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ARTIFICIAL INTELLIGENCE-SUPPORTED PATTERN RECOGNITION

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Abstract

The importance of using artificial intelligence (AI) is increasing over time and AI is breaking into more and more sectors of the economy. Nowadays, the question is no longer whether we use artificial intelligence at all, but how we could increase its use in even more work processes and tasks.

Pattern recognition is an extremely important part of artificial intelligence because the recognized patterns serve as a basis for subsequent decision-making processes. This research is based on the observation of secondary data analysis, taking into account the relevant international literature.

The research focuses on an exhaustive review of artificial intelligence-supported pattern recognition within the dynamic field of AI. The goal of the research is to examine the key components that support pattern recognition in AI systems and make it successful.

At the same time, it explores the wide range of uses for this technology in several fields and looks ahead to potential future developments to see how AI-assisted pattern recognition can influence technology in the future. Artificial intelligence will dramatically improve pattern recognition systems' efficiency in processing data, accuracy of categorization, and adaptability of datasets.

Artificial intelligence advances promote accessibility, efficiency, and accuracy in jobs ranging from automation to medical decision-making, enhancing and integrating a variety of industries. The European Union created a thorough AI strategy and greatly expanded funding for AI implementation, research, and development. Due to the timeliness and rapid development of the topic, it is important that the topic is constantly examined.

Keywords: pattern recognition, artificial intelligence, machine learning, deep learning

MESTERSÉGES INTELLIGENCIA ÁLTAL TÁMOGATOTT MINTAFELISMERÉS

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Absztrakt

A mesterséges intelligencia (AI) használatának jelentősége az idő előrehaladtával egyre növekszik és a gazdaság egyre több szektorába betör a mesterséges intelligencia. Mára már nem az válik kérdésessé, hogy használjuk-e egyáltalán a mesterséges intelligenciát, hanem az a kérdés, hogyan tudnánk fokozni a használatát még több munkafolyamatban, feladatban.

A mintafelismerés egy rendkívül fontos része a mesterséges intelligenciának, mert a felismert minták alapul szolgálnak a későbbi döntéshozatali folyamatokban. A vizsgálat szekunder adatelemzésen alapul, figyelembe véve a vonatkozó nemzetközi szakirodalmat.

A kutatás a mesterséges intelligencia által támogatott mintafelismerés alapos áttekintésére összpontosít az AI dinamikus területén. A kutatás célja, hogy megvizsgálja azokat a kulcsfontosságú összetevőket, amelyek támogatják a mintafelismerést az AI-rendszerekben és sikeressé teszik azt.

Ugyanakkor feltárja ennek a technológiának a széles körű felhasználási területeit, illetve előretekint a lehetséges jövőbeli fejlesztésekre, hogy megfigyeljük, miként befolyásolhatja a mesterséges intelligencia által támogatott mintafelismerés a jövő technológiáit. A mesterséges intelligencia drámaian javítani fogja a mintafelismerő rendszerek adatfeldolgozási hatékonyságát, a kategorizálás pontosságát és az adatkészletek adaptálhatóságát.

A mesterséges intelligencia fejlődése elősegíti a hozzáférhetőséget, a hatékonyságot és a pontosságot az automatizálástól az orvosi döntéshozatalig terjedő munkakörökben, valamint ezenkívül számos iparágat fejleszt és integrál. Az Európai Unió alapos mesterséges intelligencia-stratégiát dolgozott ki, és jelentősen megnövelte a mesterséges intelligencia megvalósításának, kutatásának és fejlesztésének finanszírozását. A téma időszerűsége és gyors fejlődése miatt lényeges a téma folyamatos vizsgálata.

Kulcsszavak: mintafelismerés, mesterséges intelligencia, gépi tanulás, mély tanulás

Introduction

It is crucial to investigate pattern recognition in the quickly changing field of artificial intelligence. It is becoming more and more important to comprehend the nuances of AI-supported pattern recognition as we move through a time of unparalleled technological growth. This study undertakes a thorough investigation of the topic, exploring the fundamental elements that underpin AI-supported pattern recognition, looking into its various application areas, and casting a glance ahead to show upcoming developments.

The ubiquitous influence of pattern recognition across multiple areas highlights the significance of AI in the current technological environment. The ability of AI systems to recognize and understand patterns in data is revolutionary in a variety of fields. The complexities of pattern recognition are becoming a focus for scholars, practitioners, and technologists alike as we approach a new era where AI is incorporated into our daily lives.

In my research, I put forward three hypotheses that I am investigating during my research, and I am looking for the possible answers. H1: Artificial intelligence-supported pattern recognition will keep developing, and allowing machines to mimic and even exceed human abilities in seeing and processing complicated data. H2: Artificial intelligence will increasingly integrate with and improve a variety of industries as it develops. H3: The European Union has committed significant financial resources to support the development of AI in recognition of the technology's strategic importance.

The main objective of this research is to get a deeper understanding of AI-supported pattern recognition by dissecting its complex components and illuminating its significant consequences for both the present and the future.

Pattern Recognition

Humans have evolved extremely complex abilities to sense their surroundings and respond accordingly. Examples of these abilities include the ability to recognize faces, comprehend spoken language, decipher handwriting, and detect the freshness of food based solely on its scent. We call this skill as human perception, and we want to give machines similar abilities (Shinde, Deshmukh, 2011).

Pattern recognition, at its core, is the task of identifying regularities, structures, or trends within data, enabling the extraction of meaningful information from seemingly complex datasets (Saba, Rehman, 2013; Szabadföldi, 2022). The use of AI in data processing is becoming more and more significant AI systems can read and comprehend complicated sensory inputs thanks to pattern recognition (Prorok, 2022). Pattern recognition is the process of finding patterns or trends in data, and AI is essential to improving the precision and effectiveness of this work.

The objective of the scientific field of pattern recognition is to classify items into several categories or classes. These objects can be pictures, signal waveforms, or any kind of measurement that needs to be identified, depending on the application. These items will be referred to by the general word patterns (Liu et al., 2006). Although pattern recognition has a lengthy history, it was mostly the result of theoretical statistics research prior to the 1960s (Abramson et al., 1963).

Important Elements

The emergence and growth of technologies like Big Data, Business Intelligence, and automation-required applications have created a demand for enhanced data analytics, which has led to the application of machine learning and other cutting-edge approaches. As a branch of AI, machine learning leverages computer methods to solve problems based on information and past data without needlessly changing the fundamental procedure. In essence, AI is the development of algorithms and other computational methods that enhance machine intelligence. It includes algorithms that use protocols that are normally inaccessible to humans to think, act, and carry out tasks (Sandhu, 2018; Alloghani et al., 2020).

Machine learning algorithms includes supervised learning, unsupervised learning, semi-supervised and reinforcement learning (Ozgur, 2004). Algorithms for supervised and unsupervised learning have demonstrated significant promise in acquiring knowledge from extensive datasets. Supervised learning measures an algorithm's capacity to generalize knowledge from accessible data with target or labeled cases. The practice of clustering data that hasn't been classed or categorized using automated techniques or algorithms is known as unsupervised learning. Another type is the semi-supervised learning, which is defined as learning with limited access to labeled data. In contrast, reinforcement learning entails an agent picking up skills through interaction with the environment to maximize a reward (Alloghani et al, 2020).

An essential part of AI are neural networks, which have different topologies for different kinds of input and tasks. This framework is based on basic neural networks, which are often referred to as feedforward neural networks or MLPs: multilayer perceptrons (Chen et al, 2017). They are made up of interconnected nodes arranged in layers, usually with an input layer, an output layer, and one or more hidden layers (Abdi et al., 1999). Basic neural networks may adapt to a variety of patterns thanks to this iterative learning process, demonstrating their adaptability (Sondak et al., 1989).

Convolutional Neural Networks (CNNs) are specialized designs that excel in computer vision and image recognition applications. Convolutional layers are a unique property of CNNs that allows them to automatically learn hierarchical representations of visual characteristics, revealing its efficiency in tasks like picture categorization and facial recognition. The network can now recognize local patterns such as edges, textures, and forms thanks to these layers (O'Shea, Nash, 2015).

Conversely, Recurrent Neural Networks (RNNs) are designed for sequential data, meaning that the elements' order matters. They excel at problems involving time-series data, natural language processing, and speech recognition because of their design. RNNs are unique in that they have memory; every neuron has a recurrent connection, which enables the network to recall previous inputs. The ability to recognize patterns and temporal connections within data sequences depends critically on this memory. RNNs are used in a wide range of fields, such as handwriting recognition, stock price prediction, and language modeling (Medsker, Jain, 2001).

A defining feature of Deep Belief Networks (DBNs) is their numerous layers of latent, stochastic variables. These models perform best in situations when there are no clear labels in the data, such as in unsupervised learning tasks. Through the utilization of the intricacy of stochastic variables across several layers, DBNs exhibit an exceptional capacity to apprehend complex patterns in the input data (Hua et al., 2015). One type of neural network architecture designed especially for feature learning and dimensionality reduction is the autoencoder, which compress input data into a lower-dimensional representation (Lopez, Walter 2020).

GANs, or Generative Adversarial Networks, present a generator and a discriminator neural network compete with one another. The discriminator assesses the validity of the false data samples that the generator creates to replicate the distribution of real data. GANs are commonly used to generate realistic synthetic data through this adversarial interplay, finding applications in image synthesis, style transfer, and other areas (Creswell et al., 2018).

Three main components make up data preprocessing. To guarantee that the input data for pattern recognition is of a high enough quality, the first stage is cleaning and imputation, which include eliminating noise, dealing with missing data, and imputing values. Normalization and scaling come in second. By standardizing data to a single scale, features with disparate units are kept from unnecessarily impacting the process of identifying patterns. The third technique is outlier detection, which strengthens the resilience of AI models by detecting and managing outliers to guarantee that trends are based on representative data (Cateni, Colla, 2013).

Because some characteristics are more useful than others at differentiating patterns in the data, feature extraction is essential for accurate pattern identification. Automatic feature extraction reduces the need for manual feature engineering by enabling algorithms to learn and extract features from raw data in the field of AI, notably in deep learning. For dimensionality reduction, methods like Principal Component Analysis (PCA) or t-Distributed Stochastic Neighbor Embedding (t-SNE) are used, which preserve significant patterns while making the data less complicated. Together, these techniques help to improve pattern recognition in AI systems' efficacy and efficiency (Cateni et al, 2012).

Application Areas

A few unique pattern recognition devices have been developed and constructed for real-world applications. Applications of pattern recognition can include the following: modeling of socioeconomic systems, remote sensing, speech recognition and understanding. Furthermore, machine part recognition, automatic inspection, medical diagnosis, identification of human faces and fingerprints, engineering reliability, and modeling of biomedical signals and images (Fu, 1982).

Pattern recognition is crucial in the field of machine vision. A machine vision system uses a camera to take pictures, which it then processes to provide descriptions of the objects it sees. A machine vision system is typically used in the industrial sector, either for assembly line automation or automated visual inspection (Theodoridis et al., 2006).

Another crucial field of pattern recognition is character, letter or number recognition, which has significant applications in information management and automation. For this reason, a technology was discovered which is the Optical Character Recognition (OCR) technology (Mori et al., 1992). OCR is a business-related technology that enables automated data extraction from written or printed text from scanned documents or picture files (Chaudhuri et al., 2017). One common use for this kind of technology in the banking industry is automated check reading, also online handwriting recognition. Automated mail sorting machines at post offices are another use for this technology (Theodoridis et al., 2006; Isheawy, Hasan, 2015).

A further significant use of pattern recognition is computer-aided diagnosis. This aims to support medical professionals in making diagnosis decision-making, but of course the doctor makes the final diagnosis. A wide range of medical data, including X-rays, computed tomographic pictures, ultrasound images, electrocardiograms (ECGs), and electroencephalograms (EEGs), have been subjected to computer-assisted diagnosis applications (Park, Lee, 1998; Theodoridis et al., 2006).

Another field that has seen a significant amount of research and development is speech recognition. The most natural way for people to exchange knowledge and communicate is through speech. Thus, scientists, engineers, and science fiction authors have long harbored the ambition of creating intelligent computers that can recognize spoken information. Software recognizes spoken text and converts it into ASCII letters, which are displayed on the screen and can be kept in memory. This system is based on a pattern recognition system, in this case spoken sounds. Furthermore, experts also use face and gesture recognition, text retrieval, fingerprint identification, and signature authentication. (Theodoridis et al., 2006).

Future Innovations

The European Union is investing €220 million to test AI applications in industry, food, healthcare, and daily life. At a press conference in Copenhagen on June 27, 2023, the European Commission, Member States, and 128 partners from academia, business, and government agencies announced a €220 million investment in four sector-specific Testing and Experimentation Facilities (TEFs) for AI. Testing and Experimentation Facilities are intended to serve as a sandbox for the development and use of AI technologies. Assist AI developers in more effectively bringing reliable AI to the market and promote its adoption in Europe. They encourage testing and experimentation with robotics, AI, and other innovative technologies from all European technology firms (European Commission, 2023a).

Among the four TEFs introduced are:

- The agrifood TEF addresses the production of food and the agricultural industry. Examples of applications include crop production optimization with AI and testing of robotic tractors.
- The TEF-Health, focused on the healthcare industry, includes robots for intervention and rehabilitation as well as sophisticated brain simulations and machine learning in medical imaging.
- With an initial focus on energy, transportation, and connectivity, the CitCom.ai TEF aims to assist in the development of technology for smart cities and communities. By allowing businesses to test and try out AI-based products in real-world settings, it will hasten the development of reliable AI in Europe.
- The AI-Matters TEF, utilizes the most recent advancements in robotics, artificial intelligence, and intelligent, autonomous systems for flexible production to strengthen the robustness and adaptability of the European manufacturing sector (European Commission, 2023a).

These expansive comparative testing and experimentation facilities are going to provide a blend of physical and virtual spaces where technology companies can receive assistance in testing their most recent AI-based hardware and software in authentic settings. This will cover validation and demonstration as well as comprehensive integration, testing, and experimentation of cutting-edge AI-based technologies to address problems and enhance solutions in a particular application sector (European Commission, 2023b).

The European Commission and the European High-Performance Computing Joint Undertaking, briefly: EuroHPC JU, pledged to provide open and expanded access to the EU's top-tier supercomputing resources for European SMEs, start-ups, and the AI community at large as part of the EU AI Start-Up Initiative. Access to cutting-edge supercomputers that can shorten training periods from months or years to a few weeks is essential for facilitating the development and scalability of AI models. In 2023 November, the European Union is at the forefront of the world in supercomputing. Because of the work of the EuroHPC JU, three of the EU's supercomputers, LEONARDO, LUMI, and MareNostrum5, are of the highest quality (European Commission, 2023c).

The European Commission will help the participating states of the EuroHPC Joint Undertaking in their efforts to expedite research, development, demonstration, and deployment of the European supercomputing infrastructure. This pledge seeks to support the Union's main objective of creating a reliable and accountable global AI ecosystem. Thus, this will entail:

- The Large AI Grand Challenge was launched, and it invites European start-ups with large-scale AI model experience to participate widely.
- Increasing the capacity of European supercomputers: Access will be provided accessible to run AI start-ups morally and responsibly so they can effectively train their models on European supercomputers.
- Improved programs and services: The EuroHPC JU will promote programs and services that use high-performance computing to promote reliable AI throughout Europe. The objective of these endeavors is to enable more accessibility for AI communities and encourage the most effective and efficient application of HPC technology for innovation in science and industry (European Commission, 2023c).

Summary

To sum up, the domain of pattern recognition is crucial to the development of artificial intelligence and has a substantial impact on a range of industries and applications. Pattern recognition's historical development, from its foundation in theoretical statistics to its current popularity in engineering and research, highlights the significance of this field in the postindustrial period.

Based on the results obtained, the confirmation of the first hypothesis is explained by the fact that AI technologies are becoming more and more proficient in activities like language understanding, facial recognition, and sensory processing as they advance, potentially surpassing human skill in these domains. Moreover, the effectiveness of data processing, classification accuracy, and dataset adaptability will all significantly increase with the integration of AI into pattern recognition systems. These developments will spur advances in a range of fields, including as industrial automation and healthcare diagnostics, completely changing the way we see and engage with the environment.

The following result serves to verify the second hypothesis. Advances in AI increases integration and enhancement of various industries, with improved efficiency, accuracy, and accessibility in tasks ranging from automation to medical decision-making. Examples of these application areas include pattern recognition in machine vision, optical character recognition in information management and banking sector, computer-aided diagnosis in healthcare, and speech recognition for natural language communication. We can see that the advancement of machine learning techniques, including supervised and unsupervised learning, has demonstrated significant potential for knowledge acquisition from large datasets. In the recognition of complicated patterns, neural networks—including feedforward neural networks and their specialized equivalents, such as Convolutional Neural Networks and Recurrent Neural Networks—have shown extraordinary adaptability and efficiency.

The toolkit of pattern recognition approaches is further expanded by Deep Belief Networks, autoencoders, and Generative Adversarial Networks, each of which has specific advantages and uses. From machine vision and character recognition to applications in the banking sector, online handwriting identification, and computer-aided diagnostics in the medical area, pattern recognition is important in many different fields. The extensive application of pattern recognition in tasks like automated check reading and the advancement of technologies like Optical Character Recognition underscore its practical relevance in real-world circumstances.

Based on my inquiry about the future, the European Union launched a comprehensive AI plan and significantly increased financing for AI research, development, and implementation, thereby realizing the correct third hypothesis of the research. Nothing shows this better than the fact that the European Union spends 220 million euros on testing artificial intelligence applications. It is evident that the European Union is committed to improving artificial intelligence technology across a range of industries, as seen by its significant investment in AI Testing and Experimentation Facilities. By offering a testing and experimentation environment, these institutions hope to accelerate the development of trustworthy AI and its uptake in Europe. The partnership with the EuroHPC Joint Undertaking supports the worldwide goal of building a strong and transparent AI ecosystem by highlighting the significance of supercomputing resources in speeding up the development and scalability of AI models.

Finally, pattern recognition is a fundamental component of artificial intelligence that is continuously developing and reaching new markets and uses. The continued developments and investments point to a bright future for pattern recognition as it becomes a more integral part of our technological environment and influences the direction of AI-driven technologies.

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