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DEEP LEARNING AND ITS ADVANCEMENTS, CHALLENGES, AND APPLICATIONS.

Eshtursunov Maruf
Termez State Pedagogical Institute,
Teacher of Computer Science,
Faculty of Natural and Exact Sciences
E-mail: eshtursunovmaruf@icloud.com
Turayev Ruziboy
Termez State Pedagogical Institute,
Department of Mathematics and Informatics,
A.Assoc. Prof., PhD.

Annotation. Deep learning, a subset of machine learning, has emerged as a transformative technology capable of solving complex problems in various domains, including healthcare, autonomous systems, finance, and creative industries. This thesis provides an in-depth exploration of deep learning's theoretical foundations, key advancements, major applications, and associated challenges. Additionally, it discusses ethical concerns such as bias, interpretability, and the environmental impact of deep learning models. The research aims to provide insights into the future of deep learning and its interdisciplinary impact.

Deep learning has already reshaped the technological landscape, but its full potential is still unfolding. As researchers push the frontiers of AI, the key challenge will be to harness deep learning's power responsibly—ensuring that AI is not only intelligent but also fair, interpretable, and sustainable. By addressing its limitations and integrating human values into AI systems, deep learning can truly become a force for good, shaping a future where intelligent systems collaborate with humans to solve the world's most pressing challenges.

Keywords: Deep learning, machine learning, AI (artificial intelegance), autonomous systems, Big Data, applications, neural networks, image recognition, speech and time-series analysis.

DEEP LEARNING VA UNING YUTUQLARI, MUAMMOLARI VA ILOVALARI

Annotatsiya. Ushbu maqolada mashinani o'rganishning bir qismi bo'lgan chuqur o'rganish turli sohalarda, jumladan sog'liqni saqlash, avtonom tizimlar, moliya va ijodiy sohalarda murakkab muammolarni hal qilishga qodir transformativ texnologiya sifatida paydo bo'ldi. Ushbu tadqiqot chuqur o'rganishning nazariy asoslari, asosiy yutuqlari, asosiy ilovalari va ular bilan bog'liq muammolarni chuqur o'rganishni ta'minlaydi. Bundan tashqari, unda chuqur o'rganish modellarining noto'g'riligi, izohlanishi va atrof-muhitga ta'siri kabi axloqiy muammolar muhokama qilinadi. Machine learningni chuqur o'rganishning kelajagi va uning fanlararo ta'siri haqida tushuncha berishga qaratilgan. Chuqur o'rganish allaqachon texnologik landshaftni qayta shakllantirgan, ammo uning to'liq salohiyati hali ham ochilmoqda. Tadqiqotchilar sun'iy intellektning chegaralarini ilgari surar ekan, asosiy muammo chuqur o'rganish kuchidan mas'uliyat bilan foydalanish bo'ladi - AI

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nafaqat aqlli, balki adolatli, talqin qilinadigan va barqaror bo'lishini ta'minlash. Uning cheklovlarini bartaraf etish va insoniy qadriyatlarni sun'iy intellekt tizimlariga integratsiyalash orqali chuqur o'rganish haqiqatan ham yaxshilik uchun kuchga aylanishi mumkin, bu esa aqlli tizimlar dunyodagi eng dolzarb muammolarni hal qilish uchun odamlar bilan hamkorlik qiladigan kelajakni shakllantirishi mumkin.

Kalit so'zlar: Chuqur o'rganish, mashinani o'rganish, AI (sun'iy intellekt), avtonom tizimlar, katta ma'lumotlar, ilovalar, neyron tarmoqlar, tasvirni aniqlash, nutq va vaqt seriyalarini tahlil qilish.

ГЛУБОКОЕ ОБУЧЕНИЕ И ЕГО ДОСТИЖЕНИЯ, ПРОБЛЕМЫ И ПРИЛОЖЕНИЯ

Аннотация. В этой статье глубокое обучение, разновидность машинного обучения, превратилось в преобразующую технологию, способную решать сложные проблемы в различных отраслях, включая здравоохранение, автономные системы, финансы и творческие отрасли. Эта диссертация представляет собой углубленное исследование теоретических основ, основных достижений, ключевых приложений и связанных с ними проблем глубокого обучения. Кроме того, в нем обсуждаются этические вопросы, такие как ошибочность, интерпретируемость и воздействие моделей глубокого обучения на окружающую среду. Цель: дать представление о будущем глубокого машинного обучения и его междисциплинарном влиянии. Глубокое обучение уже изменило технологический ландшафт, но его полный потенциал еще не раскрыт. Поскольку исследователи расширяют границы ИИ, ключевой проблемой станет ответственное использование мощи глубокого обучения — обеспечение того, чтобы ИИ был не только интеллектуальным, но и справедливым, интерпретируемым и устойчивым. Устранив свои ограничения и интегрировав человеческие ценности в системы ИИ, глубокое обучение действительно может стать силой добра, формируя будущее, в котором интеллектуальные системы будут сотрудничать с людьми для решения самых насущных мировых проблем.

Ключевые слова: Глубокое обучение, машинное обучение, ИИ (искусственный интеллект), автономные системы, большие данные, приложения, нейронные сети, распознавание изображений, анализ речи и временных рядов.

INTRODUCTION: HUMAN BRAIN AND NEUTRAL NETWORKS.

1.1 Human brain and its comparison with netural networks

1.2 Neural network

Deep learning, drawing inspiration from the human brain, employs artificial neural networks to identify significant patterns in data. It has become highly popular because of its capacity to handle large quantities of information, learn from unrefined data, and excel in tasks like image recognition, speech analysis, and decision-making. The increase in deep learning can be linked to three key factors. The human brain serves as the primary organ of the nervous system, and along with the spinal cord, makes up the central nervous system. It is made up of the cerebrum, brainstem, and cerebellum. The brain manages nearly all body activities, processing, integrating, and coordinating the information it gets from the sensory nervous system **[1.1]**

The cerebrum, which is the biggest section of the human brain, is made up of two cerebral hemispheres. Every hemisphere contains an inner core made of white matter, as well as an outer layer – the cerebral cortex – formed of grey matter. The cortex consists of an outer neocortex layer and an inner allocortex. The neocortex consists of six layers

of neurons, whereas the allocortex comprises three or four layers. Every hemisphere is split into four lobes: the frontal, parietal, temporal, and occipital lobes. The frontal lobe is linked to executive functions such as self-regulation, planning, reasoning, and abstract thinking, whereas the occipital lobe focuses on vision. In each lobe, the cortical regions correspond to particular functions, including sensory, motor, and association areas. While the left and right hemispheres are generally alike in shape and function, certain abilities are linked to one side, like language in the left hemisphere and visual-spatial skills in the right. The hemispheres are linked by commissural nerve pathways, with the largest being the corpus callosum. A neural network is made up of interconnected units or nodes known as artificial neurons, which roughly imitate the neurons found in the brain. Recent investigations have focused on artificial neuron models that more closely resemble biological neurons, demonstrating a notable enhancement in performance. These are linked by edges, which represent the synapses in the brain. Every artificial neuron obtains signals from associated neurons, processes them, and then transmits a signal to other connected neurons. The "signal" refers to a real number, and the output generated by each neuron is determined by a non-linear function of the total of its inputs, known as the activation function. The intensity of the signal at every connection is influenced by a weight that changes throughout the learning process. Generally, neurons are grouped into layers. Various layers might carry out distinct transformations on their inputs. Signals move from the initial layer (the input layer) to the final layer (the output layer), potentially going through various intermediate layers (hidden layers). A network is generally referred to as a deep neural network when it consists of a minimum of two hidden layers.[1.2]

OBJECTIVES OF THE STUDYING DEEP LEARNING AND LITERATURE DISCUSSION.

1.3 The availability of large-scale datasets (Big Data).

1.4 The exponential increase in computational power, particularly with GPUs and TPUs.

Big data pertains to data collections that are so vast and intricate that managing them with conventional database management tools becomes challenging.

It encompasses different types of data that are located outside relational databases, including documents, audio, video, and emails, along with the enhanced speed and accessibility of data. Big data is characterized by its dimensions of volume, variety, and velocity.

The conventional definition of big data was solely about the amounts of data that needed new, extensive systems/software to handle the data within a reasonable timeframe. (Yinle Zhou, 2015)

Subsequently, the definition was updated as individuals acknowledged that the issue was not solely the amount of data generated, but also the speed (transactional velocity) at which it was created and the diversity (structured and unstructured) of data. This is the source of the term "Three Vs" definition, which has at times been expanded to four Vs by adding the "veracity" (quality) of the data.

Machine learning is a category of computer algorithms that gain knowledge from examples without direct programming (Stanley Cohen, 2021), whereas deep learning is a more sophisticated machine learning algorithm based on the concept of neural networks. Deep learning algorithms can manage and operate with large data sets and also function as processors by stacking nonlinear data processing layers, as described in "Anatomy of the Brain" by John C. K. Machine learning algorithms have the ability to learn from past computations upon encountering new data, and they identify patterns to deliver consistent results (T.M. Navamani, 2019). Deep learning algorithms

are intricate, consisting of multiple layers of "neurons" and primarily utilized for classification purposes, supplied with vast data sets that can handle natural language, identify images, and learn to carry out highly advanced tasks autonomously, as detailed in "The Tell-Tale Brain" by V.S. Ramachandran.**[2.1]**

Tensor Processing Units (TPUs) are specialized hardware designed to perform specific mathematical computations necessary for artificial intelligence models, especially in the realms of machine learning and deep learning. Created by Google, TPUs signify a breakthrough in computational hardware, directly addressing the increasing need for effective processing of intricate models. To appreciate the importance of this innovation, it's essential to begin with their main role: speeding up the basic mathematical processes needed by neural networks. Neural networks are central to many current AI applications, ranging from facial recognition systems to machine translation tools and interactive chatbots such as ChatGPT. These models are arranged in layers of linked nodes, with each connection and node executing computations based on data matrices. These computations include processes such as matrix multiplication, summing elements, and various linear and non-linear transformations. For instance, picture a neural network attempting to identify an image as either a "cat" or a "dog." Throughout this process, each pixel in the image is quantified by numbers and adjusted through mathematical formulas over millions of iterations, demanding substantial computational power.

Historically, these computations were carried out by Central Processing Units (CPUs) or Graphics Processing Units (GPUs). Although CPUs excel at general tasks, they aren't intended for large-scale parallel data processing, a key requirement for machine learning models. GPUs, conversely, represented a major advancement by delivering enhanced parallel computing capability because of their architecture tailored for graphic data handling, which also showed advantages for neural networks. Nonetheless, as deep learning models evolved into more intricate structures and the volume of data increased, even GPUs started to reveal their constraints. TPUs were designed to address these constraints. In contrast to general-purpose CPUs and GPUs, TPUs are specialized devices created solely to execute the computations central to machine learning. This specific design enables them to attain markedly better performance regarding speed and energy efficiency when compared to conventional hardware. For example, TPUs can execute tasks such as matrix multiplication and addition at velocities that greatly surpass those of the most cutting-edge GPUs. **[2.2]**

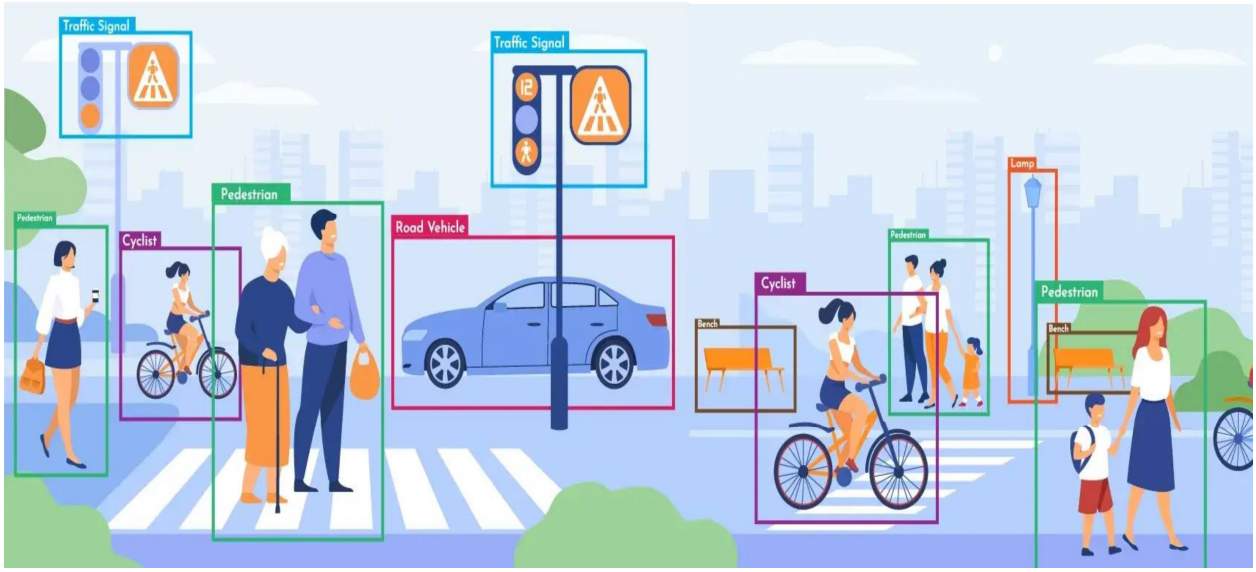
POSSIBLE OUTCOMES USING DEEP LEARNING.

1.5 Object Detection: Identify and categorize objects in images and videos, including recognizing cars, individuals, animals, or particular products in a shopping environment.

Object detection represents a key challenge in the field of computer vision. It serves as the foundation for numerous subsequent computer vision tasks, such as instance and image segmentation, image captioning, object tracking, and others. Applications for specific object detection encompass pedestrian identification, animal recognition, vehicle identification, counting individuals, face recognition, text identification, pose evaluation, and license plate recognition.

As computer vision evolves, it has moved from the "Slope of Enlightenment" to the "Plateau of Productivity" in the Gartner Hype Cycle. Due to technological advancements, greater acceptance, and real-world applications in various sectors, computer vision, particularly object detection, is moving into a stage of stability and extensive incorporation. Attention now turns from

experimental phases to enhancing and fine-tuning current applications, representing a vital step toward its complete realization and influence on businesses across multiple sectors.



1-picture. It is all about how to detect human and object using facial recognition.

3.2 Image Recognition: Identify and categorize items, settings, or facial features. A facial recognition system is a technology that can possibly identify a human face from a digital image or video frame by comparing it to a database of faces. This type of system is usually used to verify user identities via ID verification services, functioning by identifying and analyzing facial characteristics from an image provided. Work started on comparable systems in the 1960s, originating as a type of computer software. Since their creation, facial recognition systems have experienced broader applications lately on smartphones and in various technologies, including robotics. Since computerized facial recognition measures a person's physiological traits, these systems fall under the category of biometrics. Despite having lower accuracy than iris recognition, fingerprint imaging, palm recognition, or voice recognition, facial recognition systems are widely used because of their contactless nature. Facial recognition technology has been implemented in sophisticated human-computer interaction, video monitoring, law enforcement, passenger screening, employment and housing decisions, and automatic image indexing.

Facial recognition technology is utilized globally by both governments and private enterprises today. Their efficiency differs, and certain systems have been discontinued in the past due to their lack of effectiveness. The implementation of facial recognition technology has sparked debate, with assertions that these systems infringe on individuals' privacy, frequently produce inaccurate identifications, promote gender stereotypes and racial profiling, and fail to safeguard critical biometric information. The emergence of synthetic media like deepfakes has also sparked worries regarding its safety. These assertions have resulted in the prohibition of facial recognition technology in numerous cities across the United States. Increasing societal worries prompted the social networking firm Meta Platforms to disable its Facebook facial recognition system in 2021, erasing face scan data for over one billion users. The alteration marked one of the most significant transitions in the application of facial recognition throughout the technology's

history. IBM also ceased providing facial recognition technology because of comparable issues

CONCLUSION:

Deep learning has become one of the most important advancements in artificial intelligence, transforming various industries and expanding the limits of what machines can accomplish. Its capacity to handle large volumes of data, identify intricate patterns, and perform human-like decision-making has established it as the foundation of contemporary AI applications. From revolutionizing healthcare through AI-powered diagnostics to improving natural language comprehension with advanced transformer models, deep learning has already shown its vast capabilities. Nonetheless, in spite of these improvements, deep learning is still not flawless. A significant challenge is the "black box" issue—the difficulty in understanding complex deep learning models. With AI systems playing a growing role in critical decisions within medicine, finance, and criminal justice, there is an immediate demand for explainable AI (XAI) frameworks that enhance the transparency and reliability of model decisions. A significant obstacle also exists in terms of bias and fairness. As deep learning models learn from data, they naturally acquire biases found in the training datasets. Instances of racial and gender discrimination in AI-driven recruitment systems, facial recognition technologies, and predictive policing methods underscore the ethical concerns surrounding biased models. Tackling this issue necessitates not only varied and representative datasets but also algorithmic approaches to reduce bias and guarantee fairness.

Additionally, the resource-demanding characteristics of deep learning present sustainability issues. Training deep learning models, particularly large architectures such as GPT-4 or AlphaFold, necessitates substantial computational resources and utilizes significant energy. As AI research advances, it is essential to investigate more energy-efficient AI models and utilize quantum computing or neuromorphic hardware to minimize the carbon footprint of AI training methods.

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