- Classic ESN is more sensitive to the range used for input weight scaling
- Simple activation functions such as second-order (quadratic) polynomial can achieve the same performance
- Reservoirs constructed explicitly using polynomials achieved comparable performance on MG dataset but lower performance on NARMA dataset

### ACKNOWLEDGEMENTS

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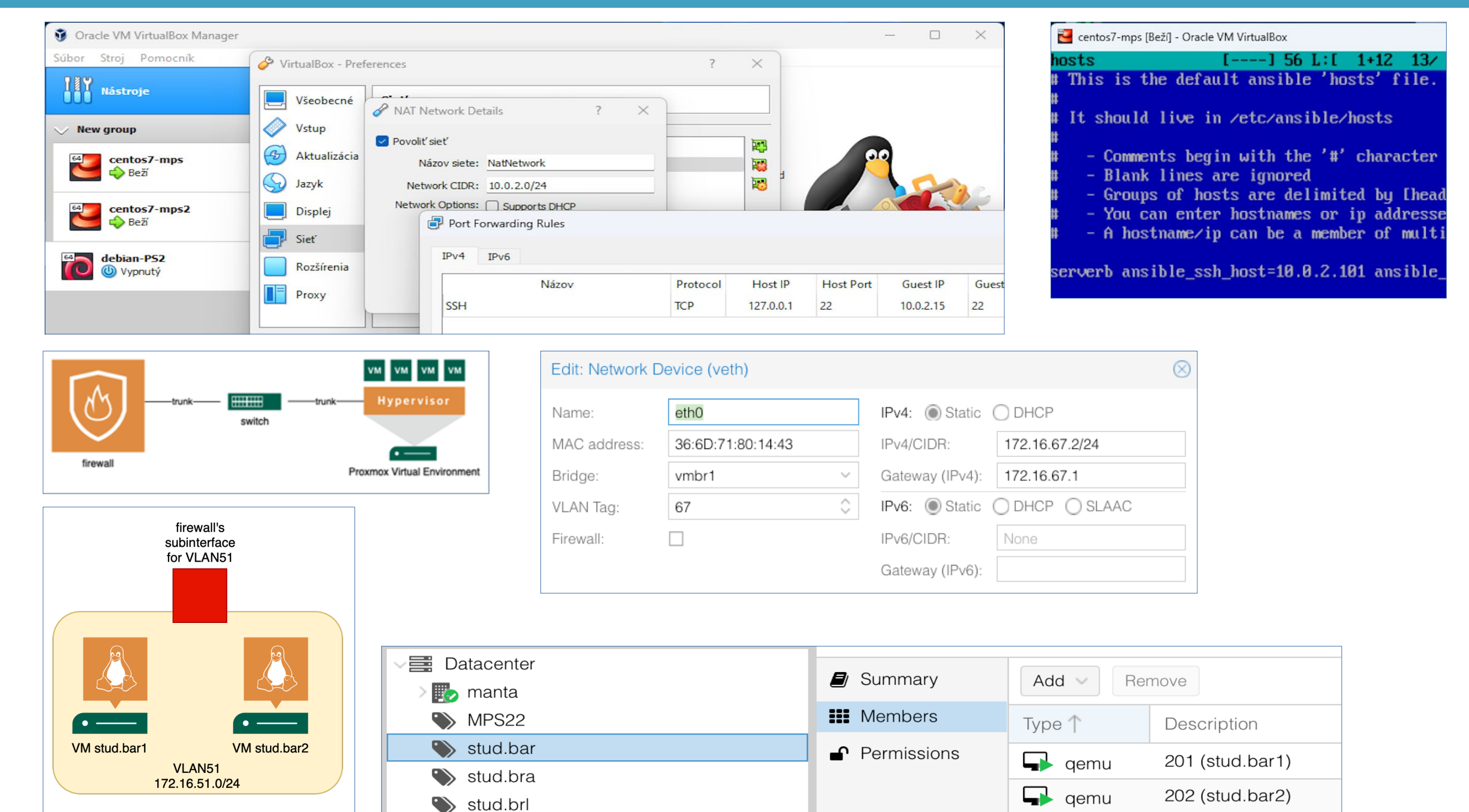
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## INTRODUCTION

Nowadays, network attacks are a constant threat that every organization connected to the Internet has to deal with. This is precisely why experts in network security solutions are in high demand on the job market. Universities also participate in the preparation of such experts in the form of face-to-face or distance education. Virtualization technologies are intensively used in both forms. The most commonly used technologies are Proxmox VE and VirtualBox. Both of these technologies were compared from the point of view of lecturers and attendees of the educational course Advanced network security solutions.

## MATERIALS AND METHODS

- students worked in VirtualBox with prepared VMs
- the final independent work used the Proxmox
- each student had three VMs (attacker, victim, firewall)
- each student had associated VLAN for VMs
- the students worked remotely in the virtual environment
- xterm.js and ssh terminal
- direct support through the internet
- presentation of implementation of security solution
- in-depth interview with the experiment participants



## RESULTS

- The students stated that PVE was better for teaching because it was worked with via a web interface and there was no need to download additional software.
- In addition, the students felt that starting with PVE was easy.
- There is no need to install any additional tool.
- Everything can be done in a web browser (Google Chrome and Firefox are recommended) running on any device.
- It should be noted that VB itself is installed as an application and then handled as a regular application.
- The PVE web GUI can also be adapted to mobile devices.
- If a CLI (Command Line Interface) is needed on a PVE node, it is possible to open the HTML5 console directly in the browser.
- Although all students appreciated the benefits of PVE in the classroom, some students worked better with VB than with PVE. A prerequisite to working with PVE was a fast and reliable Internet connection. Understandably, students in areas with a limited choice of ISPs preferred to work with VB running on their local computer. Thus, it can be concluded that for independent work on a student's computer with no or limited access to the Internet, VirtualBox is preferable to PVE.

	VirtualBox	Proxmox VE
Operating system	cross-platform tool	for Linux only
Necessity of software installation by the user	yes	no
Uploading	no	yes
Open source	yes	yes
Interface	simpler interface	more complex interface
Purpose	personal use, testing	enterprise use, professional virtualization
Valued feature, function	fast testing; VirtualBox installs as an application in a regular operating system; virtual machines only; virtualization also on PCs with CPU without virtualization support	containers and virtual machines; dynamic storage and performance scaling; web GUI; clustering; high VM availability using CEPH distributed subcore system

## CONCLUSIONS

The valued advantage of Proxmox from the lecturer's point of view was that it eliminated the problem of locating any problem that the attendee got stuck on. The lecturer did not have to search whether the problem is in the operating system on the virtual machine, or at the level of virtualization, or at the level of the operating system that runs on the attendee's computer. Thanks to the fact that the lecturer had administrative access to the PVE, he could work directly with the attendee's VMs and debug any problems. Then, using a simple video conference and sharing the application window, he could show and explain to the attendee where the problem is and how to solve it. Attendees appreciated Proxmox for the possibility of immediate work with VM without the need to install SW, since a browser is enough to work with Proxmox.

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# ANS 2023 Possibilities of using heart rate variability data to control serious games

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## INTRODUCTION

Serious games hold a significant role in education, coaching, and the acquisition of knowledge, insights, and skills through digital educational games. These games are designed with a specific purpose in mind, with entertainment serving as a secondary goal rather than the primary objective. The history of serious games dates back to the early days of computing, and their impact has grown remarkably since then. This growth can be attributed to the widespread use of computing technology in various fields.

Serious games have significantly increased in popularity and reputation due to their potential use in various fields and for different target audiences. These include primary school students, entrepreneurs, health professionals, IT employees, and senior citizens. The growing impact of serious games can be attributed to the constant improvement in device performance, such as computers, laptops, tablets, and convergent networks. This enables the development of more demanding and advanced applications, simulations, and games that necessitate specific hardware and software, advanced mechanics, and more sophisticated interactive elements.

One method for harnessing the potential of serious gaming is through the integration of specialist hardware. An illustrative example of such hardware is heart rate capture-oriented devices. The utilization of specialized hardware, specifically tailored to human physiognomy, represents a promising avenue for innovative advancements in this field. Notably, one advantage of such hardware is its ability to facilitate precise analysis of real-time data. This data is subsequently processed either instantaneously or shortly thereafter, allowing for prompt adjustments to be made to the application, simulation, or game based on the evaluation. In essence, the data obtained serves as the driving force behind the sequence of events within the application.

## DESCRIPTION

The objective of this research is to develop a hardware device capable of monitoring an individual's heart activity in real time. By analyzing the frequency of the heart rate, it will be possible to determine if the individual is in a state of rest or if their activity levels are elevated. In order to design the prototype, it was essential to consider the fundamental reasons why such a device is necessary. The central focus of this prototype is stress. Stress can be defined as an unpleasant emotional state that triggers the activation of the body's nervous system, leading to the release of stress hormones for self-protection. This physiological response includes changes in heart rate, sweat gland activity, and skin temperature. It is important to note that the sympathetic nervous system exclusively innervates the sweat glands and skin blood vessels. Furthermore, a significant aspect of this project involves analyzing and evaluating the recorded heart rate data. This information will be used to provide immediate visual feedback through applications, simulations, or serious games.

## AIM

The main aim of this research study is to present the possibility of designing and developing a prototype focused on heart activity connected to serious games (frequency). The device so designed will then need to be subjected to testing and validation for correctness in terms of the data obtained from the responder's body. The size as well as the age of the respondent will be consulted to match adequate capabilities

## MATERIALS AND METHODS

In terms of the methodology employed, the following methods will be utilized:

### Theoretical methods

- will predominantly be employed in the design and development of the prototype and software. The use of theoretical methods is crucial for studying and drawing inspiration from existing domestic and foreign sources when designing and developing the hardware and software components. Through analysis and synthesis, these methods will determine the initial stages of implementing the prototype, followed by the verification of its applications through rigorous testing with respondents.

### Agile methodologies

- agile methodologies will be employed in the design and development process, subject to the research team's consensus. The utilization of this approach offers significant benefits in terms of performance optimization and concurrent execution across various development stages, thereby enhancing the software quality. Additionally, this method embodies a remarkable adaptability to real-world circumstances."

### Hardware Prototype development

- this scientific research project aims to enhance the design and development of a mobile hardware prototype. To accomplish this, a collaborative team will be assembled, focusing specifically on the design aspect of the mobile device. The design will be based on the input requirements identified for the prototype. Furthermore, the project will entail the actual development of the prototype, which will undergo rigorous debugging and testing processes to ensure the accurate collection of data during the respondents' measurement phase.

### Empirical research

- a scientific research study will be conducted on a carefully chosen set of participants, aiming to investigate and analyze a particular phenomenon. Prior to the study, a fully developed and thoroughly tested hardware prototype will be prepared. The research will be conducted in adherence to the established guidelines and regulations governed by the ethics committee. Throughout the testing phase, data will be systematically collected from the participants' specific activities.

### Statistical methods

- analyze the data acquired from individual heart rate measurements of the participants in a scientific manner. Statistical software tools will be utilized for data processing. The results will be carefully presented and compiled to identify any discrepancies relating to gender, age, or field of study of the participants.

## CONCLUSIONS

Based on the aforementioned characterization and device description, it becomes feasible to advance its development. Prior to building the prototype, a comprehensive summation of the necessary attributes will be undertaken. These qualities must be meticulously analyzed to effectively extract pertinent data obtained from measurements. Furthermore, matters concerning device inputs, the choice between wired or wireless capture methods, and other related aspects must be resolved. Subsequently, the device, as per its design, will be tested on a representative sample of respondents while utilizing a specifically selected application.

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## INTRODUCTION

Automatic Short Answer Scoring (ASAG) for open-ended questions poses a significant risk of incorrect evaluation in terms of semantics. The syntactic complexity itself creates various pitfalls in terms of relevance/correctness of the evaluation results, without manual intervention. Currently, there are different kinds of applications that are commonly used for evaluation (Quiz in LMS Moodle, Socrative, Google Forms, Testportal in MS Teams, etc.). In order to be able to automatically and correctly evaluate the obtained test data, algorithms for semantic similarity of texts exist and are continuously being developed. Some of the most well-known models include BERT, RoBERTa, XLM-RoBERTa and MPNet. By comparing the different models, we concluded that for the answers we tested, the best approach is using XLM-RoBERTa and RoBERTa. However, it should be added that a human approach is indispensable in evaluating student knowledge.

## MATERIALS AND METHODS

The goal of semantic text similarity (STS) is to correctly evaluate how similar two texts are in terms of meaning. Characteristics of selected models:

- BERT – 2018 - bidirectional Transformer pre-trained using a combination of Masked Language Modeling and Next Sentence Prediction objectives.
- RoBERTa – 2019 - better version of BERT, where the Masked Language Modeling (MLM) objective is dynamic, the Next Sentence Prediction (NSP) objective is dropped, the BPE tokenizer is employed, and better hyperparameters are used.
- XLM-RoBERTa – 2019 - is a multilingual model trained on 100 different languages.
- MPNet – MPNet adopts a novel pre-training method, named masked and permuted language modeling, to inherit the advantages of masked language modeling and permuted language modeling for natural language understanding.

These models take a source sentence and a list of sentences in which we will look for similarities and return a list of similarity scores. For proper evaluation, it is important that the models are trained on texts in the Slovak language.

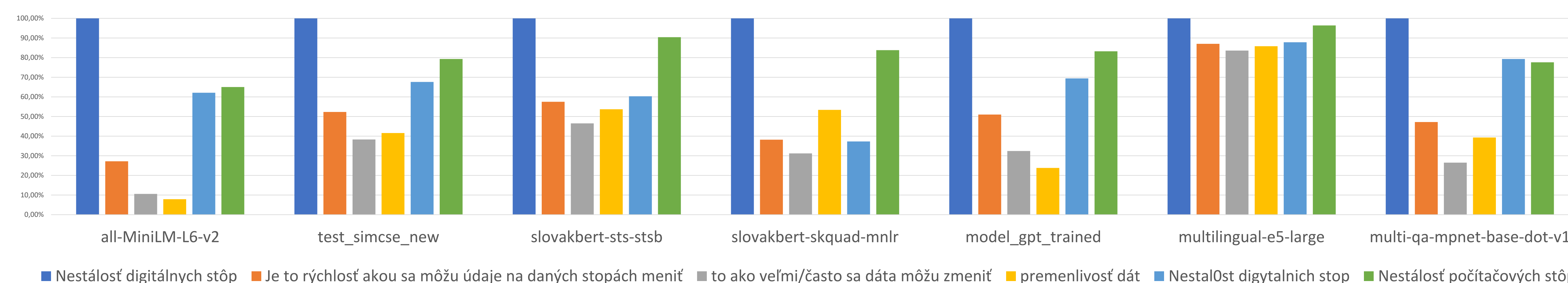
## AIM

The main objective is to evaluate the performance and accuracy of the BERT model against the commonly used RoBERTa, XLM-RoBERTa and MPNet models on students' correct answers in the evaluation form. The evaluation of semantics in comma delimited text, although having high % success rates, are not correct because they change the meaning of the sentence e.g., page layout using tables unusable, only using divs (100%) / web page structure using tables unusable, only using divs (88.9%) / page layout using tables, unusable only using divs (98%).

## RESULTS

For completeness, we present the characteristics of each of the available algorithms and their evaluation in simulation. We compared the students' expected response in the wording: „Nestálosť digitálnych stôp“ with the following sentences: „Je to rýchlosť akou sa môžu údaje na daných stopách meniť“, „to ako veľmi/často sa dáta môžu zmeniť“, „premenlivosť dát“, „Nestálosť digytnalich stop“, „Nestálosť počítačových stôp“:

- all-MiniLM-L6-v2: It maps sentences & paragraphs to a 384-dimensional dense vector space and can be used for tasks like clustering or semantic search. Only in English language. Data processing speed: 0.040s and success rate 35%.
- test\_simcse\_new: data processing speed: 0.321s and success rate 56%.
- slovakbert-sts-stsb: SlovakBERT pretrained model on Slovak language using a masked language modelling (MLM) objective. Data processing speed: 0.194s and success rate 62%.
- slovakbert-skquad-mnrl: data processing speed: 0.124s and success rate 49%.
- model\_gpt\_trained: GPT is a model with absolute position embeddings, so it's usually advised to pad the inputs on the right rather than the left. Data processing speed: 0.075s and success rate 52%.
- multilingual-E5-large: This model has 24 layers, and the embedding size is 1024. Slovak language trained. Data processing speed: 0.645s and success rate 88%.
- multi-qa-mpnet-base-dot-v1: It encodes queries / questions and text paragraphs in a dense vector space. It finds relevant documents for the given passages. Data processing speed: 0.191s and success rate 54%.



## CONCLUSIONS

The main aim of this study was to compare text-semantic sentence algorithms in student tests in the Slovak language. It is important to note that due to the specificity of Slovak grammar, it is advisable to use models that are pre-trained on Slovak grammar in testing tools. The reported measurements show that the multilingual-E5-large model shows the best answer evaluation capabilities compared to the fastest Bert model, labeled all-MiniLM-L6-v2, which was 0.040s, but on average 43% incorrectly evaluated students' answers. In conclusion, as fast and valid as the evaluated student responses are, there is a constant need for the teacher to manually check the responses.

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### INTRODUCTION

Modern systems for the control of complex processes in various areas of life actively use recurrent neural networks (RNN). A neural network with long-term memory (LSTM) allows you to predict the subsequent values of a time series. The proposed article provides a universal model of a dynamic system in SIMULINK of the MATLAB environment. Tuning the model parameters ensures the generation of a training sequence of values for the LSTM, the optimization of the RNN structure and its testing. The generation of the training sequence is synchronized with the time step of the RNN input sequence.

### MATERIALS AND METHODS

The output from the simulation model (Fig.1) is used to train the neural network.

Testing the effect of the number of neurons in the hidden layer on prediction speed.

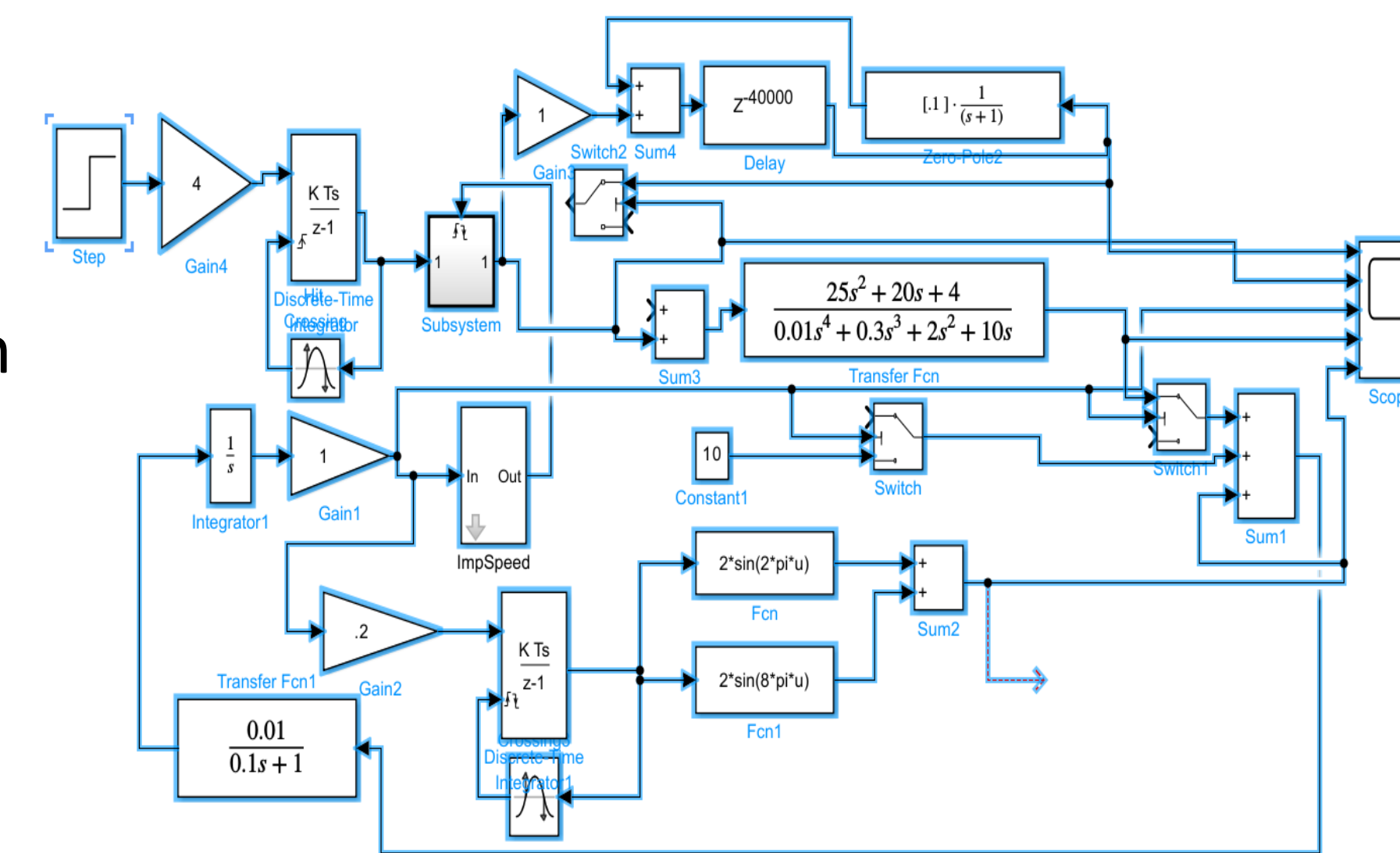


Fig. 1 Simulation Model

### AIM

Design of neural network structure optimization technology for time series prediction. The solution is a simulation model of a mechatronic position control system that is synchronized with a computer timer.

For solving time series prediction, it offers a neural network, in the design of which the main problem is determining the number of neurons in the hidden layer.

### RESULTS

Testing has shown that an increase in prediction speed and accuracy is achieved by replacing data type Float with type Integer. Since technical systems do not use higher precision because they use 8-bit converters, there is no need to provide higher precision.

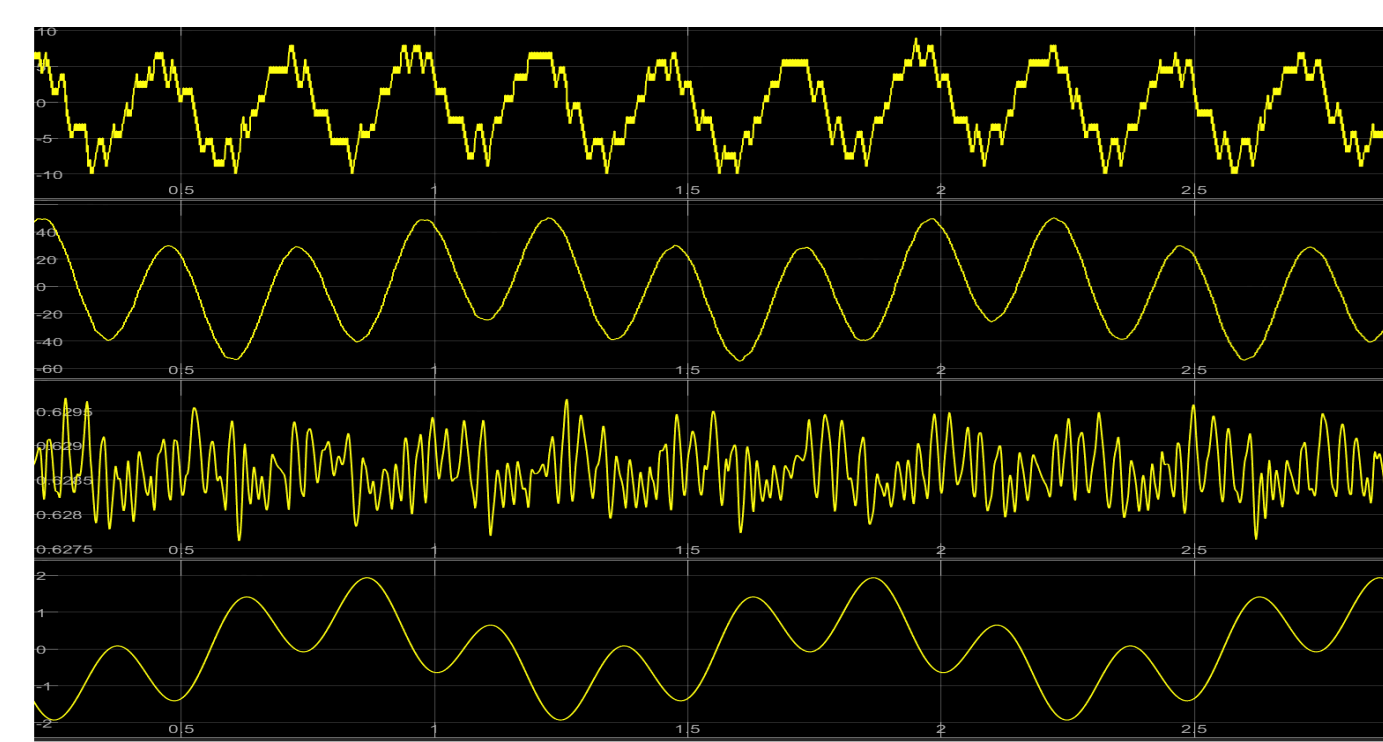


Fig. 2 Output from the simulation Model

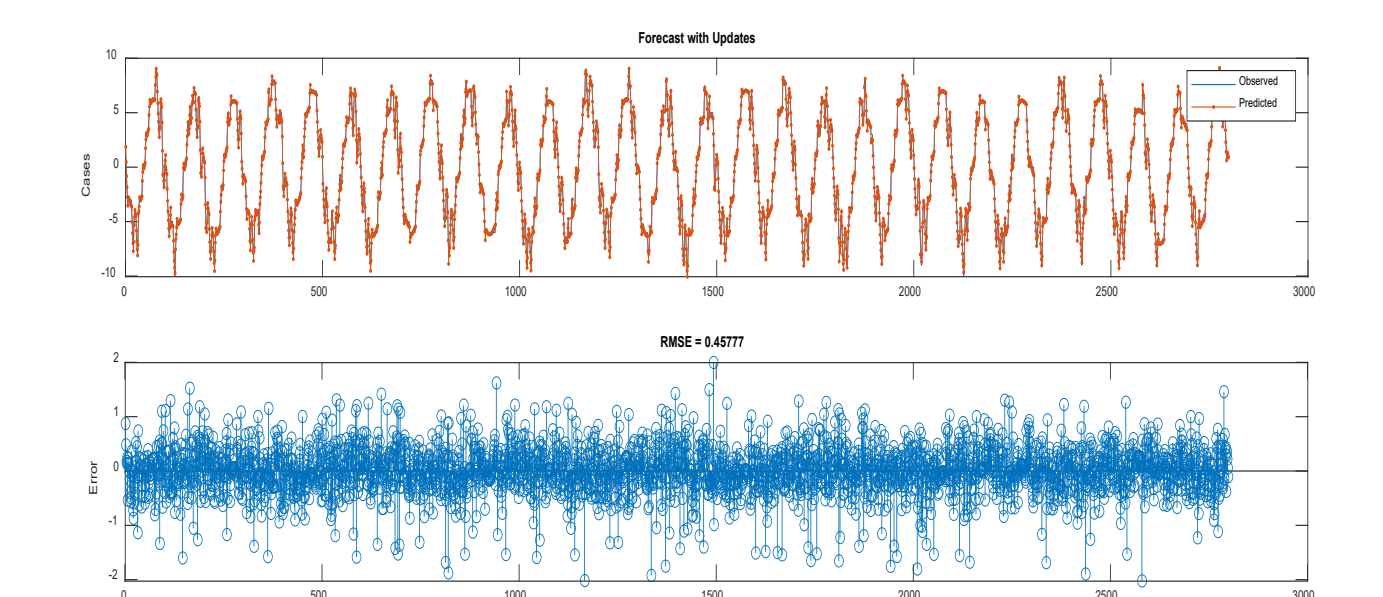


Fig. 3 The number of neurons in the hidden layer is 200

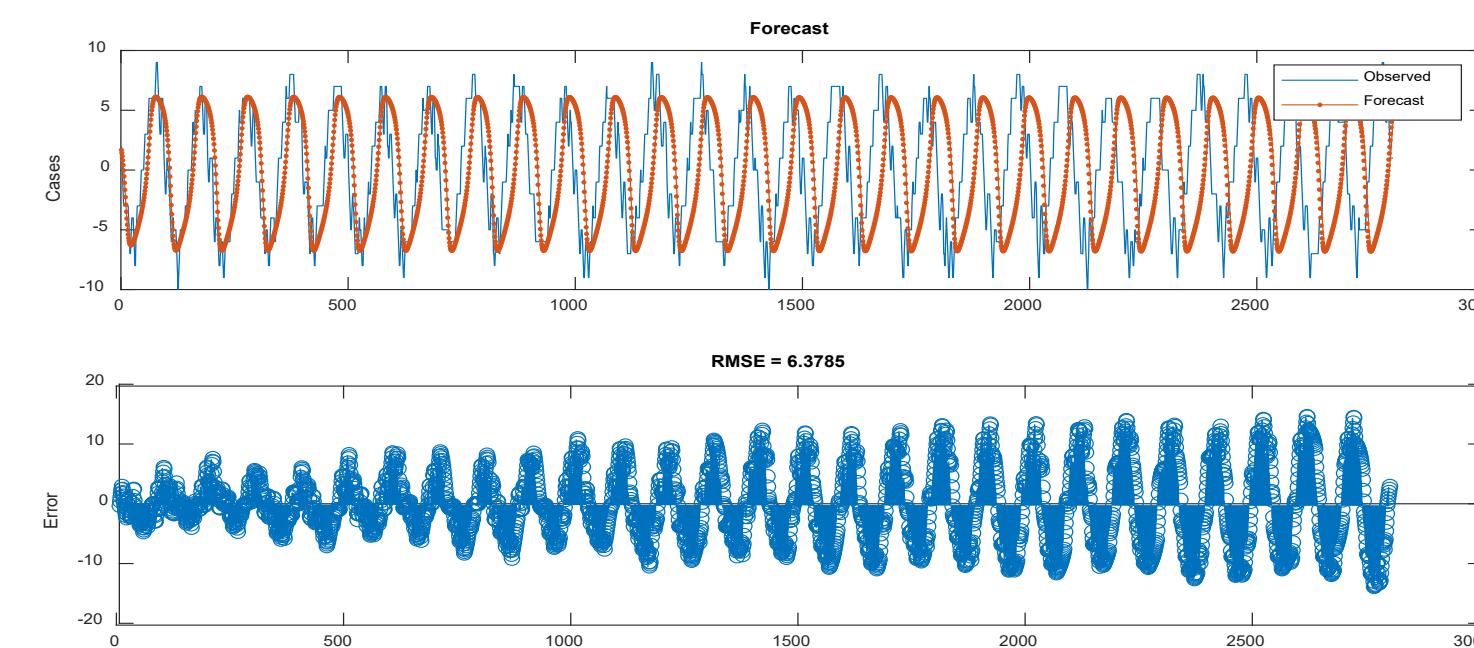


Fig. 4 The number of neurons in the hidden layer is 4

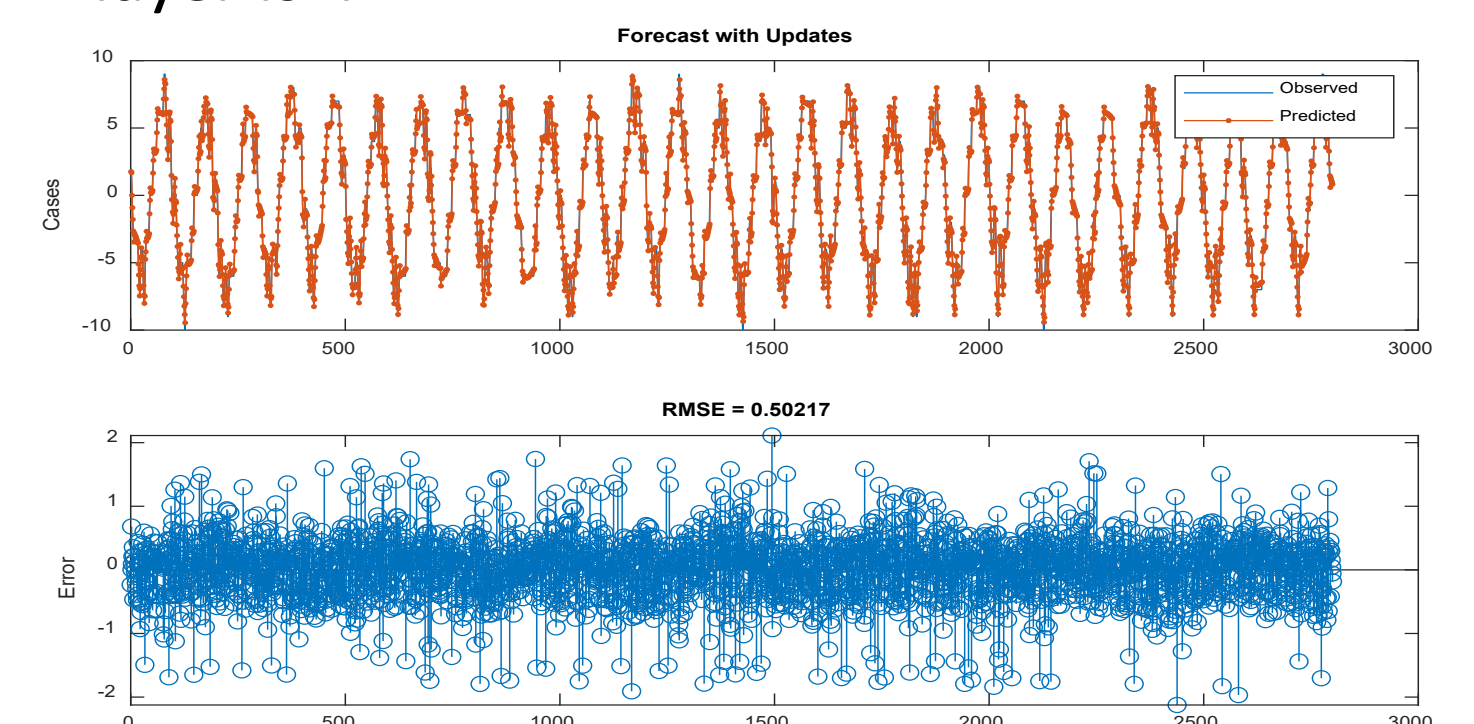


Fig. 5 The number of neurons in the hidden layer is 10

numHiddenUnits	Training	Forecast RMSE	Forecast with updates RMSE
200	41min 36sec	7.3051	0.45777
20	4min 36sec	4.2081	0.4841
10	4min 07sec	2.6541	0.50217
4	3min 53sec	6.3785	0.78708

Fig. 6 The resulting prediction table according to the number of neurons in the hidden layer

### CONCLUSIONS

- With the number of 200 neurons in the hidden layer, the learning time is extended. The result of the accuracy of the deviation or error prediction is not significantly different from the use of a smaller number of neurons. Therefore, the optimal number of neurons in the hidden layer is 10. This number ensures a shorter learning time with a prediction accuracy of 0.50217.
- Optimizing the number of neurons in the hidden layer determines the accuracy and speed of prediction.
- Control deviation prediction (control error) can be used, for example, to predict emergencies.

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## INTRODUCTION

There are a number of path planning algorithms that solve the navigation problem. Over the past two decades, various methods and improvements to algorithms have been developed to solve this problem. These methods have been presented in several research papers (Liu, Y. et al. 2018). The most used algorithms include particle filter, Monte Carlo algorithm, A\* (A star), PRM (Probabilistic Road Map), RRT (Rapidly-exploring Random Tree), Dijkstra's algorithm, Kalman filter and many others.

## MATERIALS AND METHODS

The algorithms for working with the robot:

- A star algorithm – it is often used in the game industry, in robotics, or with maps on the web precisely for the purpose of searching for the shortest path (Ravikiran, A., 2023; Geeksforgeeks, 2023).
- Heuristics Manhattan, Chebyshev and Euclidean distance (Figure 1).
- BFS algorithm - also referred to as breadth-first search algorithm belongs to uninformed types of algorithms. It is a traversal of the nodes of the graph, which starts at the initial node and gradually traverses all neighboring nodes.

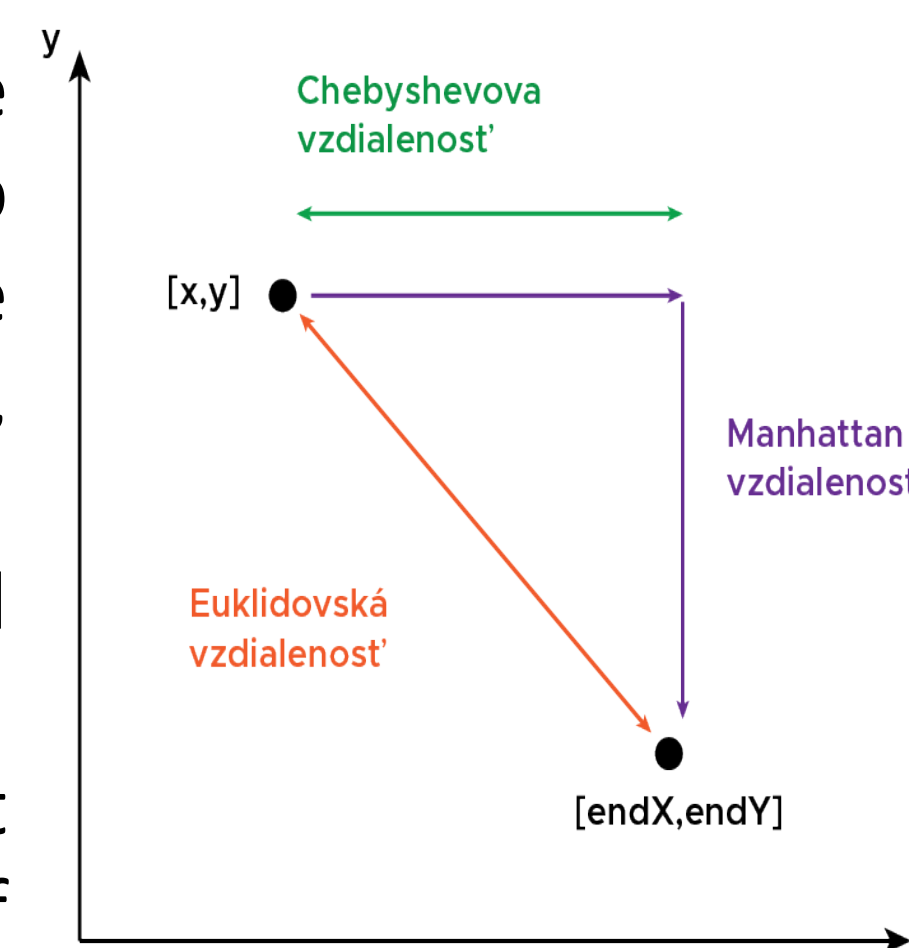


Figure 1 Comparison of distance heuristics

## AIM

The goal was to find the shortest path in the maze using Lego Mindstorms.

- Building a robot
  - Creating a maze in the shape of the letters H
  - Application of A star and BFS algorithms in Eclipse and leJOS environments.
- Comparison of algorithms:
- total path calculation time

## RESULTS

For the maze H, the BFS algorithm with the fastest computation time is the best. For the A star algorithm, the Chebyshev heuristic was the best and the Manhattan heuristic the worst. The difference in heuristics is significant in this maze. The effectiveness of this heuristic has been confirmed not only by our findings but also by scientific publications in this area. [48, 49] So we can evaluate that the BFS algorithm with the shortest time was the best for Maze H, the movement of the robot along the resulting route was equally good because it did not contain frequent divisions.

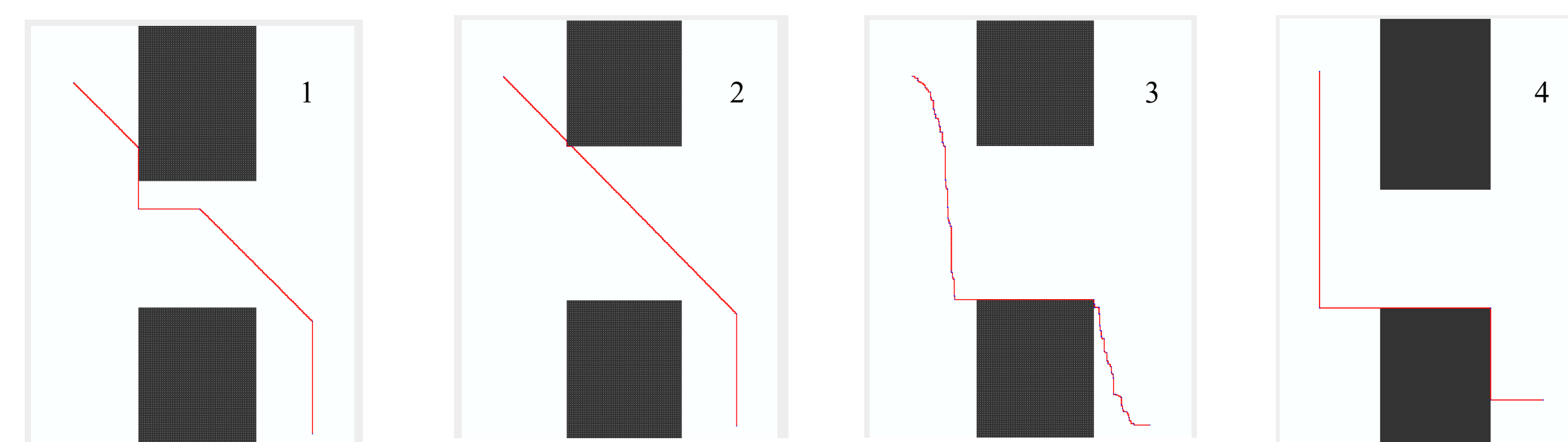


Figure 2 Resulting path for map H - 1 A\* Euclidean heuristics, 2 A\* Chebyshev heuristics, 3 A\* Manhattan heuristics, 4 BFS algorithm

Total time for path calculating of the map H (ms)				
Algorithm	A star			BFS
	Euclidean distance	Manhattan	Chebyshev	
1	6811	7795	4453	234
2	6756	8064	4461	232
3	6761	7928	4450	171
4	6779	7970	4461	187
5	6787	7922	4462	174
6	6774	8090	4476	172
7	6799	8506	4475	176
8	6779	8045	4488	177
9	6806	8324	4468	178
10	6789	8701	4478	191
<b>Average</b>	<b>6784,1</b>	<b>8134,5</b>	<b>4467,2</b>	<b>189,2</b>

Table 1 Total time for path calculating of the map H robot

## CONCLUSIONS

In this paper, we have successfully described and demonstrated the use of A\* star and BSF algorithms. Within our environment, we introduced pathfinding from setting the start and end positions. The presented facts of the two approaches show that it is important to choose the right path planning algorithm suitable for a specific application and environment.

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