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International Journal of Bioinformatics Research and Applications > 2022 Vol.18 No.1/2

Title: Optimisation of sub-space clustering in a high dimension data using Laplacian graph and machine learning

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Abstract: There are many applications like business analytics, computer vision and medical data analytics, where an unsupervised approach of learning is used for the high-dimension data (HDD) clustering. The problem of the subspace clustering is modelled as a graph problem which has to retain the critical features from the N-dimension while applying a dimension reduction technique to maintain a higher accuracy and lower computational overhead trade-off. Most of the traditional approaches suffer from the efficiency degradation when applied to HDD. An optimisation of sub-space clustering is proposed in this paper for learning models using Laplacian graph on a HDD. The proposed model addresses the curse of dimensionality problem through Laplacian matrix function to minimise the data redundancy within sub-space. The traditional K-nearest neighbour (KNN) algorithm is improvised for the non-linear classification of subspace clustering on HDD clinical importance. The proposed system offers significant increment of 99% of accuracy in clustering operation.

Keywords: subspace clustering; high dimensional data; dimensionality reduction; curse of dimensionality; Laplacian graph; graph partition problem; KNN algorithm.

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Exploring the Impact and Applications of Artificial Intelligence: Enhancing Human Capabilities across Multiple Sectors with a Focus on Education

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ABSTRACT: In the future, intelligent machines are expected to either replace or enhance human capabilities across various domains. Artificial Intelligence (AI), a subfield of computer science, represents the intelligence demonstrated by machines or software. Over the last two decades, AI has significantly improved performance across multiple sectors, including manufacturing, services, and education.AI has led to the development of rapidly advancing technologies such as expert systems. These systems are increasingly applied to address complex problems in diverse fields such as education, engineering, business, medicine, and weather forecasting. The integration of AI technology has notably enhanced the quality and efficiency in these areas. This paper provides an overview of AI technology, exploring its scope and applications across different fields. Special emphasis is given to the use of AI in education, including its definitions, searching techniques, innovations, and future prospects.

KEYWORDS: artificial intelligence (AI), artificial neurons (neural computer networks), expert system, heuristic, searching techniques

I. INTRODUCTION

Artificial Intelligence (AI) enhances machines by enabling them to perceive, reason, and act, making them smarter and more functional. This is achieved through artificial neurons (as seen in artificial neural networks) and logical frameworks such as "if-then" statements. AI technologies have reached a level of sophistication that provides tangible benefits across various applications. Key areas within AI include Expert Systems, Intelligent Computer-Aided Instruction, Natural Language Processing, Speech Understanding, Robotics and Sensory Systems, Computer Vision and Scene Recognition, and Neural Computing. Among these, Expert Systems are rapidly evolving and significantly impacting multiple domains. AI employs several techniques, including Neural Networks, Fuzzy Logic, Evolutionary Computing, Computer-Aided Instruction, and Hybrid AI, to address complex problems and enhance its applications.

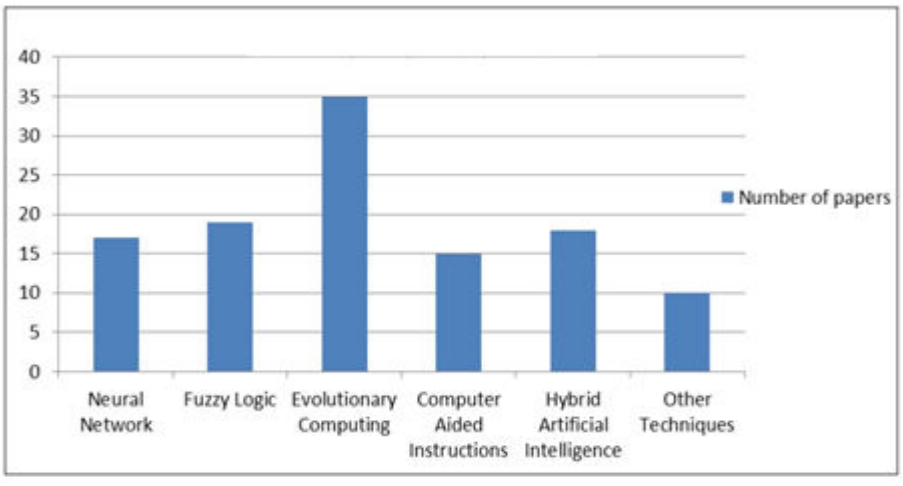

Figure 1. AI Techniques used in research

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International Journal of Information and Computer Security > 2022 Vol.18 No.3/4

Title: Auto-encoder-based technique for effective detection of frauds in social networks

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Abstract: Detection of these spam accounts has recently attracted significant attraction in the literature. Most of the spam-account detection techniques presented in the literature employ supervised learning models to achieve their goal. These models require sufficient size of spam-account samples in their training set to be trained effectively. However, obtaining such large sample sizes is a significant challenge. In many real-world scenarios, the number of such available samples is extremely limited. Due to this limitation in the training set, the spam-account detection techniques can exhibit extremely poor detection accuracy. Hence, in this paper, an effective supervised learning model-based spam-account detection technique is presented, which utilises only limited size of spam-account samples in its training set, and to achieve this desired goal, the dimension of the feature vectors in the training set is reduced through the aid of auto-encoders. Further, the spam-accounts are detected based on their corresponding hazard rates. The hazard rates are generated through recurrent neural network. An empirical analysis study is presented, in which, the proposed spam-account detection technique is compared against the contemporary technique. In this study, the proposed technique exhibits relatively superior performance in-terms of classification accuracy.

Keywords: social networks; survival analysis model; fraud detection.

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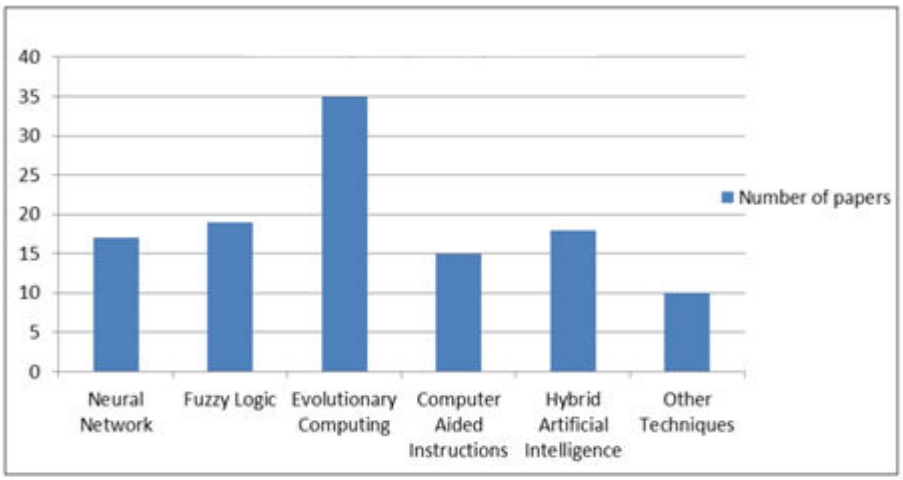

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Binding interaction between 4-Hydroxy-3-nitrocoumarin and metal ions-A spectroscopic approach

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Abstract

Metal ions play vital role in many biochemical and physiological functions when they are in very low concentrations and become lethal if certain limit is exceeded. Their detection even at very low concentration is very much essential. In this work we report the detection of metal ions Cu^{++} and Ni^{++} being members of environment pollutants using a coumarin derivative 4-Hydroxy-3-nitrocoumarin by absorption and emission spectroscopic methods. It is noticed that the metal ions are capable of reducing the absorbance (OD) and emission intensity of the coumarin derivative dissolved in Toluene, Dichloromethane and 1,2-Dichloroethane even at very low concentration of 10^{-3} M. The sample concentration is maintained at 10^{-5}M. The OD is reduced with the increase in metal ion concentration without shift in absorption peak of 272 nm. Emission intensity is also quenched by them without shifting the emission peak which is located at 555 nm. The spectroscopic data is analyzed using Benisi-Hildebrand. Binding constant values are calculated using both absorption and emission data. The values are found to be towards higher side. Gibb's free energy change which is an indication of spontaneity/non–spontaneity of compound–Metal ion binding is also evaluated. Gibb's free energy

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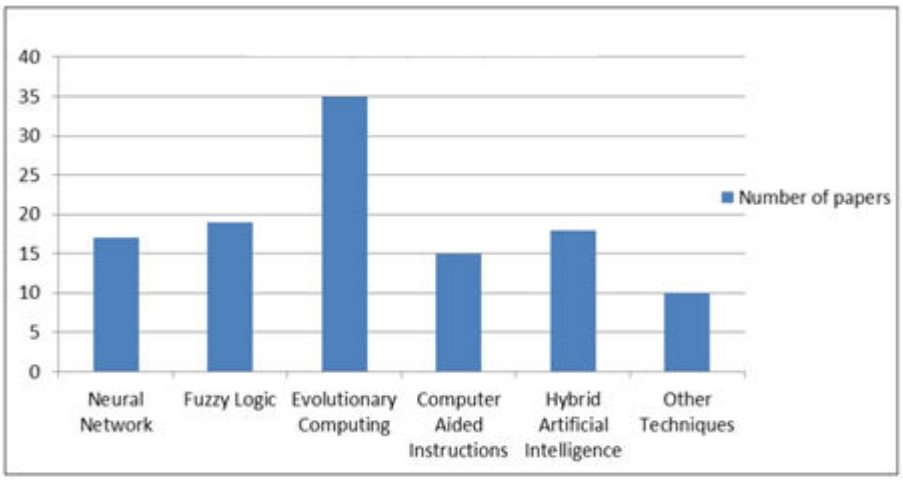

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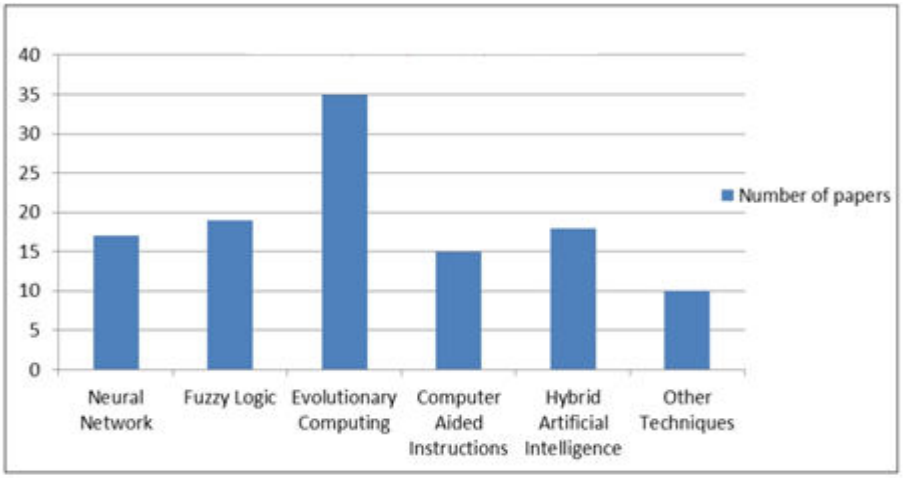

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Harnessing Predictive Data Mining in Clinical Medicine: Applications, Benefits, and Challenges in Healthcare

Sangeetha Rao S[1], Nandini S B[2], Gangappa Demannavar[3], Doreswamy G S[4], Aurbindo Koti[5]

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KEYWORDS: Clinical medicines, healthcare sector, and predictive data mining.

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In the era of advancing technology and its global proliferation, data mining has become a crucial tool from the outset of technological implementation. Data mining involves sorting through large datasets to uncover patterns and relationships that can address issues related to clinical medicine data analysis. This process enables businesses to anticipate future trends and make informed decisions, offering significant benefits. Data mining is broadly categorized into two main types: predictive data mining and descriptive data mining. Predictive data mining, in particular, is widely utilized across various fields, including clinical medicine. It applies business intelligence and other data to forecast trends in the existing marketplace, aiding businesses and clinical leaders in making well-informed, ethical decisions. The primary goal of predictive data mining in clinical medicine is to develop models that leverage patient-related information to predict outcomes and support clinical decision-making effectively. This approach allows doctors to formulate accurate diagnoses and conclusive results based on a patient's background. While a skilled clinician is essential for final decision-making, artificial intelligence software can rapidly process extensive data arrays, enhancing the decision-making process.

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Mobile Agent-based Systems for Information Leakage Prevention: A Critical Review of Distributed Models and Intrusion Detection Mechanisms

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ABSTRACT: The rise of cloud and distributed computing has led to an increase in threats related to data and information technology, making data security and leakage prevention critical in these environments. Mobile agent-based systems have emerged as innovative solutions for detecting and mitigating data intrusions and leaks across networks. This paper aims to address various challenges associated with Mobile Agent-Based Information Leakage Prevention by offering a thorough and systematic examination of the Distribution Model for this purpose. It includes a review of selected research articles published between 2009 and 2019, providing a critical analysis of distributed mobile agent-based intrusion detection systems, focusing on their design, methodologies, and limitations. Initially, a total of eighty-five papers were considered for this review. The proliferation of cloud and distributed computing has introduced new risks to data security, including vulnerabilities that can lead to data breaches and information leakage. As organizations increasingly rely on these infrastructures, protecting sensitive data has become a top priority. Traditional security measures often fall short in distributed environments, where data moves across various nodes and networks. Mobile agent-based systems have emerged as a promising solution to enhance data security and detect intrusions in such environments. This paper provides a comprehensive review of mobile agent-based approaches for preventing information leakage, particularly focusing on the challenges of implementing distributed models in intrusion detection systems. By analyzing research published between 2009 and 2019, the paper evaluates how mobile agents operate across networks, identifying potential threats and preventing data loss. The review covers key methodologies, design considerations, and the effectiveness of these systems in real-world scenarios. Out of an initial pool of eighty-five papers, the selected studies are critically examined to highlight both the strengths and limitations of mobile agent-based intrusion detection. This review aims to contribute to the ongoing discourse on data security, offering insights into future advancements and potential improvements in mobile agent technology for leakage prevention.

KEYWORDS: Mobile Agent, Distribution Model, Data Leakage Detection, Data Leakage Prevention, DLP, Security, Distributed Computing

I. INTRODUCTION

The rapid expansion of information technology and cloud computing has heightened concerns about data leakage, manipulation, and distribution. As reliance on cloud computing grows, so do concerns about the security and privacy of data within distributed networks [1]. Many businesses have fallen victim to theft, loss, or leakage of sensitive data, which can significantly damage both individual and corporate reputations and trust [2]. A prevalent cause of data leakage is the casual or negligent behaviour of employees handling shared files containing confidential information, business documents, financial statements, policies, contracts, intellectual property, and other private data [3]. When such data is transmitted through covert channels, unauthorized access becomes more likely, as these channels bypass conventional security mechanisms, leading to unintentional data leakage [4]. Research indicates that 90% of corporate data leakage could be mitigated with improved data security and leakage prevention strategies [5]. Internal security breaches often stem from deceptive attacks using legitimate credentials or insider threats. Studies [6] and [7] highlight the critical importance of information security within corporate settings, and [8] introduces a hybrid framework for detecting and preventing information leakage. Thus, information security remains a crucial area in IT, aimed at ensuring a secure computing environment for both individuals and businesses. This paper provides a critical review of distributed models for mobile agent-based data leakage prevention. The review encompasses research papers published from 2009 onwards, focusing on distributed mobile agent-based intrusion detection and prevention systems. It evaluates these systems in terms of their design, capabilities, and limitations, and includes a review of studies proposing distribution models for mobile agent-based data leakage detection and prevention. The paper discusses and compares these different methods.

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ABSTRACT: This study focuses on predictive data mining in clinical medicine, beginning with an introduction to data mining and predictive data mining, and its application within clinical settings. This study explores the growing field of predictive data mining within clinical medicine, emphasizing its role in transforming healthcare practices. Predictive data mining, a subset of data mining, involves analyzing vast datasets to forecast outcomes, identify trends, and make informed decisions. The study begins with an introduction to data mining and its predictive applications, particularly in clinical settings where accurate and timely decisions are critical for patient care. The materials and methods section outlines the key approaches used in this research, including data collection techniques and model-building methodologies. Various predictive data mining models, such as decision trees, neural networks, and support vector machines, are thoroughly examined for their specific applications in healthcare. These models help predict patient outcomes, identify disease risk factors, and optimize treatment plans, making them essential tools for medical practitioners. The study highlights the numerous benefits of predictive data mining for the healthcare sector. For medical professionals, it enhances diagnostic accuracy, supports personalized treatment plans, and improves patient outcomes. Predictive models enable early detection of diseases, reduce the occurrence of medical errors, and facilitate cost-effective treatment strategies. Furthermore, predictive data mining offers significant potential for profit-making by improving operational efficiency and reducing healthcare costs, which is particularly valuable for hospitals and healthcare organizations. The study also acknowledges the challenges and issues faced by the healthcare sector in implementing predictive data mining. These include data privacy concerns, the complexity of integrating new technologies into existing healthcare systems, and the risk of relying too heavily on algorithms. The study offers strategies to mitigate these challenges, such as adopting stricter data governance policies, enhancing collaboration between healthcare professionals and data scientists, and ensuring continuous evaluation and improvement of predictive models. This research underscores the transformative potential of predictive data mining in clinical medicine. While challenges exist, the benefits far outweigh the obstacles, positioning predictive data mining as a critical tool for advancing healthcare practices, improving patient care, and supporting the profitability and sustainability of healthcare organizations.

KEYWORDS: Clinical medicines, healthcare sector, and predictive data mining.

I. INTRODUCTION

In the era of advancing technology and its global proliferation, data mining has become a crucial tool from the outset of technological implementation. Data mining involves sorting through large datasets to uncover patterns and relationships that can address issues related to clinical medicine data analysis. This process enables businesses to anticipate future trends and make informed decisions, offering significant benefits. Data mining is broadly categorized into two main types: predictive data mining and descriptive data mining. Predictive data mining, in particular, is widely utilized across various fields, including clinical medicine. It applies business intelligence and other data to forecast trends in the existing marketplace, aiding businesses and clinical leaders in making well-informed, ethical decisions. The primary goal of predictive data mining in clinical medicine is to develop models that leverage patient-related information to predict outcomes and support clinical decision-making effectively. This approach allows doctors to formulate accurate diagnoses and conclusive results based on a patient's background. While a skilled clinician is essential for final decision-making, artificial intelligence software can rapidly process extensive data arrays, enhancing the decision-making process.

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Mobile Agent-based Systems for Information Leakage Prevention: A Critical Review of Distributed Models and Intrusion Detection Mechanisms

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ABSTRACT: The rise of cloud and distributed computing has led to an increase in threats related to data and information technology, making data security and leakage prevention critical in these environments. Mobile agent-based systems have emerged as innovative solutions for detecting and mitigating data intrusions and leaks across networks. This paper aims to address various challenges associated with Mobile Agent-Based Information Leakage Prevention by offering a thorough and systematic examination of the Distribution Model for this purpose. It includes a review of selected research articles published between 2009 and 2019, providing a critical analysis of distributed mobile agent-based intrusion detection systems, focusing on their design, methodologies, and limitations. Initially, a total of eighty-five papers were considered for this review. The proliferation of cloud and distributed computing has introduced new risks to data security, including vulnerabilities that can lead to data breaches and information leakage. As organizations increasingly rely on these infrastructures, protecting sensitive data has become a top priority. Traditional security measures often fall short in distributed environments, where data moves across various nodes and networks. Mobile agent-based systems have emerged as a promising solution to enhance data security and detect intrusions in such environments. This paper provides a comprehensive review of mobile agent-based approaches for preventing information leakage, particularly focusing on the challenges of implementing distributed models in intrusion detection systems. By analyzing research published between 2009 and 2019, the paper evaluates how mobile agents operate across networks, identifying potential threats and preventing data loss. The review covers key methodologies, design considerations, and the effectiveness of these systems in real-world scenarios. Out of an initial pool of eighty-five papers, the selected studies are critically examined to highlight both the strengths and limitations of mobile agent-based intrusion detection. This review aims to contribute to the ongoing discourse on data security, offering insights into future advancements and potential improvements in mobile agent technology for leakage prevention.

KEYWORDS: Mobile Agent, Distribution Model, Data Leakage Detection, Data Leakage Prevention, DLP, Security, Distributed Computing

I. INTRODUCTION

The rapid expansion of information technology and cloud computing has heightened concerns about data leakage, manipulation, and distribution. As reliance on cloud computing grows, so do concerns about the security and privacy of data within distributed networks [1]. Many businesses have fallen victim to theft, loss, or leakage of sensitive data, which can significantly damage both individual and corporate reputations and trust [2]. A prevalent cause of data leakage is the casual or negligent behaviour of employees handling shared files containing confidential information, business documents, financial statements, policies, contracts, intellectual property, and other private data [3]. When such data is transmitted through covert channels, unauthorized access becomes more likely, as these channels bypass conventional security mechanisms, leading to unintentional data leakage [4]. Research indicates that 90% of corporate data leakage could be mitigated with improved data security and leakage prevention strategies [5]. Internal security breaches often stem from deceptive attacks using legitimate credentials or insider threats. Studies [6] and [7] highlight the critical importance of information security within corporate settings, and [8] introduces a hybrid framework for detecting and preventing information leakage. Thus, information security remains a crucial area in IT, aimed at ensuring a secure computing environment for both individuals and businesses. This paper provides a critical review of distributed models for mobile agent-based data leakage prevention. The review encompasses research papers published from 2009 onwards, focusing on distributed mobile agent-based intrusion detection and prevention systems. It evaluates these systems in terms of their design, capabilities, and limitations, and includes a review of studies proposing distribution models for mobile agent-based data leakage detection and prevention. The paper discusses and compares these different methods.

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Advancements in Deep Learning for Materials Data Science: Applications across Atomistic, Imaging, Spectral, and Textual Data Modalities

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ABSTRACT: Deep learning (DL) has emerged as one of the most transformative technologies in materials data science, driven by its ability to process and analyze vast, complex datasets across various modalities. In recent years, DL has revolutionized how researchers handle atomistic, image-based, spectral, and textual data, automating feature identification and enabling more accurate predictions. This review provides an overview of deep learning methods in materials science, highlighting recent advancements in the field and the unique challenges associated with different data types. The rise of large-scale materials databases has propelled the use of DL in atomistic prediction, particularly for simulations at the atomic level. DL models have shown remarkable success in predicting material properties by learning from high-dimensional atomistic data, offering an efficient way to explore the structure-property relationship. In this domain, DL enables the automation of tasks traditionally requiring manual feature engineering, such as molecular dynamics simulations or quantum mechanical calculations. For image-based and spectral data, progress has been accelerated by the availability of synthetic data generated through high-fidelity forward models. DL techniques, particularly generative unsupervised models, have been employed to enhance image resolution, automate defect detection, and identify patterns in spectral data. In materials imaging, convolutional neural networks (CNNs) have proven especially useful, while auto encoders and other unsupervised models help reduce the complexity of spectral data for enhanced analysis. Natural language processing (NLP) in materials science is another rapidly advancing area. With the increasing availability of textual data, DL models such as recurrent neural networks (RNNs) and transformers have been applied to extract valuable information from scientific literature, patent filings, and experimental reports. This facilitates data mining and accelerates the discovery of new materials. The article also discusses cross-disciplinary work in uncertainty quantification, emphasizing the importance of understanding DL models' predictions in materials science. Additionally, the review highlights publicly available software tools and datasets that have supported these advancements, offering researchers easy access to resources for further exploration. Despite these advancements, challenges remain, such as the need for more interpretable models and overcoming data limitations. The article concludes by offering perspectives on future growth areas and potential challenges for deep learning applications in materials data science.

KEYWORDS: Deep Learning, Materials Data Science, Atomistic Prediction, Uncertainty Quantification

I. INTRODUCTION

The "Processing-Structure-Property-Performance" relationship is central to Materials Science and Engineering (MSE). The material structures and phenomena involved vary widely in length and time scales across these four elements, adding layers of complexity. For example, structural information can range from detailed atomic coordinates to the microscale spatial distribution of phases (microstructure), mesoscale fragment connectivity, and even images and spectra. Establishing connections between these components is a challenging endeavor.Both experimental and computational methods play crucial roles in identifying these relationships. The rapid advancement of automation in experimental equipment and the significant expansion of computational resources have led to an exponential increase in the size of public materials datasets. Numerous large experimental and computational datasets have been developed through initiatives like the Materials Genome Initiative (MGI) and the growing adoption of Findable, Accessible,

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Harnessing Predictive Data Mining in Clinical Medicine: Applications, Benefits, and Challenges in Healthcare

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Exploring the Impact and Applications of Artificial Intelligence: Enhancing Human Capabilities across Multiple Sectors with a Focus on Education

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ABSTRACT: In the future, intelligent machines are expected to either replace or enhance human capabilities across various domains. Artificial Intelligence (AI), a subfield of computer science, represents the intelligence demonstrated by machines or software. Over the last two decades, AI has significantly improved performance across multiple sectors, including manufacturing, services, and education.AI has led to the development of rapidly advancing technologies such as expert systems. These systems are increasingly applied to address complex problems in diverse fields such as education, engineering, business, medicine, and weather forecasting. The integration of AI technology has notably enhanced the quality and efficiency in these areas. This paper provides an overview of AI technology, exploring its scope and applications across different fields. Special emphasis is given to the use of AI in education, including its definitions, searching techniques, innovations, and future prospects.

KEYWORDS: artificial intelligence (AI), artificial neurons (neural computer networks), expert system, heuristic, searching techniques

I. INTRODUCTION

Artificial Intelligence (AI) enhances machines by enabling them to perceive, reason, and act, making them smarter and more functional. This is achieved through artificial neurons (as seen in artificial neural networks) and logical frameworks such as "if-then" statements. AI technologies have reached a level of sophistication that provides tangible benefits across various applications. Key areas within AI include Expert Systems, Intelligent Computer-Aided Instruction, Natural Language Processing, Speech Understanding, Robotics and Sensory Systems, Computer Vision and Scene Recognition, and Neural Computing. Among these, Expert Systems are rapidly evolving and significantly impacting multiple domains. AI employs several techniques, including Neural Networks, Fuzzy Logic, Evolutionary Computing, Computer-Aided Instruction, and Hybrid AI, to address complex problems and enhance its applications.

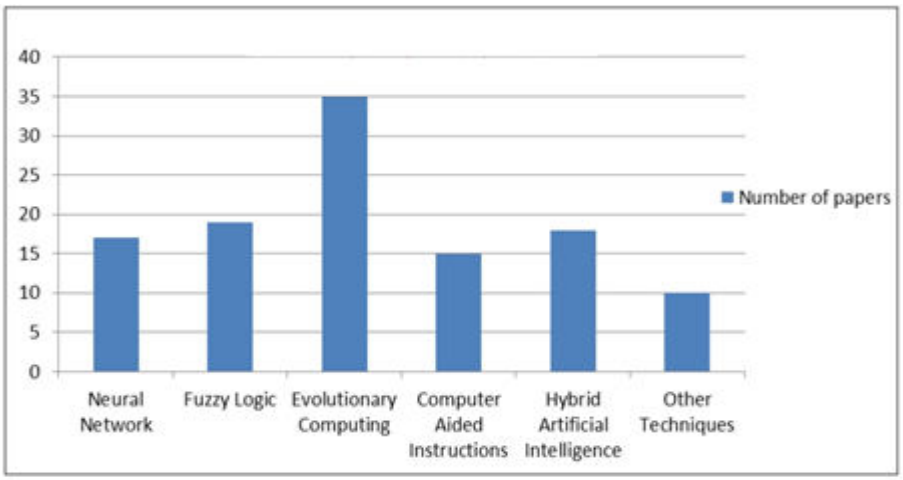

Figure 1. AI Techniques used in research

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ABSTRACT: The rise of cloud and distributed computing has led to an increase in threats related to data and information technology, making data security and leakage prevention critical in these environments. Mobile agent-based systems have emerged as innovative solutions for detecting and mitigating data intrusions and leaks across networks. This paper aims to address various challenges associated with Mobile Agent-Based Information Leakage Prevention by offering a thorough and systematic examination of the Distribution Model for this purpose. It includes a review of selected research articles published between 2009 and 2019, providing a critical analysis of distributed mobile agent-based intrusion detection systems, focusing on their design, methodologies, and limitations. Initially, a total of eighty-five papers were considered for this review. The proliferation of cloud and distributed computing has introduced new risks to data security, including vulnerabilities that can lead to data breaches and information leakage. As organizations increasingly rely on these infrastructures, protecting sensitive data has become a top priority. Traditional security measures often fall short in distributed environments, where data moves across various nodes and networks. Mobile agent-based systems have emerged as a promising solution to enhance data security and detect intrusions in such environments. This paper provides a comprehensive review of mobile agent-based approaches for preventing information leakage, particularly focusing on the challenges of implementing distributed models in intrusion detection systems. By analyzing research published between 2009 and 2019, the paper evaluates how mobile agents operate across networks, identifying potential threats and preventing data loss. The review covers key methodologies, design considerations, and the effectiveness of these systems in real-world scenarios. Out of an initial pool of eighty-five papers, the selected studies are critically examined to highlight both the strengths and limitations of mobile agent-based intrusion detection. This review aims to contribute to the ongoing discourse on data security, offering insights into future advancements and potential improvements in mobile agent technology for leakage prevention.

KEYWORDS: Mobile Agent, Distribution Model, Data Leakage Detection, Data Leakage Prevention, DLP, Security, Distributed Computing

I. INTRODUCTION

The rapid expansion of information technology and cloud computing has heightened concerns about data leakage, manipulation, and distribution. As reliance on cloud computing grows, so do concerns about the security and privacy of data within distributed networks [1]. Many businesses have fallen victim to theft, loss, or leakage of sensitive data, which can significantly damage both individual and corporate reputations and trust [2]. A prevalent cause of data leakage is the casual or negligent behaviour of employees handling shared files containing confidential information, business documents, financial statements, policies, contracts, intellectual property, and other private data [3]. When such data is transmitted through covert channels, unauthorized access becomes more likely, as these channels bypass conventional security mechanisms, leading to unintentional data leakage [4]. Research indicates that 90% of corporate data leakage could be mitigated with improved data security and leakage prevention strategies [5]. Internal security breaches often stem from deceptive attacks using legitimate credentials or insider threats. Studies [6] and [7] highlight the critical importance of information security within corporate settings, and [8] introduces a hybrid framework for detecting and preventing information leakage. Thus, information security remains a crucial area in IT, aimed at ensuring a secure computing environment for both individuals and businesses. This paper provides a critical review of distributed models for mobile agent-based data leakage prevention. The review encompasses research papers published from 2009 onwards, focusing on distributed mobile agent-based intrusion detection and prevention systems. It evaluates these systems in terms of their design, capabilities, and limitations, and includes a review of studies proposing distribution models for mobile agent-based data leakage detection and prevention. The paper discusses and compares these different methods.

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Advancements in Deep Learning for Materials Data Science: Applications across Atomistic, Imaging, Spectral, and Textual Data Modalities

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ABSTRACT: Deep learning (DL) has emerged as one of the most transformative technologies in materials data science, driven by its ability to process and analyze vast, complex datasets across various modalities. In recent years, DL has revolutionized how researchers handle atomistic, image-based, spectral, and textual data, automating feature identification and enabling more accurate predictions. This review provides an overview of deep learning methods in materials science, highlighting recent advancements in the field and the unique challenges associated with different data types. The rise of large-scale materials databases has propelled the use of DL in atomistic prediction, particularly for simulations at the atomic level. DL models have shown remarkable success in predicting material properties by learning from high-dimensional atomistic data, offering an efficient way to explore the structure-property relationship. In this domain, DL enables the automation of tasks traditionally requiring manual feature engineering, such as molecular dynamics simulations or quantum mechanical calculations. For image-based and spectral data, progress has been accelerated by the availability of synthetic data generated through high-fidelity forward models. DL techniques, particularly generative unsupervised models, have been employed to enhance image resolution, automate defect detection, and identify patterns in spectral data. In materials imaging, convolutional neural networks (CNNs) have proven especially useful, while auto encoders and other unsupervised models help reduce the complexity of spectral data for enhanced analysis. Natural language processing (NLP) in materials science is another rapidly advancing area. With the increasing availability of textual data, DL models such as recurrent neural networks (RNNs) and transformers have been applied to extract valuable information from scientific literature, patent filings, and experimental reports. This facilitates data mining and accelerates the discovery of new materials. The article also discusses cross-disciplinary work in uncertainty quantification, emphasizing the importance of understanding DL models' predictions in materials science. Additionally, the review highlights publicly available software tools and datasets that have supported these advancements, offering researchers easy access to resources for further exploration. Despite these advancements, challenges remain, such as the need for more interpretable models and overcoming data limitations. The article concludes by offering perspectives on future growth areas and potential challenges for deep learning applications in materials data science.

KEYWORDS: Deep Learning, Materials Data Science, Atomistic Prediction, Uncertainty Quantification

I. INTRODUCTION

The "Processing-Structure-Property-Performance" relationship is central to Materials Science and Engineering (MSE). The material structures and phenomena involved vary widely in length and time scales across these four elements, adding layers of complexity. For example, structural information can range from detailed atomic coordinates to the microscale spatial distribution of phases (microstructure), mesoscale fragment connectivity, and even images and spectra. Establishing connections between these components is a challenging endeavor.Both experimental and computational methods play crucial roles in identifying these relationships. The rapid advancement of automation in experimental equipment and the significant expansion of computational resources have led to an exponential increase in the size of public materials datasets. Numerous large experimental and computational datasets have been developed through initiatives like the Materials Genome Initiative (MGI) and the growing adoption of Findable, Accessible,

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