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A Brief Introduction to Data Visualization Tools and Techniques in Different Domains

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Abstract *- This research paper introduces data visualization tools and techniques in various domains. The importance of data visualization in enhancing the understanding and communication of complex data is discussed, along with the various types of data visualization tools and techniques available. The paper also covers the use of data visualization in business, social sciences, humanities, sports, environmental sciences, and healthcare. The paper concludes with a summary of the key takeaways and the potential impact of data visualization tools and techniques in various domains. The paper aims to provide a comprehensive overview of data visualization tools and techniques and to highlight their importance in various fields for effective data communication and analysis.*

Keywords *- Data visualization, Patient data analysis, Clinical outcome analysis, Game analysis, Injury analysis, Performance monitoring, Customer segmentation.*

1. Introduction

Data visualization [1][2][3] is a powerful tool for enhancing understanding and communication of complex data. It involves representing data in a graphical or pictorial form, making it easier to understand and interpret. With the increasing availability of data in various domains, such as business, social sciences, humanities, sports, environmental sciences, and healthcare, the importance of data visualization has never been greater. This research paper provides a comprehensive overview of data visualization tools and techniques and their applications in various domains. This research aims to highlight the importance of data visualization in effectively communicating and analyzing data to provide insights into the various types of data visualization tools and techniques available. Whether you are a beginner or an experienced practitioner, this paper will provide a valuable resource for improving your understanding of data visualization and its applications.

2. Overview of Data Visualization Tools

Data visualization tools [4][5] can be broadly classified into three categories: spreadsheets, data visualization software, and programming libraries.

Spreadsheets - Spreadsheets, such as Microsoft Excel and Google Sheets, are one of the most common data visualization tools used in various domains. They provide basic data visualization capabilities, such as bar charts, line graphs, and scatter plots.

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Data Aggregation in Wireless Sensor Network

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Abstract

Wireless sensor networks (WSNs) consist of sensor nodes. These networks have huge application in habitat monitoring, disaster management, security and military, etc. Wireless sensor nodes are very small in size and have limited processing capability very low battery power. This restriction of low battery power makes the sensor network prone to failure. Data aggregation is very crucial technique in wireless sensor networks. With the help of data aggregation we reduce the energy consumption by eliminating redundancy. In this paper we discuss about data aggregation and its various energy-efficient technique used for data aggregation in WSN.

Keywords: Data Aggregation, Wireless sensor network, security.

1. Introduction

Data aggregation is the process of collecting and aggregating the useful data. Data aggregation is considered as one of the fundamental processing procedures for saving the energy. In WSN data aggregation is an effective way to save the limited resources. The main goal of data aggregation algorithms is to gather and aggregate data in an energy efficient manner so that network lifetime is enhanced.. Wireless sensor networks have limited computational power and limited memory and battery power, this leads to increased complexity for application developers and often results in applications that

Machine Learning based novel Autism Spectrum Disorder Screening

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Abstract: Man tries to learn his surroundings by showing tendencies such as discovering, researching, asking questions, and noticing the relationships between objects. In other words, he tends to understand the world he lives in with various judgments. Therefore, it is important to raise individuals with advanced reasoning skills, mathematical thinking skills, proofing skills, problem solving skills, metacognitive knowledge, skills or qualifications. It can be said that this can only be possible with the right teaching models, methods, techniques and teachers who can use them in the most efficient way. In this context, the aim of the study is; To determine the difficulties in the preparation process for LGS, which has been implemented in our country since 2018, and the reflections of LGS on mathematics education applied in schools within the framework of the opinions of mathematics teachers and make suggestions accordingly. In the study, the screening model was adopted because it was tried to portray the thoughts of a certain group of participants on a subject. The sample of the study; It consists of 110 mathematics teachers who attended 8th grade classes in the 2018-2019 academic year. The data obtained from teachers' opinions were analyzed by content analysis method. According to this; The predominant opinion is that students have problems in understanding, interpreting, thinking and reasoning in the new examination system, however, because the textbooks and the exam are not parallel, teachers have various difficulties. In this direction, various activities can be organized to increase students' motivation and to gain reading habit. In addition, it is thought that it would be beneficial to provide teachers with in- service training for the exam.
Keywords: Artificial Intelligence, Machine Learning, Autism Spectrum Disorder.

1. Introduction

Machine Learning, a subfield of Artificial Intelligence, has emerged as one of the most significant and fastest-growing areas of computer science and technology. Today, computers are able to learn and complete tasks with relative ease. In the past, machine learning was applied only to dealing with datasets that could be understood by people.

The research in machine learning can be used in healthcare to improve patient diagnostics and delivery of needed treatments. The goal is to reduce the time it takes to diagnose illness, reduce the work necessary to find diseases, and also to stop disease progression through early detection. big data analysis using artificial intelligence techniques allows the prediction of disease more precisely.

Many disease classes were better represented using classifiers like ML Heart conditions and Autism Spectrum Diagnosis (ASD). On the basis of deficits in social and communication, this developmental disorder is also known as childhood disintegrative disorder, which appears in the first few years of life and impacts behaviour and speech. The majority of individuals show symptoms between two and four years of age. If you have ADHD, you could struggle with it throughout your life, but it may get better. Unfortunately, some of the children with ASD make progress in developmental skills from age 18 months to two then stagnate. Some with ASD have more assistance in their day-to-to-day lives; others don't. Affected people will have problems in forming relationships and communicating, and may display certain quirks or mannerisms. Toddlers do not pay attention and turn their heads away from their mothers and pretend not to care when their interests are not the same as those of others between 12 months and 3 years old. They all use delayed speech and vocabulary, and can point or only point to things, but do

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Research Article

A Comparative Review on Object Detection System for Visually Impaired

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Abstract: Vision is one of the key senses allowing citizens to communicate with the natural world. There are about two hundred million blind people globally and visually disabled people obstruct numerous everyday practices. It is also really critical that blind people recognize their world and realize with which items they communicate. This paper review all the method and tool related to camera-based device to enable the blind person interpret text patterns written on items kept in hand. This is the system for helping individuals with visual disability interpret and translate text patterns to the audio output. The framework first suggests the approach to take an image from the camera and the area of the target to retrieve the object from the context and derive a text pattern from that object. Diffrent algorithm is assessed in various scenes. The observed text is linked to the blueprint and translated into the performance of the voice. Localized and binarized text patterns utilising Optical Character Recognition (OCR). The text is translated to an audio output. The voice quality is given to theblind person.

Keyword: OCR, Visually blind person, Machine learning, Deep Learning, SVM, Accuracy

1. Introduction

Computer science has taken a fundamental role in the devel- opment of the daily activities of the human being, presenting tools that provide solutions to problems in different areas. There are lots of research focuses on artificial intelligence; emphasizes in his machine learning course how applications based on bio-inspired algorithms, machine learning and evo- lutionary techniques, allow for example to have information about traffic, make weather predictions, generate security with biometric recognition, control crops, obtain location thanks to automatic mapping or even allow us to interact on social networks.

The challenge of computer science is to extract useful information fromthe environment in which humans interact, in order to create mathematical, statistical or quantitative models that can represent these natural processes of man [1]. From there we try to put all these techniques at the service of people to facilitate fluid interaction with texts, images and conversations. It is also at this point where it has been shown that there are certain barriers that prevent said fluid interaction, for example there are physical limitations that make people have problems both in receiving information and in communicating ideas (blind or deaf-mute people), on the other hand there may be cultural barriers,

Therefore, the motivation of this research is given, the fact of building a technological tool supported by computerscience (in this case Deep Learning) that allows to overcome some of these barriers, through the creation of a service that recognizes and automatically characterize images taken or provided by a user.

The following text presents in the background, a historical tour of the evolution of computer science and, more precisely, the evolution that probabilistic algorithms have had, as well as works that likewise have wanted to identify objects in images using deep learning.

A. Background

Taking into account that this is a work focused on develop- ing a technological tool based on computer science, it is really important to contextualize its birth, some of its history and development in the service of human beings, and then deepen the techniques that They are planned to be implemented in the development Computer science has been historically recorded since the construction of the first useful devices to keep accounts and solve mathematical problems. Over the years there were im- portant contributions from researchers such as Leibniz, Pascal and Babbage to achieve an approximation to a first computer and the first algorithms.

The development of computers was then limited to the advancement of new technologies, the machines that were cre- ated were the size of rooms. Still, downsizing these machines wasn't the only important issue; scientists

Original Article

Weight Pruning-UNet: Weight Pruning UNet with Depth-wise Separable Convolutions for Semantic Segmentation of Kidney Tumors

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Abstract

Background: Accurate semantic segmentation of kidney tumors in computed tomography (CT) images is difficult because tumors feature varied forms and occasionally, look alike. The KiTs19 challenge sets the groundwork for future advances in kidney tumor segmentation. **Methods:** We present weight pruning (WP)-UNet, a deep network model that is lightweight with a small scale; it involves few parameters with a quick assumption time and a low floating-point computational complexity. **Results:** We trained and evaluated the model with CT images from 210 patients. The findings implied the dominance of our method on the training Dice score (0.98) for the kidney tumor region. The proposed model only uses 1,297,441 parameters and 7.2e floating-point operations, three times lower than those for other network models. **Conclusions:** The results confirm that the proposed architecture is smaller than that of UNet, involves less computational complexity, and yields good accuracy, indicating its potential applicability in kidney tumor imaging.

Keywords: *Depth-wise separable convolution, kidney, kidney tumor segmentation, pruning, weight pruning-UNet*

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Introduction

The American Cancer Society[1] has reported on the prevalence of kidney cancer in both men and women. Overall, the life-time risk to develop kidney cancer is approximately 1/48 and 1/83 for men and women, respectively. The types of kidney cancer in this study were of an advanced stage. Kidney cancers are generally this advanced stage because the kidneys are situated deep inside the body and are not physically perceived on a physical inspection. Several imaging methods are currently in use to track the growth of kidney tumors. This imaging method has become increasingly popular because it can selectively extract diseased tissues and retain additional stable tissue. This approach was successful in treating small kidney masses. After the precise evaluation of the kidney tumor, details such as the kidney, tumor structure, and others can be collected. In a recent study,[2] it was difficult to derive the essential details from computed tomography (CT) or magnetic resonance imaging scans. Kidney tumors vary in color, form, and scale and have a similar appearance to their parenchyma and other nearby tissues. Given the segmentation of the kidney[3] tumor area, segmenting kidney tumors are extremely difficult.

At present, there is an increased need to deploy deep learning solutions on mobile handheld devices,[4] embedded systems, or machines with minimal resources. An important reason why convolutional neural networks (CNNs) are challenging to train is because they are overparameterized,[5] and they typically require greater computational power and storage space for training and inference. Deep learning researchers have claimed many "pruning" strategies or quantizing learned parameters on broad image datasets.[6-8] Others have concentrated on teaching compact models[9-11] from scratch by factorizing regular convolution layers into depth-wise separable convolution layers for cheaper computations.

Although CNNs have achieved the best results in functional implementations, robustness and accuracy (AC) remain

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Article

Sentiment Analysis and Classification Using Convolutional Neural Network Architecture

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Abstract: As the number of textual data is exponentially increasing, it becomes more important to develop models to analyze the text data automatically. The texts may contain various labels such as gender, age, country, sentiment, and so forth. Using such labels may bring benefits to some industrial fields, so many studies of text classification have appeared. Recently, the Convolutional Neural Network (CNN) has been adopted for the task of text classification and has shown quite successful results. In this paper, we propose convolutional neural networks for the task of sentiment classification. Through experiments with three well-known datasets, we show that employing consecutive convolutional layers is effective for relatively longer texts, and our networks are better than other state-of-the-art deep learning models.

Keywords: deep learning; convolutional neural network; sentiment classification

1. Introduction

In the Big Data era, the amount of various data, such as image, video, sound, and text, is increasing exponentially. As text is the largest among them, studies related to text analysis have been actively conducted from the past to the present. In particular, text classification has drawn much attention because the text may have categorical labels such as sentiment (e.g., positive or negative), author gender, language category, or various types (e.g., spam or ham). For example, the users of Social Network Services (SNS) mostly represent their sentimental feeling, and they often share some opinions about daily news with the public or friends. Emotional analysis involves mood categories (e.g., happiness, joy, satisfaction, angry), while sentiment analysis involves categories such as positive, neutral, and negative. In this paper, we target the sentiment analysis that classifies the given text into one of sentiment categories. On websites about movies, people are likely to post their comments that probably contain sentiment or opinions. If such a sentiment is accurately predicted, then it
will be applicable to various industrial fields (e.g., movie recommendation, personalized news-feed).
Indeed, the international market of movies is growing much faster than before, so many companies
(e.g., Netflix) provide movie recommendation services that essentially predict the sentiment or rating scores of customers.

There have been many studies that have adopted machine learning techniques for text classification. Although the machine learning techniques have been widely used and have shown quite successful

Multilevel Ensemble Method to Identify Risks in Chronic Kidney Disease Using Hybrid Synthetic Data

Publisher: IEEE

Cite This

PDF

Karamsetty Shouryadhar ; P Kiran Rao ; Subarna Chatterjee All Authors

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Abstract: This research was conducted with the goals of developing models that have an accurate classification of chronic kidney disease (CKD) and locating significant prognostic f... **View more**

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Abstract:

This research was conducted with the goals of developing models that have an accurate classification of chronic kidney disease (CKD) and locating significant prognostic factors within a clinical dataset. In chronic kidney disease, accurate classification and identification of major risk factors contribute to improved prognoses and provide assistance to nephrologists. The data source is not balanced enough to serve as a benchmark for any machine learning or deep learning models due to privacy concerns and other factors. As a result, it is difficult to achieve consistent accuracy with an imbalanced dataset, and there will be a variance in results with various machine learning models due to the fact that there are so many different factors involved. A multiple-level ensemble learning system was utilised in the proposed research in order to classify chronic kidney disease using a hybrid synthesised dataset. A hybrid synthesised dataset is one that contains both the original dataset as well as the synthesised data that was produced using the ADASYN method. The most important risk factors for chronic kidney disease are accounted for in the model that was proposed. The F1-score and accuracy were two of the metrics that were utilised in this research. Furthermore, the plot demonstrates that the multilevel ensemble is superior to the conventional machine learning techniques in terms of consistency and accuracy. The variance was calculated using the proposed model by iterating for a total of 150 times, which is a significant reduction when compared to multi-level ensemble techniques using hybrid preprocessed datasets. The accuracy of classifying patients with chronic kidney disease was significantly improved by using a multi-level ensemble. These models and parameters highlight the significance of current health status information in estimating the likelihood of developing kidney disease as well as its progression.

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Recommender System based on Deep Neural Network and Long Short Term Memory

Sandeep Kumar Rachamadugu ; Jayanarayana Reddy Dwaram ; Kiran Rao Patike All Authors

Abstract: To provide relevant recommendations for clients, a recommendation system is essential in online commerce, streaming services, and news article websites. Existing methods ... View more

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Abstract:

To provide relevant recommendations for clients, a recommendation system is essential in online commerce, streaming services, and news article websites. Existing methods in recommendation systems are limited by the cold start problem. The Deep Neural Network (DNN) – Long Short-Term Memory (LSTM) technique is developed in this study to improve the efficiency of recommendation systems. The DNN method is used to predict new user ratings based on prior user ratings, while the LSTM method is used to recommend a relevant movie to the user. The user-item similarity was calculated and used in the LSTM algorithm to offer the relevant recommendation. The LSTM approach has the advantage of storing relevant information over time and making appropriate recommendations. The proposed DNN-LSTM (Deep Neural Network-Long Short-Term Memory) technique in the recommendation system is evaluated using the MovieLens 100k and 1M datasets. In the MovieLens 100k dataset, the proposed DNN-LSTM approach has an RMSE of 0.431, while the existing HCBCF (Hellinger Coefficient Based Collaborative Filtering) method has an RMSE of 0.871.

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A Study of Heterogeneity Characteristics over Wireless Sensor Networks

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Abstract: Wireless Sensor Networks(WSN's) have potential capabilities to build novel IOT applications to monitoring /tracking the physical activities in the field of wild life, Smart home, disaster recovery, battle field and so on. WSN's are purely application specific, by behavior WSN's broadly classify into two categories, namely homogeneous and heterogeneous. In Homogeneous all the sensor nodes are same type / energy/link capability and more, where as in heterogeneity these parameters will be vary application to application. In this paper we primarily focus on elimination of overlapping of existed survey and proposed extensive survey results in terms of potential performance of various clustering and routing protocols in Heterogeneous WSN's.

Index Terms: *WSN's, Heterogeneity, IOT (Internet of Things).*

[1]. Introduction

Wireless sensor networks (WSN) is a collection of homogeneous and heterogeneous sensor nodes that are spatially scatter to observe an environmental or physical condition such as sound, pressure, temperature etc. [1][2]. These sensors collect the information from the environment and forwarded the data to the nearest nodes finally it reaches to the Base station. Sensors nodes are equipped with small battery, limited memory and processing capability. For sending and receiving data sensor nodes consumes its resources like energy, storage and computational capacity. Typical wireless sensor network applications are natural calamity relief operations, Biodiversity mapping, smart buildings, Industrial surveillance, Precision horticulture and health care [3-6]. To maintain large scale sensor networks design and develop efficient clustering and routing algorithms are the major research challenges. Some of the current research challenges are real time data scheduling, energy management, protocol programming abstraction, privacy and security, localization aspects [7].As per functional and technical metrics wireless sensor networks are broadly classified into two types namely homogeneous and heterogeneous extensively presented in [8-10].In Homogeneous all the sensor nodes are same type / energy / link capability and more, where as in heterogeneity these parameters will be vary application to application. In past decades many researchers focused and contribute the efficient techniques towards homogeneous. Which are lagging in heterogeneous conditions? Efficient clustering, energy optimization, Scalable routing, node deployment strategies, data fusion/ aggregation are the major research goals and some are still open issues.

Applications of Internet of Things in Manufacturing

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ABSTRACT- Paper presents the literature study on Internet of thingbased manufacturing. In today competitive markets, Industry not only used Automatic machine but also make co-ordination between them. Nowadays there is need to maintain balance between Man and machine. Used available resources effectively in order to achieve optimal performance and improve efficiency. Data is a source of information and Industry has been handled huge amount of data. There is need of tool to process, operate and remotely access this huge amount of data, here IoT makes its possible. Through IoT we can change whole scenario of Industrial working environment. It's increased the production rate as well as improve the efficiency of Industry. This provides a promising opportunity to build powerful services and applications for manufacturing.

INTRODUCTION

With the globalization of the world's economy, manufacturing enterprises are facing severe competition from their worldwide counterparts in terms of product price, function, quality, cost, lead-time, etc. and growing pressure to meet higher environmental standards due to the "enhanced producer responsibility". Meanwhile, consumers have more diversified and demanding needs, e.g., customized products.

These challenges push the manufacturing industry to embrace new technologies to keep competitive and meet user demands. The Internet of Things (IoT), which has great potential in transforming the manufacturing sector, attracts tremendous attention from both academia and industry. IoT envisions the seamless interconnection of the physical world and the cyber space, and the pervasive presence of them around us. The embedding of tiny electronics into physical objects and the networking of them, make them "intelligent" and seamlessly integrated within the resulting cyber-physical infrastructure. Thus, IoT can bring the greatly enhanced horizontal integration of various manufacturing resources used in different stages of manufacturing processes, and vertical integration of them at different hierarchical system levels. This provides unprecedented opportunities for existing or whole new manufacturing services and applications to leverage such advanced interconnection. For example, the connectivity between smart machines, production facilities, etc. will enable them to autonomously exchange information, trigger actions and control each other independently.

REVIEW OF LITERATURE

A recent executive survey conducted by Forbes Insights found that the biggest challenge in building out IoT capabilities is the quality of IoT technology. Many companies are facing problems with the adoption of industrial IoT during identification of automated process for achieving highest effectiveness (Raj Ven, 2018). Adopting IoT technology in the manufacturing industry is one of the shot ways for getting competitive advantages and it helps to create enterprise value in the process (Toya Peterson, 2016). Press release of IoT Analytics (2018) said that the 4th industrial revolution (I4.0) employs a combination of multiple technologies that manufacturers are implementing to realize key use cases for improving efficiencies, generating revenues and reducing risks. The product and service market of I4.0 is predicted to grow to $310 billion by 2023. As per the survey conducted by the Accenture, Business insider & SAP (2015) of 1400 owners of business, 60 percent of the global manufacturers will use connected devices to analyse and optimize processes, 36 per cent of the business leaders understand IoT, out of this, only seven per cent are able to implement it. Also, it is found that $70 billion would be capitalised by manufacturers in IoT by 2020 and product development and assembly costs can be reduced to 50 per cent.

KEYWORDS-

Internet of Things, Manufacturing, Remote Accessing process and control

METHODOLOGY- During manufacturing, IoT gives alert and reminder about various operation carried out in operation floor. It's always Indicates us about sequence of operations and SOP at successive stages of the production. IoT enabled manufacturing in term of architecture, deployment and business model, data acquisition and processing, modelbased decision-making. It greatly reduces the manufacturing errors/ defects which increase production rate and quality of the product. This paper analyses how IoT strategy facilitates to increase customer value, creates different opportunities for competitive advantage, and transform the business process to increase profit in industries. In order to achieve the objectives of the study, secondary data were collected from web sources and journals to identify the benefits and challenges on implementation of IoT in the engineering and manufacturing sectors.

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Confident Multi-Factor Authentication on web application

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Abstract: Evaluation of Captcha technologies towards prevention of phishing attacks as User Authentication Online guessing attacks, relay attacks and shoulder surfing attacks are handled, where Captcha as graphical passwords (CaRPS). CaRPS is click-based graphical passwords it performs a sequence of clicks on an image is used to derive a password. Confident Multi-Factor Authentication. Consumers now have strong protection from the thousands of fraudulent attacks that occur daily, without compromising the user experience. Confident Multi-Factor Authentication generates onetime passwords by prompting users to solve an image-based challenge on their mobile phone. Multi-Factor Authentication is a secure, out-of-band (OOB) authentication process for you and easy-to-use additional security for your users Confident Multi-Factor Authentication makes it easy to add strong authentication to your web application.

Key terms: reCAPTCHA, Graphical Passwords, Captcha as Graphical Password Scheme (Carps), phishing attacks, Confident Multi-Factor Authentication.

I. INTRODUCTION:

The majority of the clients are attempting to sign up for a free email administration offered via Gmail or Yahoo. Before you can submit your application, you first need to breeze through a test. It's not a hard test - truth be told, that is the point. For you, the test ought to be basic and clear. However for a computer, the test ought to be practically difficult to solve. This kind of test is a CAPTCHA. They're otherwise called a kind of Human Interaction Proof (HIP). You've likely seen CAPTCHA tests on loads of Web sites. CAPTCHAs are short for Completely Automated Public Turing test to distinguish Computers and Humans One from the other. The expression "CAPTCHA" was begat in 2000 by Luis Von Ahn, Manuel Blum, and Nicholas J. Container (all of Carnegie Mellon University, and John Langford (then of clients are surely human. The motivation behind a CAPTCHA is to square structure entries from spam bots – robotized scripts that reap email addresses from freely accessible web structures. A typical sort of CAPTCHA utilized on most sites requires the clients to enter the series of characters that show up in a contorted structure on the screen.

TabNet to Identify Risks in Chronic Kidney Disease Using GAN's Synthetic Data

Publisher: IEEE

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P. Kiran Rao ; Subarna Chatterjee All Authors

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Abstract: The objective of this study was to develop a system for chronic kidney disease (CKD) and to identify relevant prognostic features using a clinical dataset. Accurate class... **View more**

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Abstract:
The objective of this study was to develop a system for chronic kidney disease (CKD) and to identify relevant prognostic features using a clinical dataset. Accurate classification and major risk factors in chronic kidney disease lead to better prognosis and assist nephrologists. Due to privacy and other factors, the data source is not balanced to trail any models. Therefore, it is difficult to achieve consistent accuracy with an imbalanced dataset, and there will be a variance in results with different machine learning models. In the proposed study, GAN's generated synthesised dataset, which is very close to the original dataset, is used. A hybrid synthesised dataset consists of the original dataset along with the synthesised data generated with the GAN model. The proposed model also includes the most important risk variables for CKD. The metrics used in the study include F1-score, accuracy, and from the plot, it shows that the TabNet with GAN's synthetic data is more consistent and more accurate than the traditional machine learning techniques with imbalanced dataset. The proposed model iterated for 150 times to get the variance, which is much less than in proposed techniques with hybrid preprocessed datasets. The proposed work significantly increased the classification accuracy of chronic kidney disease. These models and parameters show how important health status data is for predicting the risk of and development of kidney disease.

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A review of uncertainty in data visualization

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Abstract: This paper provides a brief overview of uncertainty visualization along with some fundamental considerations on uncertainty propagation and modeling. Startingfromthevisualizationpipeline,wediscusshowthedifferent stages along this pipeline can be affected by uncertainty and how they can deal with this and propagate uncertainty information to subsequent processing steps. We illustrate recent advances in the field with a number of examples from a wide range of applications: uncertainty visualization of hierarchical data, multivariate time series, stochasticpartialdifferentialequations,anddatafromlinguistic annotation.

Keywords: Uncertainty visualization, multivariate data, hierarchical data, partial differential equations, linguistics

ACM CCS: Human-centered computing → Visualization theory, concepts and paradigms

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1 Introduction

Virtually any information comes with some aspect of uncertainty. The way we visually represent uncertainty can have a strong influence on how we perceive such information. Still, uncertainty is often neglected in general, and thus rarely considered in visual analysis and dissemination processes. There are two reasons for this: First, we tend to interpret visualizations as truthful because they are easier to understand in this case; less straightforward interpretation, as usually accompanied by uncertain data, must be learned. Second, many visualization techniques cannot handle uncertain data; then, the only option is to consider the most likely realization of the data and omit aspects of uncertainty.

Let us illustrate the topic and the aforementioned problems for the simple example of weather forecasts. Ideally, one would like to have a definite forecast concerning temperature and rain, although weather cannot be predicted with pin-point precision. Showing only the most likely temperature and rain, i.e., without the forecast range, it is virtually impossible to assess how much one can trust the weather forecast. Interestingly, there are different ways in which weather forecasts are communicated, for example, in TV news shows in the U.S and Germany. A probabilistic representation, as often used in North America, will tell the viewer the percentage of a certain event (rain in a given region), this way conveying theuncertainty,whereasinGermany,weatherchartsoften just show the most likely outcome of the forecast as a single illustration.

In the example of weather forecasts, we can directly convey uncertainty by numbers or simple visualizations like bar or line charts. However, what can we do if we have complex data like massive tree structures, multivariate data, or simulation results from science and engineering along with uncertainties? Here, it is already challenging to find visual representations that ignore uncertainty, but the problem becomes even more pronounced for uncertainty visualization.

In this paper, we want to provide a brief introductionintothegeneraltopicofuncertaintyvisualization,discussing some background, terminology, and fundamental

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AI & The Digital Revolution

***Abstract*— Artificial intelligence (AI) is an emerging technological field with immense transformative potential. Within this context, we discuss the diverse ways AI is transforming innovation. We introduce a conceptual framework in which we argue AI plays two roles: originator and facilitator. Additionally, we discuss different applications and implications for innovation theory and practice using a reflection on the traditional innovation process and the front end of innovation perspective. For this, we use the perspectives of AI as technology push, AI as market pull, AI to advance steps in the innovation funnel as well as AI as a contributor to new product development. Finally, we discuss future directions for research in these fields.**

***Index Terms*— Artificial Intelligence, Emerging Technology, Innovation, Emerging Technologies**

1. INTRODUCTION AND BACKGROUND

Artificial intelligence (AI) is set to become the key enabling technology of the 21st century. Hence, it is unsurprising that investors worldwide have set their sights on AI companies, particularly AI-related startups (see Figure 1). AI companies attracted over $26 billion in investments in 2019 alone.[1] It is also unsurprising that in the past decade, both private and governmental programs have exponentially increased their investments in this technology. AI's generative and mutable characteristics have enabled the rapid identification of potential applications by entrepreneurs and innovators alike. While the hype around the technology is not new [1], [2], digitization is increasingly driving AI's potential into a new dimension within the broader phenomenon of digital transformation [3].

Figure 1. Deals and funding of AI-related startups. (Source of data: https://venturebeat.com/2020/01/22/cb-insights-aistartup-funding-hit-new-high-of-26-6-billion-in-2019/)

While AI's development as a technology is exciting, an open question remains: How will AI transform innovation at different levels? AI has the potential to change how innovators make decisions [4], how ideas and new products and services are generated and designed [5], [6], and how data from users is leveraged for new business models [7], among other areas. We propose to organize these potential AI areas in relation to the innovation process [8], identifying how potential applications of AI technology resonate with the specific challenges of innovators.

To this end, we introduce a two-part conceptual framework: The first part views AI as a technology that can fulfill different roles within a company, and the second looks at AI and its use along the company's innovation processes. In the following sections, we introduce both parts and discuss them using examples from existing field applications, as well as describe potential areas for future research and limitations to this framework.

2. AI as a technology in the management context

AI is included in the larger set of digital technologies (including e.g., blockchain or IoT). It shares common characteristics related to the nature of technology, but it also has differential aspects that help to explain the continued attention the technology has received.

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