AUGMENTED INTELLIGENCE:

DEEP LEARNING, MACHINE LEARNING, COGNITIVE COMPUTING, EDUCATIONAL DATA MINING

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Bentham Books

Advances in Computing Communications and Informatics

(Volume 3)

Augmented Intelligence: Deep Learning, Machine Learning, Cognitive Computing Educational Data Mining

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Advances in Computing Communications and Informatics

Volume # 3

Augmented Intelligence: Deep Learning, Machine Learning, Cognitive Computing,

Educational Data Mining

Series Editors: Pradeep Kumar Singh, Bharat Bhargava & Wei-Chiang Hong

Volume Editors: Om Prakash Jena, Alok Ranjan Tripathy, Brojo Kishore Mishra & Ahmed A. Elngar

ISSN (Online): 2737-5730

ISSN (Print): 2737-5722

ISBN (Online): 978-981-5040-40-1

ISBN (Print): 978-981-5040-41-8

ISBN (Paperback): 978-981-5040-42-5

First published in 2022.

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PREFACE

Augmented intelligence is an alternate approach to artificial intelligence (AI), which emphasizes on AI's assistive role, underlining the fact that cognitive technology is intended to improve human intelligence instead of replacing it. It enhances human skills of reasoning in a robotic system or software, including expectancy, educational Mining, and problem solving, recollection & sequencing, and decision-making capabilities. With the collaboration of Machine Learning, Deep Learning and Cognitive Computing it can be highly implemented technologies in the near future. It can overcome the human limitations that hinder effective research. This AI layer complements knowledge workers' efforts and allows them to essentially automate or drastically reduce the time devoted to low-value tasks, while focusing more on higher impact issues. Augmented Intelligence can eliminate time-consuming tasks, freeing up teams to focus on higher value analysis.

There are many research problems which are NP-Complete. Being a research fellow, one has to provide an optimal solution to the hard-to-solve problems in different sectors of optimization problems. For such needs, this book will give helpful insight while identifying problem statements and then the idea to develop time-optimal strategies for such unresolved issues. This book is also helpful to write articles on various issues which involve Augmented Intelligence based on ML, DL, Cognitive Computing and its various applications in real life scenario. They can grab the opportunity from this book to devolve some new algorithms, models, patents based on Augmented Intelligence to design more robust, efficient, accurate models.

This book will be able to define the model which supports Knowledge Discovery, educational model design, self-learned system, logical reasoning, virtual learning, social network analysis, *etc*.

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CHAPTER 1

Integrating Educational Data Mining in Augmented Reality Virtual Learning Environment

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Abstract: Virtual learning environments have become an essential tool, incorporated in learning activities in educational institutions and individuals' homes, especially during the COVID-19 pandemic. Digital devices provide the platform for the learning environment, but learning sometimes becomes passive and boring. Augmented reality provides learners with the needed motivation, engagement, thereby boosting the learner's activity within the virtual learning environment. It augments the traditional learning materials with 3D objects, animations, audio and visual elements, which offer better interactivity for a rich learning experience.

This study aims to give an overview of the development of an augmented reality system to provide a virtual learning environment that delivers a more engaging and motivating lesson, story and experience. The study incorporates Scrum methodology, an agile software development practice that uses small increments called sprints to develop the virtual learning environment in several usable modules. The study also discusses the software tools, Blender and Unity 3D, to develop 3D models and the augmented reality modules for the virtual learning environment. The system uses image targets as markers to project 3D objects to augment the images from the traditional learning materials and offer a better visual experience. The development incorporates features of Educational Data Mining to optimise users' learning styles and learning experiences. This chapter will demonstrate augmented reality technologies to implement a virtual learning environment that will offer an interactive and engaging learning experience.

Keywords: Augmented Reality, Agile Development, Educational Data Mining, Virtual Learning Environment.

1.1. INTRODUCTION

The educational system has gone through several technological incorporations over the years. Educational institutions have transformed the teaching and learning process, resulting in progressive consequences [1].

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Despite its limitations, the traditional classroom remains an essential aspect of education. Both instructors and learners still value the face-to-face model of teaching.

Virtual learning environment have become an essential tool incorporated in learning activities in educational institutions and individuals' homes, especially during the COVID-19 pandemic. Schools were closed down, and the management of these institutions resorted to virtual class sessions to continue teaching when it did not seem like the pandemic would soon be over.

Some institutions utilised live teaching sessions; students log in to online video conferencing and collaborative systems to watch and listen to their instructors delivering lectures. These systems provide features for questions *via* chat or using the device's microphone, just like students raising hands to ask questions in class. Others instead use recorded class sessions (audio or video) and make them available online for students to watch online or download to their devices and watch offline. Such systems provide discussion forums to encourage peer discussions with the instructor to moderate the questions and comments posted.

Digital devices provide the platform for the learning environment, but learning sometimes becomes passive and boring. Students usually watch or listen to these sessions while getting distracted and find themselves doing other activities alongside. Augmented reality provides learners with the needed motivation, engagement, thereby boosting the learner's activity within the virtual learning environment. It augments the traditional learning materials with 3D objects, animations, audio and visual elements, which offer better interactivity for a rich teaching and learning experience for both instructors and learners.

1.2. VIRTUAL LEARNING ENVIRONMENTS (VLE)

Virtual learning environments usually comprise resources and tools used within a network-connected computer systems environment. A wired or wireless network shares information among the connected systems. The information includes text, image, video and audio files shared among various stakeholders in the virtual learning environments, running on the internet or an institutional intranet. Such networks also allow communication between students and their instructors within the virtual learning environments. The communication could be synchronous, occurring simultaneously from both nodes, or asynchronous, occurring at different times based on the time schedules of the users. Virtual learning environments provide the platform within the educational infrastructure to accommodate all these functionalities [2].

The educational sector has embraced virtual learning environments to promote information and content sharing and communication among students and instructors [1]. Studies have shown that peer interaction and collaborative learning activities are essential for a virtual learning environment in education. A virtual learning environment provides the platform for students to collaborate individually or in groups to learn and work on activities and projects without being physically around each other. Virtual learning environments deliver content in various formats and allow students to apply different strategies in the learning process. Students can use learning materials based on preference and suitability. They can revisit previous content and control the pace of learning at their convenience [2].

Learning environments come with a focus on the delivered content. Virtual learning environments are built-in with features, activities and content to support the engagement and interactivity of learners and create an immersed state within the VLE [3].

The development and implementation of a virtual learning environment should focus on its content and the presentation to the students. Students have varied learning styles; some prefer reading text, others listen to audio files, and others watch video demonstrations. A properly structured virtual learning environment will provide the necessary resources for students to access learning materials in the format they are convenient with, and they should have the option of switching between different formats of the same content [4].

Several studies have recommended features and functionalities that should be present in a virtual learning environment [4 - 7]. An implemented system might not have all these features (Fig. **1**) deployed. However, all of these have unique functionalities that will make a virtual learning environment provide an outstanding teaching and learning experience for both instructors and students and all other necessary stakeholders.

1.3. AUGMENTED REALITY (AR)

Augmented reality technology offers a richer augmentation to information by including virtual objects implanted into images; the virtual objects come in various forms – text, images, audio, video, animation, 3D models. Augmented reality gives an illusion of the objects within the same physical environment [8 - 10]. Augmented reality uses virtual objects displayed in a real-world physical environment to provide an enhanced experience.

Some studies on augmented reality evidence the enriched teaching and learning experience AR provides to its users [11].

CHAPTER 2

Brain and Computer Interface

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Abstract: Brain-computer interfaces (BCIs) are defined as the science and technology of devices and systems responding to neural processes in the brain that generate motor movements and to cognitive processes (*e.g*., memory) that modify motor movements. Advances in neuroscience, computational technology, component miniaturization, the biocompatibility of materials, and sensor technology have led to the much-improved feasibility of useful BCIs. Brain-Computer Interface can be developed by engineers, neuroscientists, physical scientists, and behavioral and social scientists as a team effort. A study on brain computers (BCI) discusses how the brain and external systems interact. In intrusive systems, electrodes are implanted in the cortex; in non-invasive systems, they are mounted on the scalp and use electroencephalography or electrocorticography to monitor neuronal activity. The BCI systems can be generally ranked based on the location of the electrodes used for detecting and measuring neurons in the brain. This WTEC report was intended to compile and reveal to government decision-makers and the scientific community the information on global developments and patterns in BCI research. The design of hardware, device architecture, functional electrical stimulation, non-invasive systems of communication, academic and industrial cognitive and emotional neuroprosthesis has been discussed in this chapter. The purpose of the present chapter is to review the current sensor technologies used for invasive and non-invasive BCI approaches throughout North America, Europe, and Asia. We have visited and/or interacted with key laboratories with expertise in these areas. Although not completely comprehensive, this chapter gives an overview of the major sensor technologies being developed for potential BCI applications.

Keywords: Cortex, CNS tissue, ECoG strips, Electrode cap, Electrocorticography, Emotional neuro-prostheses, EEG signals, Etching technique, Geometric electrodes, Invasive, Integrated chip, Micro-heater, Multi-electrodes, Non-invasive, Neurosurgical technology, Neuronal map, Polyimide microelectrode, Sensor technology, Sensor Technology, Silicon-based Electrodes.

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2.1. INTRODUCTION

This chapter offers a description of the sensors in the brain-computer interface technology (BCI) data set. We divide sensor technology into two fundamental categories for this chapter. First of all, we speak about "invasive" technologies, including brain implantation surgical techniques involving mostly the multi-electrode recording of microelectrode arrays inserted directly into the brain to test single-cell action potential. The key subject of this chapter is a big growth market for sensor technology [1]. We should point out that this technology has not been approved for the trials on human beings [2]. Furthermore, observations of subduing or epidural stripes of electrode arrays that monitor cortical potential [3], which is somewhat similar to EEG recordings on the skull surface, will be addressed, as this is the main use of these intrusive electrodes for human epilepsy surgery [4]. However, the development of other BCI applications may be improved. Secondly, the "nonspecific" technologies are discussed, involving mainly "Wet" silver (Ag) or gold (Au) multi-electrode EEG registration arrays of pull electrodes that are mounted on the surface of the crane to monitor EEG operation. These electrodes come from a variety of sources online, but relatively little development has occurred in this field [5]. We warn that "non-invasive," scalp-invasive, BCI-technology applications are often used acutely and can become more invasive for people at home or at work. Further advancement of technologies in this field will be addressed briefly.

2.2. WHAT IS BCI?

The term "BCI" has been popularized and was first published by UCLA professor Jacques Vidal. Vidal is well known in peer-reviewed arts as the scientist of BCIs [6]. A brain-computer interface is an effective communication interaction between the external device and the central nervous system, also known as a mind-machine interface [7], that circumvents the use of encapsulation. This travels through the cortex straight to the device instead of from the cortex to the finger on the keyboard by the musculoskeletal mechanism [8].

Brain interface devices shown in these times need deliberate thinking, although potential implementations will work smoothly [9]. sThe old method to BCI, which required the implantation of a mechanical device in the brain, and it seemed to monitor as a genetic component of the body, is being replaced by current, in-depth information on non-invasive BCI. BCIs are built to increase the sensory-motor or human cognitive processes, support them or restore them. This incorporates electrical engineering, information science, biomedical and neurosurgical technology [10].

2.3. BCI SENSOR WORLD OVERVIEW

The bulk of European BCI sciences include “non-invasive” sensor technology [11], *i.e*., multi-electrode recording from EEG electrode arrays on the skull floor [12, 13]. This sensor technology has seen very little development and needs to be greatly improved [14]. In Europe, several BCI sites are capable of delivering sensing devices, which may help advance the production of “invasive” sensor technology [15].

Brain-machine interfaces (BMI) [18], while they are designed to solve the same problem, are substantially different from BCIs, expressing the purpose of a subject in robotic orders [16]. BCI acts in a manner that is understood to equate with actions but is diffusing and unspecified with the macroscopic brain function (mostly EEG) [17]. BCI has already achieved progress and is ready for patients to use, building on accessible EEG research and machine learning techniques details [19, 20].

2.4. HISTORY OF IMPLANTABLE ELECTRODES

CNS history of implantation of electrodes dates back to Hess' early work with original feline implants in the 1930s' [21]. In the 1970s, however, implantable electrodes saw a more recent adaptation. The development of 50 μm tungsten microwire arrays was recorded by Selman and Bach in the early 1970s in the electrophysiological records and the early 1980ies by Chapin & Woodward (1986). In essence, many laboratories use this type of technology for more frequent single-unit recordings and many animal BCI applications. The accurate monitoring and functionality of individual wires for electrode recording sites are some of the difficulties with multi-wire arrays [22].

Wise and Angell developed the principle of the use of integrated chip (IC) technology to improve the microelectrodes from 1970 to 1975 [23]. In the next several years, various articles were written; Bement Standard wire electrode works were ground breaking in the 1980s, varying in diameter, with a duration exposed of up to 1 mm, from 13 to 200 μm [24]. Fig. (**2.1**) provides an illustration of a high-density array of embedded micro disk for recording up to 128 wires in spontaneously movement mice. Wire electrode is widely used by rats, primates, animals, and late monitoring purposes [25].

CHAPTER 3

Potential Use of Tree-based Tools for Chemometric Analysis of Infrared Spectra

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Abstract: One of the most elegant and versatile techniques of machine learning is the decision tree. The decision tree is a simple tool to predict and explain the relationship between the object and the target value, recursively partitioning the input space. Tree ensembles such as random forest and gradient boosting trees significantly improve the predictive power of supervised models based on tree weak predictors. In a random forest, the generalized error that is included in the model prediction is dependent on the correlation strength between the trees and the individual predictors' quality. The random selection of features in each node split is at the core of random forest, which makes it as effective as other complex machine learning techniques while having a lower computational cost, which is appealing in the analysis of large data matrices such as those generated by infrared spectroscopy because most analysts do not have computers with high processing capacity for implementing those complex models. Also, techniques based on the decision tree are more robust to noise, which is preferable for the analysis of trace level contaminants. In this chapter, we present the techniques based on decision trees and apply them to solve problems related to classification, regression, and feature selection in spectra obtained experimentally and provided by public repositories. Comparisons of the performance obtained with techniques based on the decision tree in relation to other chemometric tools are also performed.

Keywords: Analytical screening, ATR, CART, Chemometrics, Data mining, Discriminant analysis, Decision trees, Feature selection, FTIR, Gradient boosting machines, Machine learning, Non-parametric models, Non-Linearity, Neural Networks, NIR, Predictive models, Supervised learning, Random forest, Regression, Supervised learning, Validation.

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3.1. INTRODUCTION

The association of spectroscopy and multivariate calibration methods has enabled the analysis of complex spectra of multicomponent systems. Therefore, it has been used in a wide variety of regression methods [1]. The application of new pattern recognition algorithms, such as methods based on decision trees, has grown in recent years due to its advantages and ability to solve complex problems for the purposes of classification and calibration [2]. Decision tree models, capable of modeling linear and non-linear relationships, stand out among the various regression methods for being easy to understand, fast and non-parametric [1].

To improve the predictive performance of the decision tree, a large number of tree-based algorithms have been developed, such as decision forests [3]. The use of decision tree-based methods has become popular in a wide variety of areas [4], for example, food quality and authenticity, metabolomics and ecology [2].

The best-known decision tree method is the Classification and Regression Tree (CART). CART is a binary tree representation capable of describing the relationships between dependent (numerical or categorical) and independent variables with sufficient precision [5]. It is a supervised non-parametric technique used for the purposes of classification and regression [6]. CART is an algorithm used in local linear and non-linear adjustment with categorical (classification) or continuous (regression) variables. This algorithm is used in the random forest (RF) as a tree growth algorithm [1].

The decision forest method best known is the Random Forest (RF) [7]. RF consists of a group of unadjusted decision trees that grow by a bootstrap sampling of training data and random selection of variables [1]. RF has become popular due to the simplicity of training and adjustment parameters and due to the ability to deal with complex non-linear systems [8].

Gradient Boosted Trees (GBT) is another ensemble-based method used to reduce the error of 'weak' predictors as decision trees by repeatedly running and recalibrating the weights [9]. The GBT algorithm can be combined with several machine learning methods promoting an improvement in the accuracy of the prediction results. In addition, the GBT algorithm adds the advantages of having a low degree of overfitting and good generalization performance [10].

In this chapter, we presented some tree-based techniques as CART and random forest (for more details regarding other tools based on decision trees, the study of James *et al*. can be referred to [11]) and applied them to solve problems related to classification, regression and feature selection in FTIR spectra obtained

experimentally and provided by public repositories. The performance of the applied decision tree-based techniques was compared to the performance of other chemometric tools.

3.2. DECISION TREES (DT)

Typically used in classification operations, decision trees are elegant machine learning tools that are based on a decision model that express conditional control instructions. Decision trees generate rectangular subsets, A_j, recursively partitioning the data set, one X attribute at a time, making inferable decisions at each step. All trees start from a root node, from which all other nodes will originate. A node with outgoing edges is called a test or internal node. The rest, which originate from the branches and find their end, are called leaves or decision nodes. In operation, each internal node divides the attribute space into a predetermined number of sub-spaces, according to a discrete function. The number of branches varies according to the complexity of the tree.

Each internal node contains an attribute being tested, and, especially in the classification trees, each leaf represents a different class. Also, it is common for the leaves to have a vector of continuous values that informs the probability that the target value is predicted with certain accuracy [12]. The instances are, therefore, classified from the root to the leaves, as shown in Fig. (**3.1**).

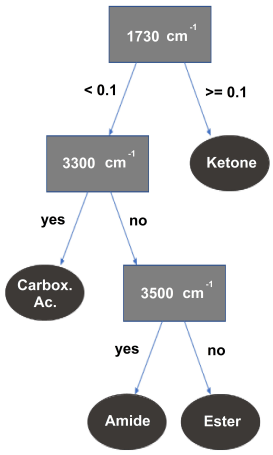

Fig. (3.1). Example of a decision tree using spectral information.

In Fig. (**3.1**), the internal nodes were represented by rectangles and the leaves by ellipses. The first internal node in the series is the root. It is interesting to note that

CHAPTER 4

Applications of Deep Learning in Medical Engineering

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Abstract: As a result of considerable breakthroughs in the field of artificial intelligence, deep learning has achieved exceptional success in resolving issues.This work brings forth a historical overview of deep learning and neural networks and further discusses its applications in the domain of medical engineerings - such as detection of brain tumours, sleep apnea, arrhythmia detection, *etc*.

One of the most important and mysterious organs of our body is the brain. Like any other organ, our brain may suffer from various life-threatening diseases like brain tumours which can be malignant or benign. Analysis of the brain MRI images by applying convolution neural networks or artificial neural networks can automate this process by classifying these images into various types of tumours. A faster and more effective method can be provided by this method for detecting the disease at a key stage from where recovery is possible.

Sleep apnea is a sleeping disorder involving irregular breathing. The brain detects a sudden decrease in the level of oxygen and sends a signal to wake the person up while he is sleeping. Cardiac arrhythmia refers to a group of conditions that causes the heart to beat irregularly, too slowly, or too quickly, *e.g*., atrial fibrillation. Deep learning along with bio-medical signal and audio processing techniques on respiratory sound datasets and ECG datasets have huge potential in the detection of these diseases. Deep learning outperforms the existing detection algorithms and a good amount of effort on feature engineering, augmentation techniques, and building effective filters can get a high accuracy result.

Keywords: Artificial intelligence, Artificial neural networks, Atrial fibrillation, Automation, Audio processing, Brain tumours, Bio-medical signal processing, Cardiac arrythmia, Convolution neural networks, Deep learning, ECG, EEG, Feature engineering, Machine learning, MRI imaging, Neural networks, Optimization, Signal processing, Signal analysis, Sleep apnea.

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4.1. HISTORICAL OVERVIEW OF DEEP LEARNING

4.1.1. Machine Learning

Machine learning can be defined as methods used to make a computer learn and automate various tasks without being explicitly programmed [1]. Tom Mitchell provides a modern definition of machine learning. "A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at Tasks T, as measured by P, improves with experience E." These methods or algorithms work on the data, learn important features from that data, and then apply these learned features to make important decisions to new sets of data. For example, machine learning algorithms are used in online music streaming services or video streaming services to make a recommendation to its users based on the user's listening preferences.

In earlier days, when the penetration of internet in the society and the use of technology in everyday life was less, the amount of data generated was less, and the training of machine learning algorithms on such a small amount of data led to problems known as overfitting. Overfitting decreases the accuracy of machine learning algorithms as it performs poorly on test data. So, researchers, data scientists, and machine learning engineers would primarily focus on how to solve this problem of overfitting.

But with time, the size of datasets began to increase. Nowadays, several GBs of data can be found on various topics and the problem of overfitting began to disappear as the dimensionality of the data began to increase. But processing such a huge dataset using machine learning algorithms is not possible as the learning capacity gets saturated, which leads to underfitting. This happens because machine learning algorithms use shallow structures.

The deep neural networks used in deep learning algorithms have large learning capacities as they can handle a large number of parameters. When compared to machine learning techniques, the performance of deep learning owing to overfitting is either the same or worse. So, whenever the dataset is huge, the use of deep learning techniques is most suitable. They increase the learning capacity of the models as they have better optimization techniques and use large computational resources.

4.1.2. Neural Networks

A neural network is a web of neurons [2]. In biology, these are similar to the neurons present in the brains of any living organisms, while in computer science,

these are artificial neurons used to solve complex mathematical, statistical, or artificial intelligence problems. These artificial neurons mimic the working of the human brain. The deep learning algorithms use these deep neural networks, as shown in Fig. (**4.1**), to train the model.

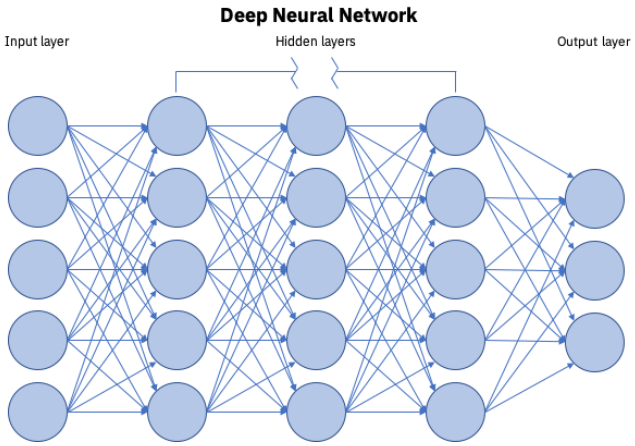

Fig. (4.1). Architecture of a Deep Neural Network.

Neural networks must include numerous layers, not just one or two, to answer difficult real-world artificial intelligence concerns.In Fig. **4.1**, the neurons are arranged in various layers, which are in turn connected to adjacent layers with some numerical weights. In feedforward operations, the neurons in each layer receive some signal and transfer it to the neurons in the adjacent layer after performing some mathematical calculations on the input and passing it through an activation function [3].

In each hidden neuron j, the weighted sum of input neurons is first calculated as in Equation 1a:

$$Net_j = \sum_{i=1}^{d} x_i w_{ji} + w_{j0} \quad \textbf{(1a)}$$

Where Net_j is the total activation value of the neuron, w_{ji} are the weights of connections between the input layer and the hidden layer, w_{j0} are the bias terms associated with each neuron, and x_i is the input value. This value is then passed through a special activation function like $y = g(Net_j)$, which is used to remove the linearity in the data. If the total activation value is greater than the threshold value of the activation function, then the value is transmitted to the next neuron; otherwise, it will not get transferred.

CHAPTER 5

Bankruptcy Prediction Model Using an Enhanced Boosting Classifier based on Sequential Backward Selector Technique

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Abstract: Corporate bankruptcy prediction is one of the most crucial issues that impact the economic field, both on the local and global scale. The primary purpose of bankruptcy prediction is to investigate the economic state of any corporation and evaluate its distress level. Several machine learning and deep learning models have been used to predict financial failure. However, there is still no technique that resolves all the problems faced in this field. As such, we propose a machine learning model that constitutes a feature selection phase and a classification phase to predict corporate bankruptcy. This technique combines the sequential backward selector (SBS) with AdaBoost and JRip algorithms. The first phase uses SBS to select the best subset of features for the training. The second phase trains the AdaBoost with the JRip classifier to predict each target class. This model is evaluated using the highly imbalanced Polish bankruptcy dataset. The comparative analysis of our model with other techniques proves the efficiency in predicting corporate bankruptcy with an average of 91% of the AUC metric.

Keywords: Bankruptcy prediction, Boosting technique, Classification, Feature selection, Polish bankruptcy dataset, Python, Rule-based classification, Two-stage method, Weka, Wrapper methods.

5.1. INTRODUCTION

The dilemma of predicting corporate bankruptcy aims to differentiate firms with a likelihood of distress from healthy corporations. It is a phenomenon that may be

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caused by unsuitable decision-making. It impacts the economic field on the local and global scale since it renders all institutions involved vulnerable. Thus, emerged the need for tools that allow monetary institutions to predict bankruptcy. This need heightened the interest of researchers and scientists in the field of corporate bankruptcy [1 - 5].

Many studies have proffered several solutions for financial failure prediction. These articles focused on the structure of the data, the features, and the target classes of samples to find a relationship between the characteristics and the target classes to perform the prediction [6]. These existing works are split into statistical methods and artificial intelligence techniques. The statistical models consist of using mathematical and statistical principals to formulate a relationship between variables in the data, such as Multivariate Discriminant Analysis (MDA) [7], Linear Discriminant Analysis (LDA) [8], and Quadratic Discriminant Analysis (QDA) [9]. But these methods fail to obtain valid hypotheses for individualistic features due to their presumptuousness for the multivariate normality, linear separability, and independence of the predictive variables [10]. The artificial intelligence methods aim to build models based on machine learning and deep learning algorithms like Decision Trees [11], Support Vector Machines [12], and Artificial Neural Networks [13]. These algorithms can build cognitive functions/pattern recognition based on high dimensional datasets. Subsequently, they do not make assumptions when dealing with data distribution [14]. Unfortunately, most of these algorithms are black-box models. They fail to accommodate the data imbalance problem, which is a common factor in bankruptcy datasets.

Recently, the use of ensemble methods demonstrated their ability to give relatively precise predictions for bankruptcy, specifically AdaBoost [15], Gradient Boosting [16], and eXtreme Gradient Boosting (XGBoost) [17]. The data imbalance phenomenon is a challenge when dealing with classification since the samples of one class outnumber those of the others, which creates fluctuations in the training sets. Since the ensemble methods use a set of classifiers instead of a single classifier that is capable of dealing with the imbalanced data [18], these methods are sensitive to noisy data and outliers.

In this context, we present a bankruptcy prediction model based on Adaptive Boosting (AdaBoost) algorithm. This algorithm is very apt at dealing with the data imbalance issue. It is also compatible with almost any learning algorithm, which allows for an expanse of experimentation. In our approach, we combined AdaBoost with the JRip algorithm. This novel approach was trained on the extracted data from the Sequential Backward Selection (SBS) technique.

The remainder of this paper follows this structure: Section 2 is a discussion of the related work concerning the bankruptcy prediction problem. Section 3 explains the proposed approach. Section 4 analyses the proposed method and conducts a comparison with other studied algorithms. Finally, section 5 provides a set of perspectives for future work.

5.2. RELATED WORK

Several algorithms have been proposed to predict company bankruptcy. The research splits into statistical and artificial intelligence techniques.

5.2.1. Statistical Techniques

Statistical methods use mathematical and statistical principles to formulate a relationship between variables and their significance in the data. The most popular statistical methods include LDA, MDA, QDA, LRA, and FA.

These techniques were the starter point in predicting corporate bankruptcy. Single Discriminant Analysis [19] and Multivariate Discriminant Analysis [20] were the earliest models used in this field. Although many criticized their inability to adjust to the variables and support their normality [21], statistical methods provided an interesting concept, which motivated researchers to invest more in them. Consequently, this leads to the introduction of the logit and probit model [22]. Still, this technique was also found to be flawed because of the high risk of the predictions falling outside the appropriate range of the classification. The focus then shifted to put more value in the data characteristics. Combining the logit and probit model and factor analysis model procured a solution that gave better results. The solution was eventually considered the most favourable one at the time for its high performance [23].

Statistical techniques are well versed when extracting relationships between variables. However, they are unable to adapt to high dimensional financial datasets. Nowadays, they are deemed ineffective in resolving the issue of corporate bankruptcy prediction.

5.2.2. Artificial Intelligent Techniques

Statistical methods need to work with structured data to predict bankruptcy [10]. Intelligent techniques, however, are successful in solving the problem, thanks to their ability to mould to the data and spontaneously extract knowledge to procure accurate models [24].

CHAPTER 6

Detecting Ballot Stuff Collusion Attack in Reputation System for Mobile Agents Security

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Abstract: A Mobile Agent (MA), when dispatched in a decentralized peer-to-peer (P2P) electronic community, is forced to do a transaction with unfamiliar hosts. Such unfamiliar hosts are malicious in nature and can tamper agent's code, state, and data. To solve integrity, confidentiality, availability, and authenticity threats from hosts, this paper proposes a soft security approach. Under this approach, a trust-based reputation model called MRep is proposed. The model considers first-hand information called Direct Reputation (DR) obtained from trust gathered through Source Host (SH). The model assumes SH to be a pre-trusted host that possesses past transaction experience from the destination host. The destination host (DH) is the target host with which the agent wishes to do a transaction in the future. Indirect Reputation (IDR) is obtained from recommenders having a past transactional history with the DH. A collusion attack takes place when these recommenders collaborate to give false recommendations about DH. Ballot Stuff and Bad Mouth collusion occur when recommenders collude to give a positive and negative rating to dishonest and honest DH, respectively. The methodology is based on Similarity Filtering (SF) that uses Euclidean Distance (ED) and single linkage clustering techniques. ED is calculated between consecutive recommender's past recommendation value called 'F-Score' and recommendation value given by SH for DH. Clustering merges recommenders into two clusters. Scatter plots give two clusters. One cluster contains recommenders that gave an exceptionally high or low rating to DH while the other cluster gave a rating close to the rating given by SH. Bernoulli's trial helps to know the effect of collusion on the Final Reputation (FR) of DH when the number of colluders increases and decreases in the system. The reputation errors are calculated and statistically verified using Binomial Probability Distribution. Validation graphs show that when the chance of collusion (p) is less than 0.5, the probability of reputation error p(x) decreases with an increase in the number of colluders(x). When p is equal to 0.5, p(x) first increases and then decreases with an increase in x and when p is greater than 0.5, p(x) increases with an increase in the number of colluders(x). We compare SF with Bayesian Filtering (BF), Outlier Filtering (OF), and No Filtering (NF) when 20%, 40%, 60%, and 80% collusion arises in the system. The proposed SF approach helps filter ballot stuff colluders. MRep gives less error in FR of DH, even when 80% collusion arises in the system.

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Keywords: Binomial probability distribution, Ballot stuff, Bad mouth, Collusion, Direct reputation, Euclidean Distance, Hosts, Indirect reputation, Mobile agents, P2P, Single-linkage clustering.

6.1. INTRODUCTION

P2P networks consist of some important properties that attracted many researchers to talk about trust and reputation issues. These issues help agents to find the trustworthiness of peers (hosts) before the actual transaction. Since each peer plays the role of both server and client, P2P networks do not require any central control [1]. Peers are also called hosts, where the actual execution of the agent takes place. Reputation-based systems collect facts about the properties of hosts, analyze them, aggregate facts about them, and finally disseminate these aggregated facts to all other hosts in the network [2]. Our earlier paper discussed how these systems could be used in mobile agent technology to secure mobile agents [3]. To ensure security, trust, and reputation-based systems are built where mobile agent finds the trustworthiness of the host's behavior before performing an actual transaction with them. In the earlier paper, the MRep model is proposed to determine the trustworthiness of the host with which mobile agent wants to pursue transaction [4]. Since all hosts are autonomous in nature, they can check each other's trustworthiness using social mechanisms of reputation. A reputation-based system collects facts about the properties of the host. It analyzes and aggregates the facts about it and finally disseminates these aggregated facts to all other hosts in the network [5]. In an e-commerce scenario, an agent is dispatched by the user in the network for selling or buying (transactional purpose) products. For this purpose, it performs possible negotiations with sellers (hosts). Since an agent has no past behavioral information, it carries a lot of suspicion and mistrust on hosts. An entity that trusts are called a trustor and an entity on which the trustor trusts is called the trustee. Our proposed MRep model consists of a trustor (agent) that collects feedback from recommending hosts (recommenders) to derive the reputation of the DH. The model considers recommendations from only those hosts that possess past transaction history with the DH. Recommendation reputation (rating) helps the mobile agent to predict the trustworthiness of the DH. Unfortunately, the recommendations given by recommenders or raters collaborate to give false ratings to make DH's reputation low or high in the market. These recommenders collude to act as if they are one single unit. Such recommenders are called colluders. These colluders keep the information about each host's transaction and recommendation history. Ballot stuff collusion occurs when recommenders collude to give a fake positive recommendation for non-reputable DH while bad-mouth collusion occurs when recommenders give fake negative recommendations for reputable DH [6]. Bad-mouth colluders not only give

negative ratings for the honest (reputable)host but also give fake positive ratings to each other. This results in severe damage to the system. Colluders damage the recommender's recommendation reputation of honest recommending hosts by spreading negative opinions about those hosts with whom they had not even performed transactions. Through such collusion activity, hosts create a conflict in DH transactional behaviors and its recommendation reputation values. Colluders prevent their recommendation reputation by sending honest recommendations for those hosts who agree to collude with them. Section two discusses the proposed reputation model in brief. Section three classifies related works and limitations. Section four explains the proposed similarity-based filtering (SF) methodology to detect colluders. Section five discusses experimental results of SF in ballot stuff and bad-mouth collusion. Section six envisages statistical simulation to show how FR increases and decreases with a probability of reputation error. Section seven shows error values in FR of DH. Section eight highlights comparative analysis and discussions. Section nine concludes the paper with future scopes.

6.2. TRUST BASED REPUTATION SYSTEM

Mobile agents are migrating programs that consist of code, data, and state [7]. In an e-commerce scenario, an agent on behalf of the user is left in the network for selling or buying products. Agent as a buyer carries no idea about host transaction behavior and performs possible negotiations with seller host because sellers are executing host platforms. Agent gets trapped by the execution environment of hosts because it does not carry the host's past behavioral information [8, 9]. An agent has to manage the risk while transacting with the host without its prior experience and true knowledge of the host's reputation. Hence, the need arises to develop strategies to establish trust for ensuring security by assessing the destination host's direct and indirect reputation [4]. The entity that trusts are called the trustor and an entity on which the trustor trusts is called the trustee. The model assumes the mobile agent as trustor and DH as trustee. Reputation systems signify soft security related to trust & reputation of interacting entities while hard security is related to authorizations and certifications of entities [10]. These systems consist of the trustor (agent) that collects feedback from the recommending hosts about the trustee. The feedback score given by recommending hosts is called recommenders. Recommenders give ratings for DH depending on their past transaction and recommendation history. Unfortunately, the feedback score (recommendation)given by recommenders or raters collaborate to give unfair ratings to declare DH's reputation low in the market. These recommenders collude to act as if they are one single unit. Such fake united recommenders are called colluders. Colluders keep information about each host's transaction and recommendation history. The paper aims to identify colluders,

CHAPTER 7

Crow Search Algorithm: A Systematic Review

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Abstract: Cognitive computing and Artificial Intelligence (AI) are Computer Science branches which aim to create machines and ingenious technologies that are capable of working and thinking like humans. Evolutionary computing is a subfield of AI that uses nature-inspired mechanisms (algorithms) and solves problems through processes that mimic the behavior of living organisms. Researchers have focused on several meta-heuristic algorithms, and the Crow Search Algorithm (CSA) is one of the recently developed algorithms dependent on the astute conduct of crows. CSA is a populace-based methodology. It works by storing excess food in hiding places and extracting the food when necessary. This algorithm has been used in different fields such as medical diagnoses, fractional optimization problems, and energy problems. Several modifications have been made to this algorithm, and the current research focuses on a systematic review of the applications of the crow search algorithm in the medical domain and the variants of CSA and its application in different engineering fields.

Keywords: Application of CSA, Crow search algorithm, Evolutionary algorithm, Medical diagnosis, Meta-heuristic algorithm, Variants of CSA.

7.1. INTRODUCTION

One of the most difficult concerns in recent decades has been diagnosing and addressing medical disorders. Cognitive Computing and Artificial intelligence techniques have revolutionized the sphere of diagnosing clinical problems and proposing treatments in addition to their primary ability to analyze over the past years. Algorithms focusing primarily on machine learning are among the first algorithms that were designed and used for analyzing medical data because they comprise many tools that are crucial in this field. One of the fundamental challenges in the health care system is to obtain an efficient utilization of

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expensive assets while maintaining or providing quality care. To enhance the product-ability in health care system, optimization is applied in each field, starting from activity scheduling to prediction of diseases. In optimization, the objective is to find the best solution among many alternative solutions or the properly adequate solution to a given problem. In daily life, everyone is dealing with optimization problems, *i.e*., finding the shortest route from home to the workplace subject to traffic constraints or organizing our agenda. Most human brains are appropriate in finding solutions to these everyday problems effectively because they are still solvable due to the limited dimension. Some problems, however, appear much larger in scale than computer algorithms are designed to handle. There are no efficient algorithms for these complex problems since the majority of such techniques are typically tailored to the problem at hand, and they seek to take full advantage of the particularities of this problem. Since they are always too greedy, they are usually stuck in a local optimum, and therefore fail to achieve the desired global optimum solution. To obtain the optimal global solution, several metaheuristic algorithms are proposed [1] which were found to be very efficient for solving very complex problems. Heuristics algorithms are designed to solve a particular problem without being able to generalize or refer to other related problems. In contrast, a meta-heuristic method stands for a higher-level heuristic in the context that it guides its design [2]. The meta-heuristic algorithms are broadly classified as single solution-based algorithms and population-based algorithms. In the first case, a random result is produced and enhanced until the optimal solution is found, whereas, in the second category, solutions are generated in a given search space and -try to improve until the optimal solution is achieved. However, the second category can find the global optimum, whereas the first category fails to do so. Therefore, researchers are motivated towards population-based algorithms. Thusly, we may use one of these approaches to develop a particular procedure to gauge an approximate answer for an optimization issue. In the area of global optimization, a large number of Meta-heuristic Algorithms (MA) such as Particle Swarm Optimization [3], Ant Colony Optimization [4], Bat algorithm [5], Artificial Bee Colony Optimization [6], Crow search Algorithm (CSA) [7] had been proposed over the years to solve complex engineering problems in a reasonable amount of time by harmonizing the exploration and exploitation criteria. The classification of meta-heuristic algorithms includes evolutionary-based algorithms, physics-based algorithms, and Swarm Intelligence algorithms. Swarm Intelligence (SI) is a part of the meta-heuristic, which is related to flocks that depend on the interaction between each other by following some basic instructions [8].

One of the meta-heuristic algorithms proposed by Askar Zadeh in 2016 is the Crow search algorithm; it relies upon analyzing the smart behaviors of crows through the potential of crows to conceal their food in protected locations and

chase other crows to obtain their food. It has been applied successfully to different science and engineering fields of optimization [9]. Nonetheless, the current and focused analysis of this algorithm is lacking in the literature. Furthermore, the CSA was no longer compared to new algorithms; since then, many new algorithms have been introduced. Experimenting with CSA on a wider variety of test functions and comparing it to modern and reliable algorithms would, therefore, further expose the use of the algorithm. As a result, the objective of this paper is to first study the principles of CSA in addition to its basic structure and features and secondly,provide a comprehensive and detailed review of the state of the art CSA algorithm. Thirdly, it offers various CSA applications, especially in the medical field. Finally, we conclude the paper by summing up the progress and evaluating future patterns in the study. These work will be of great assistance to researchers in further growth and implementation work in the area.

7.2. CROW SEARCH OPTIMIZATION

7.2.1. Overview of Crow Search Optimization

Optimization has played a very important role in several areas, not limiting to engineering problems. These problems consist of complex objective functions, various decision variables, and a huge set of constraints, which add complexity to an already complicated problem of optimization. Such constraints take the search from a conventional optimization methodology to a modern area of analysis, *i.e.*, swarm intelligence pioneered in the 1980s by Beni and Wang [6]. SI mimics the collective intellect of the living creature of nature [6]. Each new algorithm focuses on two features: first, finding solutions close to the actual optimal solution, thus reducing the gap between them, and second, finding the solution in the least possible time, and thus less search time. Several optimization algorithms have been proposed over the past years, as each has its own advantages and disadvantages. The crow search algorithm is a newly developed algorithm that imitates the social intelligence of crows and their way of collecting food. It is a metaheuristic algorithm inspired by crows' intelligent behaviors. Crows are among the wisest creatures in the world as shown in the mirror test [9]. There are numerous bits of proof indicating crows' astuteness. Crows can recollect faces, trade data with one another, take the nourishment and get it far from others by concealing the assortment of food sources [9]. They are clever criminals as they take additional consideration, for example, changing concealing spots from time to time so they can abstain from being casualties later on. Crows utilize a learned way to deal with concealing their nourishment and taking others' nourishment. In the subsequent sections, the features of CSA, the algorithmic structure of CSA, along with the Pseudocode and flowchart, are prearranged for understanding and implementation of CSA in different fields of optimization.

CHAPTER 8

The Quantitative and Qualitative Assessment of Re-Search Conducted Using Computational Intelligence for the Diagnosis or Treatment of COVID-19

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Abstract: The effect of the COVID-19 pandemic has prompted a large number of studies targeted at understanding, monitoring, and containing the disease. However, it is still unclear whether the studies performed so far have filled existing knowledge gaps. We used computational intelligence (CI)/Machine Learning (ML) technologies and alliance areas to analyse this massive amount of information at scale. This chapter assesses the scholarly progress and prominent research domains in the use of CI/ML technologies in COVID-19 research, focusing on the specific literature on computational intelligence and related fields that have been employed for "diagnosis and treatment" of COVID-19 patients.The "Web of Science" database was used to retrieve all existing and highly cited papers published up to November 2020. Based on bibliometric indicators, a search query ("Computational Intelligence or Neural Networks or Fuzzy Systems or Evolutionary Computation & Diagnosis or Treatment & Coronavirus or Corona Virus or COVID-19") was used to retrieve the data sets. The growth of research publications, elements of research activities, publication patterns, and research focus tendencies were computed using 'Biblioshiny' software and data visualization software 'VOS viewer.' Further, bibliometric/scientometrics techniques were incorporated to know the most productive countries, most preferred sources & their impact, three-field plot, and the most cited papers. This analysis provides a comprehensive overview of the "COVID-19" and CI-related research, helping researchers, policymakers, and practitioners better understand COVID-19 related CI

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research and its possible practical impact. Future CI / ML Studies should be committed to filling the gap between CI / ML research.

Keywords: Computational intelligence, Bibliometric study, China, Computational modelling, Corona virus, Coronavirus, COVID-19, Diagnosis, Diagnosis tools, Evolutionary computation, Fuzzy sets, Fuzzy systems, India, Machine learning, Neural networks, Pandemic, Scientometrics, Treatment, Visualization, Web of science.

8.1. INTRODUCTION, BACKGROUND, AND OVERVIEW

Because this infectious disorder (virus) used to be first recognized in the year 2019 December, it has emerged as a universal epidemic and takes induced infections in lots of people. As of July 2020, the 'coronavirus' dying toll exceeded 6,87,000 global, and the variety of infections and deaths continues to increase. The weekly decline trend of Europe and Southeast Asia has not been interrupted iduring the COVID-19 pandemic and new cases and deaths in the region, the largest contribution of the Americas region continue to be the same. However, when the number of cases is relatively low, new cases (15%) and deaths (15%) in Africa this month represent the highest prosperity. Eastern Mediterranean and Western Pacific also noted that new cases and deaths increase this month. Such a serious condition is directed to increased risk in global health care systems and immense harm in the world economic system [1]. To fight 'COVID-19', various nations remain working to nourish modern; and positive apparatuses to overaw this disaster. Managers, leaders of the enterprise, and scholars alike are dedicating ample sources and effort to reducing the consequences of this disease. A few months ago, several kinds of research and solutions for the fight towards 'COVID-19' were developed and utilized. For instance, speedy screening strategies, the use of various kinds of clinical information, along with 'X-rays,' 'Computed Tomography' (CT) scans, and necessary signs, have permitted a suitable diagnosis and virus observing. Using social media data, computer structures are being designed for risk profiling, affected person investigation, contact tracing, or propagation modelling.

The present research proposes that Computational Intelligence processes can also gain a comprehensive overview of human specialists in certain medical image diagnosis tasks, consisting of lung diseases [2 - 4]. Compared to other lung diseases, such as lung nodule detection [5, 6], tuberculosis diagnosis, and lung cancer screening [7] (Ardila *et al.*, 2019), isolating COVID-19 from special pneumonia has unique difficulty, *i.e.*, the high similarity of pneumonia of various kinds and massive variants in specific phases of the identical type. Therefore, an

emerging CI diagnosis algorithm particular to 'COVID-19' is necessary. The CI diagnosis algorithm also has the benefits of high efficiency, high repeatability, and effortless large-scale deployment.

For now, the combinations of computational intelligence mechanisms with numerous strategies and systems under numerous application circumstances may require exclusive types of computational intelligence techniques, consisting of 'records analytics ',computational modeling', high-speed computing, 'artificial intelligence'; and specifically it's the subfield of 'machine learning', several scientists have dedicated their efforts to growing structures of 'Computational Intelligence', especially for the fight towards 'COVID-19'. By mid-November 2020, over 118,883 scholarly articles have been published about COVID-19, SARS-CoV-2, nCOV-19, and other associated coronaviruses [8]. But these scholarly articles didn't study the significant issues in applying computational intelligence in detail to wrestle the 'COVID-19' pandemic. Hence, it would be crushing to refine and review research related to "Computational Intelligence" from such a massive number of articles. To consider the above perceptions, now is the time to scientifically categorize and analyse the present development of bibliometric study on CI.

8.2. RELATED STUDIES

Bibliometric analysis was performed by the faculty of different countries from Taiwan, South Africa, Nigeria, USA, and Malaysia [9] from a few disciplines to know approaches applied by machine learning in controlling coronavirus. A good volume of literature was referred to see the background work against the Coronavirus and machine learning applications. The different academic database was used for data collection (DBLP, ACM Digital Library, IEEExplore, Science Direct, Springer Link, PubMed, Scopus, and Web of Science) which stores prominent and peer-reviewed journal citations, abstracts, and publications. The keywords included for the study were *"deep learning and COVID-19", "convolutional neural networks and COVID-19", "artificial neural networks and COVID-19", "machine learning and COVID-19", "decision tree and COVID-19", "COVID-19 and diagnosis tool", "COVID-19 and decision support system"*. Each topic briefly discussed techniques and mechanized by summarizing the algorithm, performances, contribution, and benefit for controlling COVID-19. For analysis, 30 documents were selected for the study purely on machine learning applications; the top publication was performed on the implementation of CT Scans. Most of these algorithms were developed using convolutional neural networks on COVID-19 in majority of the publications published in 2020. Collaborative works dominated in machine learning, and the top productive country was China followed by the USA; the top coupling department was

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