

№	Статья и ссылка	Аннотация
1	<p>Sagindykov, B., & Bimurat, Z. (2024). IMPLEMENTATION OF THE ALGEBRA OF HYPERDUAL NUMBERS IN NEURAL NETWORKS. <i>Scientific Journal of Astana IT University</i>, 20, 5–17. https://doi.org/10.37943/20ERZJ2964</p>	<p>For the numerical solution of problems arising in various fields of mathematics and mechanics, it is often necessary to determine the values of derivatives included in the model. Currently, numerical values of derivatives can be obtained using automatic differentiation libraries in many programming languages. This paper discusses the use of the Python programming language, which is widely used in the scientific community. It should be noted that the principles of automatic differentiation are not related to numerical or symbolic differentiation methods. The work consists of three parts. The introduction reviews the historical development of the general theory of complex numbers and the use of simple complex, double and dual numbers, which are a subset of the set of general complex numbers, in various fields of mathematics. The second part is devoted to the algebra of dual and hyperdual numbers and their properties. This section presents tables of the basis element of elementary functions with dual and hyperdual arguments, based on multiplication rules. Two important formulas for finding the numerical values of a complex function's first and second derivatives by expanding functions with dual and hyperdual arguments in the Taylor series are also obtained. A simple test function was used to verify the correctness of these formulas, the results of which were checked analytically as well as through implementation in a programming language. The third part of the paper focuses on practical applications and the implementation of these methods in Python. It includes detailed examples of case studies demonstrating the effectiveness of using hyperdual numbers in automatic differentiation. The results highlight the accuracy and computational efficiency of these methods, making them valuable tools for researchers and engineers. This comprehensive approach not only validates the theoretical aspects but also showcases the practical utility of dual and hyperdual numbers in solving complex mathematical and mechanical problems.</p>

		<p>Keywords: dual numbers, hyperdual numbers, automatic differentiation, Taylor series expansion</p>
2	<p>Kulakayeva, A., Tikhvinskiy, V., Nurlankyzy, A., & Namazbayev, T. (2024). COMPARATIVE ANALYSIS OF THE EFFECTIVENESS OF NEURAL NETWORKS AT DIFFERENT VALUES OF THE SNR RATIO. <i>Scientific Journal of Astana IT University</i>, 20, 18–30. https://doi.org/10.37943/20TTRV6747</p>	<p>This work is devoted to a comparative analysis of the effectiveness of neural networks, CNN and RNN, at different SNR ratios. The research conducted within the framework of this work showed that CNN convolutional neural networks demonstrate higher efficiency in speech signal recognition tasks, regardless of different levels of SNR ratio and language. Thus, the CNN neural network showed stable superiority over RNN under all conditions, especially at low SNR ratios. It was revealed that with an increase in the SNR ratio, the difference in accuracy between the CNN and RNN neural networks decreases, but the CNN continues to lead, which indicates its higher adaptability and ability to learn under conditions of different noise and interference levels. It is especially important to note that the advantage of CNN becomes noticeable at low SNR values, where the accuracy of the RNN decreases more significantly. As a result, with an SNR ratio of 3 dB, the recognition accuracy using CNN was 80% for the Kazakh language, whereas RNN showed a result in the region of 75%. With an increase in the SNR ratio to 21 dB, the difference in accuracy between CNN and RNN decreased, but CNN continued to lead, reaching 88% accuracy compared to 86% for RNN. In addition, the results showed that the effectiveness of the CNN and RNN depended on the language in which they were trained. Neural networks trained in Kazakh showed the best results in recognizing Kazakh speech but also successfully coped with recognizing the Russian language. This highlights the importance of considering language features when developing and training neural networks to improve their performance in multilingual environments.</p> <p>Keywords: artificial neural networks, convolutional neural network, recurrent neural network, voice activity detector, signal-to-noise ratio</p>
3	<p>Kuatbayeva, A., Sergaziyev, M., Issenov, D., & Yedilkhan, D. (2024). DEEP NEURAL NETWORK AND CNN MODEL OF DRIVING BEHAVIOR PREDICTION FOR</p>	<p>This research applies deep neural networks (DNN) and convolutional neural networks (CNN) to the modeling and prediction of driving behavior in autonomous vehicles within the Smart City context. Developed,</p>

AUTONOMOUS VEHICLES IN SMART CITY. *Scientific Journal of Astana IT University*, 20, 31–47. <https://doi.org/10.37943/20MNZJ4935>

trained, validated, and tested within the Keras framework, the model is optimized to predict the steering angle for self-driving vehicles in a controlled simulated environment. Utilizing a training dataset comprised of image data paired with steering angles, the model achieves autonomous navigation along a designated track. Key innovations in the model's architecture, including parameter fine-tuning and structural optimization, contribute to its computational efficiency and high responsiveness. The integration of convolutional layers facilitates advanced spatial feature extraction, while the inclusion of repeated layers mitigates information loss, with implications for potential future enhancements. Clustering algorithms, including K-Means, DBSCAN, Gaussian Mixture Model, Mean-Shift, and Hierarchical Clustering, further augment the model by providing insights into driving environment segmentation, obstacle detection, and driving pattern analysis, thereby enhancing complex decision-making capabilities amid real-world noise and uncertainty. Empirical results demonstrate the efficacy of Gaussian Mixture and DBSCAN algorithms in addressing environmental uncertainties, with DBSCAN displaying robust noise tolerance and anomaly detection capabilities. Additionally, the CNN model exhibits superior performance, with lower loss values on both training and validation datasets compared to an RNN model, underscoring CNN's suitability for visually driven tasks within autonomous systems. The study advances the field of autonomous vehicle behavior prediction through a novel integration of neural networks and clustering algorithms to support sophisticated decision-making in autonomous driving. The findings contribute to the development of intelligent systems within the Smart City framework, emphasizing model precision and computational efficiency.

Keywords:

self-driving cars, machine learning, Mean-shift clustering, Udacity car simulator, Gaussian mixture model, K-means clustering, DBSCAN, self-driving cars; machine learning; Mean-Shift Clustering; Udacity Car

		Simulator; Gaussian Mixture Model; K-Means clustering; DBSCAN; hierarchical clustering.
4	<p>Zhukabayeva, T., Karabayev, N., Nurusheva, A., & Satybaldina, D. (2024). A METHOD OF VULNERABILITY ANALYSIS IN WIRELESS INTERNET OF THINGS NETWORKS FOR SMART CITY INFRASTRUCTURES . <i>Scientific Journal of Astana IT University</i>, 20, 48–61.</p> <p>https://doi.org/10.37943/20VPSX8675</p>	<p>The article proposes an approach to information security vulnerability analysis and threat modeling in wireless Internet of Things networks for Smart City infrastructures. Currently, such infrastructures are becoming increasingly widespread in a variety of Smart City application areas, including industrial life support systems, pipelines, communication networks, and transportation systems. The wide coverage of end users, the critical nature of such infrastructures and the value of their inherent assets determine the increasing importance of solving problems of determining the security level of such infrastructures and the timely application of protective measures. The ultimate goal of the proposed approach is to assess the security of the infrastructure. This article analyses articles at the intersection of the subject area of vulnerability and attack analysis in information systems and networks and the area of Smart City infrastructure issues. The proposed approach includes the use of an analytical model of an intruder which, together with the analysis of the specification of a specific Smart City infrastructure, allows us to determine the current types of attacks. In order to obtain infrastructure security assessments, the CAPEC database of wireless network vulnerabilities and attack patterns is analysed. In this case, the main attributes of the attacks are identified, unified and transformed into a single format using the numerical values of the considered attributes. The feasibility of the proposed approach is also analysed and its main advantages and disadvantages are considered. In addition, the main areas of further activity and tasks related to testing and improving the proposed approach in practice are identified.</p> <p>Keywords: internet of things, wireless networks, smart city infrastructure, attack, vulnerability</p>
5	<p>Karabaliyev, Y., & Kolesnikova, K. (2024). KAZAKH SPEECH AND RECOGNITION METHODS: ERROR ANALYSIS AND IMPROVEMENT PROSPECTS. <i>Scientific Journal of</i></p>	<p>This study offers a detailed evaluation of automatic speech recognition (ASR) systems for the Kazakh, examining their performance in recognizing the phonetic and linguistic features unique to the language. The Kazakh language presents specific challenges for ASR</p>

	<p><i>Astana IT University, 20, 62–75.</i> https://doi.org/10.37943/20DZGH8448</p>	<p>due to its complex phonology, vowel harmony, and the presence of multiple regional dialects. To address these challenges, a comparative analysis of three leading ASR systems were conducted—Kaldi, Mozilla DeepSpeech, and Google Speech-to-Text API—using a dataset of 101 recordings of spoken the Kazakh text. This study focuses on the systems' word error rates (WER), identifying common misrecognitions, especially with the Kazakh-specific phonemes like "к," "н," and "ү." Kaldi and Mozilla DeepSpeech exhibited high WERs, particularly struggling with Kazakh's vowel harmony and consonant distinctions, while Google Speech-to-Text achieved of the lowest WER among the three. However, none of the systems demonstrated accuracy levels sufficient for practical applications, as errors in recognizing Kazakh's agglutinative morphology and case endings remained pervasive. To improve these outcomes, a series of enhancements are proposed, including adapting acoustic models to better reflect Kazakh's phonetic and morphological traits, integrating dialect-specific data, and employing machine learning methods such as transfer learning and hybrid models. Additional steps include refining data preprocessing and increasing dataset diversity to capture Kazakh's linguistic nuances more accurately. By addressing these limitations, the ASR systems can better handle complex sentence structures and regional speech variations. This research thus provides a foundation for advancing Kazakh ASR technologies and contributes insights that are vital for developing inclusive, effective ASR systems capable of supporting linguistically diverse users.</p> <p>Keywords: The Kazakh speech recognition, Automatic speech recognition , Kaldi, Mozilla DeepSpeech, Google Speech-to-Text API, Speech recognition errors, Phonetic analysis, Acoustic model adaptation, Linguistic features, the Kazakh language processing</p>
<p>6</p>	<p>Bakirov, K., Tussupov, J., Tultabayeva, T., Makangali, K., Abdikerimova, G., & Yessenova, M. (2024). ADVANCES IN THE DESIGN AND OPTIMIZATION OF SMART IRRIGATION SYSTEMS</p>	<p>Urban vertical farming has emerged as a sustainable and innovative approach to addressing the increasing global demand for food in rapidly growing and densely populated cities, where traditional agriculture faces</p>

	<p>FOR SUSTAINABLE URBAN VERTICAL FARMING. <i>Scientific Journal of Astana IT University</i>, 20, 76–90. https://doi.org/10.37943/20NNYR9391</p>	<p>significant challenges due to space and resource constraints. A primary issue in these systems is the efficient management of critical resources, particularly water and energy, which are essential for maintaining high crop productivity and environmental sustainability. This study introduces, develops, and evaluates a mathematical model that integrates Internet of Things (IoT) technology to optimize water and energy usage in a hydroponic vertical farming setup. The model utilizes real-time environmental data collected from IoT sensors to dynamically adjust irrigation and energy consumption, ensuring minimal waste while sustaining optimal conditions for plant growth. Extensive simulations conducted using Python demonstrate substantial improvements in Water Use Efficiency (WUE) and significant energy savings, validating the model's effectiveness. The study also presents practical case studies from regions like Singapore, Qatar, and Malaysia, showcasing how the integration of renewable energy sources, such as solar photovoltaic panels, with advanced smart irrigation technologies can lead to up to 50% growth rate improvements. Despite existing challenges, such as high initial capital investments, technical complexities, and the need for continuous maintenance, the findings indicate that modular and scalable system designs offer a promising path forward. Future research should aim to reduce overall costs and enhance system adaptability for various urban environments. Ultimately, this research provides a scalable and efficient framework for advancing urban agriculture, with the potential to contribute significantly to global food security and promote the sustainability of urban ecosystems.</p> <p>Keywords: vertical farming, internet of things, automation, smart irrigation systems, artificial intelligence, machine learning, water management, sustainable urban agriculture, crop yield optimization</p>
7	<p>Mukhatayev, A., Biloshchytskyi, A., Biloshchytska, S., & Medetbek, A. (2024). A MODEL FOR PLANNING THE WORKLOAD OF TEACHERS, TAKING INTO ACCOUNT RISKS AND IN ACCORDANCE WITH THE</p>	<p>A model for planning the workload of teachers is proposed to address the unique demands of a credit-modular system in higher education, aligning with the European Credit Transfer and Accumulation System (ECTS) standards. This model seeks to balance teacher workload by</p>

<p>REQUIREMENTS OF THE EUROPEAN SYSTEM OF CREDIT MODULES OF HIGHER EDUCATION. <i>Scientific Journal of Astana IT University</i>, 20, 91–101. https://doi.org/10.37943/20ASCK9705</p>	<p>considering various types of associated risks, such as shortages of qualified staff, limited resources, and the risk of department overload. The primary objective is to structure teaching plans for discipline modules in a way that optimizes available university resources while adhering to credit requirements. To maintain stability in higher education institutions and support the creation of new educational programs, it is essential to address key challenges. The ongoing progressive changes in the education sector of the Republic of Kazakhstan necessitate efforts to enhance the effectiveness of higher education institutions, develop innovative educational programs, and improve the overall quality of education. Key aspects of this model involve integrating risk management into the planning process, which allows for a more adaptive and resilient approach to curriculum design. By systematically linking different types of workloads to associated risks, the model facilitates the development of balanced teaching plans that support both educational quality and staff well-being. The study concludes that this model can be a powerful tool for optimizing teacher workload distribution, potentially enhancing the stability of the educational process. Additionally, the model lays the groundwork for the creation of software tools that could automate workload planning, enabling higher education institutions to mitigate risks more effectively. The proposed approach, therefore, not only improves planning accuracy but also aligns with European higher education standards, ensuring a sustainable, high-quality educational experience.</p> <p>Keywords: Teacher workload planning, curriculum optimization, European Credit Module system, discipline</p>
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