A CONTEXT AWARE DECISION-MAKING ALGORITHM FOR HUMAN- CENTRIC ANALYTICS:

ALGORITHM DEVELOPMENT AND USE CASES FOR HEALTH INFORMATICS SYSTEM

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A Context Aware Decision-Making Algorithm for Human-Centric Analytics: Algorithm Development and Use Cases for Health Informatics System

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ISBN (Online): 978-981-5305-96-8

ISBN (Print): 978-981-5305-97-5

ISBN (Paperback): 978-981-5305-98-2

First published in 2024.

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FOREWORD

In the dynamic and ever-progressing realm of healthcare informatics, the confluence of data-driven decision-making and human-centric analytics emerges as a crucial field with immense potential to transform patient care and propel healthcare systems toward unprecedented heights of excellence. "A Context-Aware Decision-Making Algorithm for Human-Centric Analytics: Algorithm Development and Use Cases for Health Informatics Systems" is not just a book; it is a comprehensive expedition into the cutting-edge world of algorithmic innovation, meticulously crafted for the complexities of health informatics.

At its essence, health informatics is the art and science of utilizing data to inform decisions that enhance patient outcomes, optimize healthcare procedures, and catalyze breakthroughs in medical research. In this book, the authors undertake an enlightening exploration into the world of context-aware decision-making algorithms. Their journey is one that not only challenges conventional approaches but also deeply engages with the subtle interplay of human-centric analytics. What sets this book apart is its holistic approach to algorithm development, effectively addressing the myriad dimensions of health informatics. It delves into the nuances of context awareness and extends to the tangible implementation of decision-making algorithms in real-world settings. Each chapter weaves a rich narrative of insights, methodologies, and practical applications, collectively highlighting the transformative role of human-centric analytics in reshaping healthcare.

The interdisciplinary content of the book, drawing expertise from computer science, data analytics, healthcare management, and artificial intelligence, epitomizes the collaborative ethos essential for navigating the complexities of health informatics. In an era where innovative healthcare solutions are more critical than ever, the algorithms showcased here stand as harbingers of advancement, charting a course towards a healthcare future that is both efficient and empathetically patient-focused. The authors, esteemed authorities in their fields, introduce groundbreaking algorithmic innovations and present compelling, real-world use cases. These applications range from clinical decision support to individualized patient care, exemplifying the algorithms' versatility and capacity for adaptation in diverse healthcare scenarios.

This book is invaluable for healthcare practitioners, researchers, and decision-makers. It offers a beacon of knowledge and innovation, guiding the way to a future where health informatics is leveraged to its fullest potential for improving patient care and the evolution of healthcare systems worldwide.

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PREFACE

A new era in healthcare has been brought about by technological advancements; this period is characterized by the intelligent use of data to support decision-making and improve the human-centered aspects of patient care. To explore the complex field of health informatics, our book, "A Context-Aware Decision-Making Algorithm for Human-Centric Analytics: Algorithm Development and Use Cases for Health Informatics System," provides a detailed examination of algorithms and how they can revolutionize decision-making processes.

The awareness that algorithm development and human-centric analytics are increasingly intertwined and have become crucial to the development of healthcare systems catalyzed this book. The creation of algorithms suited to the details of health informatics has become essential as we manage the elaborated patient data, clinical workflows, and the varied demands of healthcare stakeholders.

This book chapter offers an overview of studies, perspectives, and applications that together add to the conversation on context-aware decision-making in health informatics. These sections encompass a range of multidisciplinary viewpoints from computer science, artificial intelligence, data analytics, and healthcare administration. This reflects the teamwork needed to address the complicated problems in health informatics.

The creation of algorithms has significant ramifications for the provision of healthcare services in the real world and is not only an academic undertaking. Beyond theoretical concepts, the proposed algorithms provide workable answers to the challenges of contemporary healthcare delivery. The use cases showcased the exciting potential of algorithms, ranging from individualized patient care to clinical decision support systems. The focus of this book is on the aspects below.

Smart health trackers - Fitbit wearables are popular fitness tracking devices that offer a range of features designed to help individuals monitor and improve their health and well-being. The Fitbit data is extracted using the Fitbit APIs to perform a deeper analysis of the data and understand the correlation and anomalies present in the data and the implications on the user using suitable ML models.

Gallstone Detection - Detecting gallstones using object detection involves the application of computer vision techniques to identify and locate gallstones within medical images, typically ultrasound or CT scans. Object detection algorithms such as SSD - EfficientDet, Faster R-CNN, and Mask R-CNN are employed to automate this process, providing faster and more accurate analysis.

Diabetic Retinopathy - Diabetic retinopathy is a diabetes complication that affects the eyes and can lead to blindness if not detected and treated early. This model uses improved LSTM based on a hybrid Harris Hawk and Mayfly model to identify and categorize hemorrhages.

We invite readers to embark on a journey of "A Context-Aware Decision-Making Algorithm for Human-Centric Analytics," exploring the intricate interplay between algorithms, human-centric analytics, and the future of healthcare.

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CHAPTER 1

INTRODUCTION

Abstract: Healthcare analytics indeed plays a crucial role in leveraging data from various sources to identify trends, patterns, and insights that can lead to improvements in healthcare delivery and decision-making. Feature selection is particularly important in healthcare analytics because it helps identify the most relevant data attributes or features that contribute to predictive models or analysis. By selecting the most informative features, healthcare professionals can build more accurate models and gain better insights into patient outcomes, treatment effectiveness, disease prediction, and more. Challenges in healthcare data include issues related to data quality, privacy concerns, data integration from disparate sources, and the complexity of healthcare systems. Overcoming these challenges requires robust analytics techniques and methodologies tailored to the healthcare domain. Machine learning algorithms play a significant role in healthcare analytics by enabling predictive modeling, clustering, classification, and other tasks. Choosing the right algorithm depends on the specific healthcare application and the nature of the data being analyzed. This chapter outlines Feature Selection algorithms and discusses the challenges associated with healthcare data. It also introduces an abstract architecture for data analytics in the healthcare domain. Furthermore, it compares and categorizes various machine learning algorithms and techniques according to their applications in healthcare analytics.

Keywords: Big data, Data analytics, Electronic Health Record (EHR), Healthcare analytics, Machine learning algorithms.

1. INTRODUCTION

In the context of human beings, healthcare refers to the diagnosis, treatment, and prevention of diseases, illnesses, injuries, and other impairments in order to maintain and enhance overall health. The healthcare industry is comprised of organizations that provide clinical sorts of help, manufacture medical equipment or pharmaceuticals, provide clinical protection, or coordinate the delivery of medical services to patients. The snowballing of healthcare data has created the potential to use data-driven methodologies, such as machine learning technologies, to aid diagnosis. Healthcare organizations create and collect huge volumes of information that contain useful signals and information that go beyond conventional analytical approaches [1]. As human beings, we are hardwired to take in information and process it in context. Whether we are aware of it or not,

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the situation in which we find ourselves often determines how and why we behave. This environment is diverse, subjective, and ever-changing [2]. But for machines, deriving this contextual information is difficult.

The term "context" [3, 4] refers to any piece of data that helps paint a picture of how something functions within the healthcare system [5]. A context is characterized by information derived from the environment [6]. In the field of healthcare, researchers often overlook contextual features. Any information that may be used to describe the conditions of distinct entities and their interactions is referred to as context. Context, according to Almazan, "comprises one or more relationships that an information item has with other information items". Any entity, real or virtual (such as a person, a computer, or an object), as well as a concept (such as place, time, and so on), may be an information item [7].

All things that can influence how a system operates or how a user interacts with it are considered entities [7]. When seen from a phenomenological point of view, the setting is regarded as an interactional dilemma in which the relationship quality that exists between two things or between two actions is referred to as contextuality, the contextual characteristics are defined on the fly, the attribute of context is the one that is caused, and context is generated by the action [8]. A predicate connecting two or more information items is referred to as a relationship, and this connection is subject to alter at any moment and for any cause [9].

A programme or workflow is said to be context-aware [10] if it considers the environment in which it operates. The definition of context awareness states, "A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the task being performed by the user". Better matching of healthcare services to the medical conditions and needs of patients under health monitoring; increased ICU space outcome *via* advanced ML models; and the integration of a cloud-based medical appointment scheduling application are just some of the ways in which "context-aware workflows" can enhance the quality of healthcare delivery, use limited healthcare and human resources more efficiently, and improve the health of patients. It is possible to employ context information in a transitional setting. Replicated internal context data in a workflow variable or current external context data in the context management system might be used [11].

The term "context awareness" refers to the concept that an application is able to comprehend the surroundings in which it is operating and modify its behavior automatically depending on the data it has gleaned from its surroundings rather than requiring direct input from the user. Therefore, applications of this type would make use of context information to determine the current state of the environment, store user preferences in order to gain a better understanding of the situation that currently exists in the environment, invoke some context actions in order to adapt their behavior, and optionally notify the user or update a user interface [12].

KD Anind [13] defines a context-aware system as one that takes the user's current activity into account when determining what data and services are most useful to them. Byun *et al.* make a similar argument, emphasizing that context awareness allows for the extraction, interpretation, and application of contextual information, as well as the adaptation of functionality based on the context in which it is being used [14].

Both the field of computers and the field of social sciences have come to acknowledge the significance of contextual information as a crucial modelling factor [15]. It is hard to design and build applications that can understand their surroundings. The process of acquiring context is not an easy one. Context information is multi-dimensional; it may be received from diverse and dispersed sources (*e.g.*, electronic health records, patient files, apps); it can be either dynamic or static; and it can need an extra interpretation in order for an application to find it useful. The process of adaptation may be connected to the semantics of the programme and may be based on a variety of different techniques, depending on the level of dynamism that is necessary. Applications that are aware of their context require certain methods of development [16].

Context-aware computing aims to collect and make use of data about the current setting in order to show pertinent data or deliver services that are suitable for the current environment [17]. The term “context” refers to both the conceptual setting in which an application is utilized (the user's profile, preferences, and social circumstances) and the physical setting in which the programme is executed (which is typically heterogeneous and resource-constrained). To deliver results from an application that meets the requirements of its users, it is necessary to collect and make sense of data from several context sources [18].

Context has many different dimensions; to name a few, it can include perceptual information, environmental information (such as the amount of pollution), physical information (such as one's current location), social information (such as one's family and co-workers), and temporal information (such as the time of day). One's context also includes non-perceptual information like recollections of prior encounters or their emotional state [2]. There are different context parameters considered for our research work. Some of them includes age, gender, data from

CHAPTER 2

Analyzing Healthcare Data to Identify Anomalies and Correlations

Abstract: Wearable devices focused on fitness, safety, and data monitoring have become increasingly common. It is not surprising, given that a sedentary lifestyle can lead to various health issues such as weight gain, chronic and acute illnesses, and reduced productivity in daily life. Researchers from both business and academic settings have delved deeply into monitoring fitness, examining aspects like sleep patterns, cardiac health, activity levels, overall well-being, and recovery from illness. They employ a range of techniques including deep learning, machine learning, and statistical methods to analyze the data collected by these wearables. This study aims to gather data from Fitbit Inspire HR and Fitbit Versa using the Fitbit API and to investigate any anomalies, trends, and correlations within the collected healthcare data. The data is classified using the K-means algorithm based on various parameters of the Fitbit healthcare data.

Keywords: Activity monitoring, Fitbit data, Healthcare analytics, Health behaviors, K-means, Machine learning.

1. INTRODUCTION

In today's society, individuals are increasingly concerned with maintaining a healthy lifestyle because of the growing awareness of the importance of health [1]. Physical fitness is an important component of a healthy lifestyle since it helps to lower the severity of many chronic illnesses [2]. Many people use wearable devices these days to track their health and fitness. Digital health technology is used to treat a physical or psychological ailment in this health field and treatment choice. Behavioral and lifestyle adjustments are the cornerstones of the treatment.

A person’s health can be assessed using a mobile phone and wearable health trackers. Some of the applications and benefits of using wearable devices include tracking progress, providing free exercise trainers and advice, assisting in goal setting, monitoring health, having a user-friendly fitness tracker interface, and assisting the individual in remaining motivated. Consumers may buy fitness monitoring wearable devices that can measure and compute crucial fitness data

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patterns built on activity and physiological characteristics. With today's commercially off-the-shelf (COTS) wearable devices, it is possible to measure the comfort of a building's inhabitants by measuring metrics such as ambient air temperature, relative humidity, skin temperature, sweat rate, and heart rate. These data could be used not only to improve human well-being but also to create a better indoor environment [3].

Data is collected using biosensors such as heart rate sensors, sleep activity monitoring sensors, movement identification sensors, *etc.* Accelerometers are sensors used to deliver data on the movement features of step count and distance. They are also used to measure altitude for tracking the number of stairs a person has climbed, and other sensors incorporated into wearable health trackers [4]. Wearable devices are being used in health applications for a variety of reasons, including the detection of diseases and fitness level [4].

The data acquired on the human body is used in the healthcare arena to efficiently communicate vitals. The significance of health trackers to monitor and analyze patients' well-being has risen as a result of the growing demand among consumers to receive healthcare with the convenience of their own homes [5].

There is a challenge presented by the data gathered by health monitors in terms of their quality, reliability, and safety [6, 7]. By reducing overall medical expenditures and improving response times, health trackers are revolutionizing the relationship between patients and their physicians. This is especially true for senior patients [8]. Wearable gadgets such as health trackers can measure vital indications, such as heart rate, blood pressure, and temperature, estimate energy expenditure, count walking steps, assess movement, sleep efficiency, and other indicators throughout the day [9].

Real-time data analytics will enhance healthcare quality. There was a time when even a slight increase in body temperature required a visit to the doctor. However, modern wearable gadgets allow for continuous monitoring of vital signs, sometimes starting a day or two before a scheduled doctor's appointment.

Fitbit Inc [10] has dominated the wearable industry with its wide line of products, which includes activity trackers, smartwatches, and other wireless devices. The data of the individuals in this trial was collected and analyzed using Fitbit Inspire HR and Versa wearable devices from the wearable firm. Fitbit allows us to keep track of our health in a simple and practical method. Many stories about Fitbit wearables saving people's lives are regularly shared with us [11]. In the medical field, Fitbit wearable devices are being urged to be used for patient monitoring with existing medical facilities [12, 13]. Fitbit devices and in-app experiences can provide support at home for patients being discharged from the hospital or those managing a chronic disease.

Data may be kept locally on the Fitbit device as well as transferred to the cloud, where it is synced with the Fitbit cloud. Data can also be pushed from the device to the cloud. APIs that are clearly outlined for accessing synchronized data may provide users with the ability to access data. Users can better grasp their fitness levels thanks to Fitbit. Wearable technology, such as economic health monitors, helps eliminate health inequities and provide the public with high-quality, universal, and economical healthcare [14].

Fitness trackers are already intended to enable physicians by streamlining the evaluation of the well-being of older persons and patients in need of medical attention. Patients and the elderly must be monitored periodically so that their information may be used to foresee problems. The visualization and interpretation of therapeutically relevant data is a difficulty for patients in critical care [15]. Tracking actions using health monitoring trackers aids in the battle against lethargy, and eating and sleeping problems, all of which may be hazardous to a patient's identity [16].

Conventional data processing technologies cannot keep up with the processing demands of emerging applications. As a result, a variety of machine-learning technologies have been applied to data processing *via* wearable devices. In order to give therapeutic interventions, machine learning techniques are quickly being implemented in healthcare establishments [17].

The amount and complexity of healthcare information produced by the Fitbit wearable gadget are significant. Machine Learning is applied to the existing data collected by the wearable devices to forecast medical state [18]. As a result, analyzing the data and extracting insight from it are difficult [19].

Healthcare informatics system employs modern machine learning techniques to uncover anomalies in data, and data visualization provides a clear grasp of how to classify a patient's status. The term "machine learning" (ML) refers to a strategy that is rooted in mathematics and statistics, and it is connected to both supervised and unsupervised learning strategies by the use of data mining methods. Fig. (**1**) depicts the basic Machine Learning algorithms, namely supervised, unsupervised, and reinforced learning.

CHAPTER 3

Object Detection for Healthcare Data Using Deep Convolutional Neural Networks

Abstract: Gallstone disease is a prevalent chronic condition impacting individuals worldwide, posing significant challenges to healthcare systems globally. It ranks among the most common ailments encountered by individuals seeking emergency care due to abdominal discomfort. The complexity of gallbladder ultrasound scans arises from numerous factors, including variations in gallbladder anatomy. In this study, we propose a healthcare informatics system aimed at identifying and analyzing gallstones. We conduct a thorough examination of several state-of-the-art object detection algorithms, including Faster Region-based Convolutional Neural Network (Faster R-CNN), Mask Region-based Convolutional Neural Network (Mask R-CNN), and Single Shot Detector (SSD) Our approach, which combines elements of Mask R-CNN, SSD, and Faster R-CNN, facilitates the precise detection of gallstones within the gallbladder by leveraging region-based proposals. We specifically focus on training the Mask R-CNN model with various backbone networks. Ultrasound images utilized in our experiments were sourced from medical professionals, encompassing diverse demographic characteristics such as gender, age, and urban/rural residence. Our findings demonstrate that the Mask R-CNN model, with a Resnet-101-FPN backbone network, excels in gallstone detection, surpassing alternative techniques in object localization accuracy.

Keywords: Deep learning, Faster R-CNN, Healthcare, Informatics system, Mask R-CNN, Streamlit, SSD.

1. INTRODUCTION

We humans have a natural ability to perceive the environment around us. Regardless of the lighting or shade of the scene, we can segment an object from its background and recognize it. Humans can easily distinguish features and shades, and can react to and even estimate the emotions of other people in photographs. Important facets of healthcare include medical imaging, vision systems for healthcare applications, pattern recognition, big data and data mining, multimodal integration, affective computing, biometrics problems, and the analysis and detection of actions, emotions, and behaviors [1]. Computer vision

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systems and algorithms, on the other hand, have a lot of trouble perceiving the environment as we do [2].

Computer vision is more about understanding higher-level abstractions or knowledge of the world from images. Artificial intelligence is the larger realm and computer vision forms one aspect of Artificial Intelligence. Firstly, the majority of computer vision applications are inverse model applications, which are difficult to implement. We have no idea how a picture is captured or what the camera settings were at the time the image was captured. Secondly, high-dimensional image data is one of the issues with computer vision. Computer vision is AI-complete. There are no full models of the human visual system currently available. Finally, the verifiability of the mathematical or physical models for these kinds of systems is non-trivial. In recent years, computer vision has shown enormous promise for a number of computer-assisted medical applications, paving the way for the adoption of augmented reality and improved representation in the area of healthcare. This is due to the fact that computer vision is able to recognize images [3]. For the last several years, computer vision in healthcare has been extensively researched and studied. Assistive machine vision has already entered the mainstream of clinical practice, despite the fact that the medical field is a highly significant area of research for this field.

Computer vision is a field that works with learning-based vision that deals with localizing and recognizing occurrences of particular sorts of visual objects in digital pictures. Object detection is a profession that falls under computer vision. Because it is one of the most basic glitches in computer vision, object detection provides the basis for an extensive variety of additional computer vision responsibilities, such as instance segmentation [4-7], image annotation [8-10], object tracking [11] and so on. Object detection may be broken up into two distinct areas of study, according to our preferences, from an application point of view that is generic object detection and detection application. Generic Object Detection seeks to investigate various approaches for identifying various sorts of objects inside a single framework in order to imitate human vision and cognition. The term “Detection Application” refers to detection in a variety of different application contexts, including, but not limited to, the detection of pedestrians, faces, and texts, amongst others.

The object detection algorithms created are centered on automated feature learning approaches based on deep learning. For detection and classification issues, Deep learning is a Machine Learning technique that learns representations, or features, from raw data independently [12]. Object detection has been given new life in recent years thanks to the fast development of deep learning methods. These approaches have resulted in astounding advancements, and the field as a whole has been propelled to the forefront of research with unprecedented focus. Deep learning methods [12] have gained significant achievements with bio-medical and applications related to healthcare, like diagnosing lung nodules [13], breast lesions [14] or CT-scan brain injuries [15], MRI segmentation of brain regions [16 – 17], and emotion classification using EEG data [18 – 19]. Computer vision technologies for facial analysis are being used to diagnose medical problems [20]. The use of deep learning in healthcare is largely seen as a critical step toward enhancing treatment quality [21]. In many image identification tasks, deep neural networks, particularly convolutional neural networks, outperform the current cutting-edge techniques. Image categorization [22], image segmentation [23], and object identification [24] are some of the examples.

According to the Ministry of Health and Family Welfare of the Government of India, the prevalence of gallstones in India's adult population was reported to be 6.12%. Gallstones are little pebble-like objects that form in the gallbladder, which is positioned underneath the liver. The gallbladder is a digestive organ that is accountable for the storage and concentration of bile, which is a digestive fluid that is then released into the gastrointestinal tract to aid in digestion. Cholecystitis is the name given to the inflammation of the gallbladder when it occurs. Problems with the gallbladder are often brought on by a bile ducts' obstruction, which are the tubes that convey bile amid the liver, gallbladder, and small intestine. Cholecystitis is caused mainly by a gallstone obstruction. Tumors, infections, and blood circulation problems are some of the other reasons that can cause Cholecystitis.

In the majority of instances, gallstones do not cause any obvious symptoms. Gallstones or other gallbladder problems can be identified by a strong aching in the upper right or center of the abdomen, discomfort that extends to or radiates to the right shoulder or back, a sore belly that is sensitive to touch, fever, shaking, nausea and vomiting, and jaundice. Jaundice is a yellowing of the skin and eyes that can occur as a result of gallstones or other gallbladder problems. There is a strong correlation between age and gender in gallstone disease; nevertheless, men and women have distinct metabolic risk factors that contribute to the development of gallstones. It is hypothesized that gender has a role in gallstone disease as a contextual component [25]. Compared to men, women are at a higher risk [26 – 28]. Because of the effects of progesterone, the gallbladder is unable to empty properly, which leads to an accumulation of cholesterol in the bile and the formation of gallstones. Gallstones have an effect on the hormones that govern female reproduction. Obesity also plays a role, as fatter bodies store more oestrogen hormones. Interruption of bile production, which increases the risk of cholesterol crystallization and gallstone development, is a risk associated with rapid weight loss. Gallstones are more common in those with diabetes and other

CHAPTER 4

An Enhanced Deep Learning Technique to Detect and Classify Hemorrhages Based on CNN with Improved LSTM by Hybrid Metaheuristic Algorithm

Abstract: Diabetic retinopathy (DR) is the main cause of blindness in diabetic patients. Early and accurate diagnosis can improve the analysis and prognosis of the disease. One of the earliest symptoms of DR is hemorrhages in the retina. Therefore, we propose a new method for accurate hemorrhage detection from retinal fundus images. Here, the proposed method uses the modified contrast enhancement method to improve the edge details from the input retinal fundus images. In the second stage, a convolutional neural network (CNN) with improved LSTM based on hybrid Harris Hawks with Mayfly (HHMO) is proposed to detect and classify the hemorrhages. Finally, the proposed CNN with HHO-LSTM is compared with the existing techniques including machine learning and deep learning techniques such as Naïve Bayes, SVM, ANN, etc., and traditional CNN, LSTM, and other techniques, respectively. Therefore, the comparison can prove that the proposed model is more effective in detecting and classifying Hemorrhages in the retina due to diabetic retinopathy. The performance metrics considered in this work are accuracy, specificity, sensitivity, f1-score, precision, *etc*.

Keywords: Diabetic retinopathy (DR), Fundus images, Harris Hawks with Mayfly (HHMO), Hemorrhages.

1. INTRODUCTION

1.1. Diabetes

An increase in blood glucose levels is the primary cause of diabetes. The blood vessels will suffer from irreparable harm if this irregularity continues for a long time. A diabetic person is more likely to experience kidney disease, eye loss, Gingivitis, lower limb paralysis, and foot sores. Even heart attack as well as stroke are serious risks for diabetic people [1]. The disorders are classified as damage to the nephrons in the kidney and in the brain, and diabetic retinopathy (damage to the eye) depending on body components that are impacted by an increase in blood glucose levels.

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The World Health Organization (WHO) anticipates that by 2050, diabetes will rank as the sixth major cause of mortality. There were 108 million people with diabetes in 1980, but by 2014, there were 422 million diabetic people worldwide. As per these statistics, there had been a rise in the percentage of diabetic patients over the age of 18 from 4.7 percent to 8.5 percent. The majority of diabetes victims are those who live in poverty. Diabetes has been diagnosed in around 61.3 million Indians between the ages of 20 and 79, according to recent estimates. It is necessary to be prepared for the possibility that by the year 2030, this number will have increased to 101.2 million.

1.2. Diabetic Retinopathy

A steady increase in blood glucose is harmful to the blood vessels in the retina, which may cause damage to the retina. An increase in the amount of sugar in the blood may mainly damage the capillaries, which then makes it possible for blood to leak into the eyes and ultimately causes the visual system to become impaired. The ability of the human body to heal itself is inbuilt. When the brain recognizes a loss of blood, it prompts the cells that are nearby to become active so that they can take control of the situation [2]. This pattern of behavior results in abnormal growth of blood vessels. They have an effect on the person's eyesight throughout the course of time. As a result of this, it is imperative that a diabetic patient always choose to participate in regular eye examinations. An ophthalmologist should examine and keep track of the patient's retina on a frequent basis. Some eye testing methods include slit lamp biomicroscope, optical coherence tomography (OCT) [3], fundus fluorescein angiography (FFA) [4], and fundus photography. These methods are used to diagnose the disease in its earliest stages. Fundus photography is a technique used by optometrists, ophthalmologists, orthoptists, as well as other qualified medical practitioners to track the development of specific eye problems or diseases.

One crucial step in the study of the retina is the segmentation of the vascular tree. This study proposes an interactive method for segmenting blood vessels from retinal fundus images using Canny edge detection. By merely gliding the pointer over a certain vessel, semi-automated segmentation of that vessel can be performed. Following that, edge detection methods as shown by the Canny algorithm will be used. The created graphical user interface will allow for interactive selection of the vessels (GUI) [5]. An essential method for examining the retina's arteries as well as veins is retinal vascular segmentation. Blood vessel segmentation is essential in this type of research because fundus imaging is used by many medical professionals to detect an extensive range of medical glitches [6].

Due to the significance of fundus vessels, numerous fundus vascular segmentation techniques have been developed over time. It is a laborious operation. Additionally, fatigue makes it more prone to mistakes. Additionally, as each person may interpret the image differently, there can be some variations in the segmentation results from different individuals. Therefore, a simpler and quicker segmentation technique should be developed. There are countless techniques for edge detection that are utilized in image segmentation. Canny's strategy is a versatile edge detection technique that works quite well [7]. However, it still has several problems and is not flawless. Because there are so many variables, it is possible to make virtually endless adjustments, even if they just slightly enhance the outcomes.

Additionally, the size of the Gaussian kernel employed can affect the placement of the edges due to the Gaussian smoothing in Canny's approach. The semi-automatic edge segmentation technique Livewire is an example. During medical presentations or debates, drawing attention to certain vessels can be a helpful strategy. When compared to manual segmentation, the automated edge-detection technique in vessel segmentation will be discussed [8].

The most leading factor for sight problems in people with jobs in industrialized nations is diabetic retinopathy (DR), whose prevalence is inversely correlated with the prevalence of diabetes. About one-third of diabetes patients experience DR, and there are currently millions of diabetics worldwide, with that number rising quickly [9]. In the past, DR has been regarded as the most typical microvascular consequence of diabetes. Through the clear cornea, ophthalmic examinations make it simple to spot the Vein appearances of DR, such as Microaneurysms, capillary failure, vascular flashing, retinal vascular leaking, diabetic macular edoema (DME), proliferative DR with pathological retinal neovascularization (RNV), and retinal and vitreous haemorrhage [10].

Early detection of DR aids in properly managing and perhaps even preventing the damage of vision. Photographing the fundus of the eye is one imaging technique that allows you to see the retina, optic disc, and macula, among other important anatomical components. Ophthalmologists evaluate these fundus photos for the presence of critical DR indicators such as haemorrhages [11]. Depending on where they are located inside the retina, haemorrhages typically look like a “dot,” “blot,” or “flame.”

The earliest clinically discernible symptoms of DR are circular, localized capillary dilations known as microaneurysms. The dilations typically manifest as little red dots that can be found in groups or alone, although they have no impact on ocular vision. Red lesions are collectively known as haemorrhages and microaneurysms,

CHAPTER 5

CONCLUSION

1. CONCLUDING REMARKS

With improved technology in healthcare and a wide array of research, there is tremendous melioration towards viable implementation of Machine Learning. In this chapter, a summary of our research work is presented and significant contributions are highlighted. This thesis discusses the development of context-aware decision-making health informatics systems to analyze Human Centric Wellness. The various algorithms used in the development of the system, parameters, and performance metrics are analyzed. To achieve better performance metrics, real-world data is collected and augmented.

In Chapter 1, we discuss the introduction to healthcare and how the provision of medical care is a crucial component of society, essential to the upkeep of order and tranquility, which is necessary for inclusive living. This chapter outlines many issues in the healthcare industry in the current world and thus presents the motivation for the research work. Different kinds of input data are used to predict the wellness of individuals using Machine Learning models.

In Chapter 2, healthcare textual data such as the heartbeat data, number of steps walked, total distance walked, step count, and sleep data are collected using Fitbit Wearable devices. On the basis of the sleep data, a k-means clustering method is used in order to categorize the sleep score as either sleeping, restless, or awake. The data on men's and women's heart rates, measured in beats per minute, were plotted against the passage of time and subjected to statistical analysis for seven different age groups: 35–40 years, 40–45 years, 45–50 years, 50–55 years, 55–60 years, and 60 years and older. The results showed that men have a higher heart rate than women. In this experiment, we have used several models such as XGBRegressor, RandomForestRegressor, ElasticNet, GradientBoostingRegressor, and Lasso and parameters to see which are best for each model. After that, the Root Mean Square Error, often known as RMSE, is computed for each model by applying the 10-fold cross-validation. The root mean square error, abbreviated as RMSE, is an industry-standard approach for measuring the accuracy of a model's predictions of quantitative data. A better fit is shown by lower RMSE values. If the major objective of the model is prediction, RMSE is a good indicator of how accurately it predicts the response. It is also the most crucial criterion for fit. It was found that the Gradient Boosting Regressor is the best algorithm because it has the lowest Root Mean Square Value compared to other models. Hence, Gradient Boosting Regressor is used to predict the heart rate. The parameters used in this model are n_estimators, max_depth, learning rate, and loss. To identify the components that contribute to the experiment's anomalous behavior, first determine which data is strongly connected. We discover that the total distance travelled and the total number of steps taken have a strong correlation, but the total number of steps taken and the number of calories consumed have a poor correlation.

It is explained in Chapter 3 that gallstones are a condition that is both very common and quite serious. Gallstones are one of the major reasons for hospitalizations all over the globe. This Healthcare Informatics System, which is built on deep learning, may be used as a supplement to bridge the gap between reviewers and to limit the occurrence of false positives. The information is gathered from both urban and rural settings alike. Annotations are added to the data with the assistance of trained medical specialists. We have exhibited the training and testing of models to identify gallstones called SSD – EfficientDet, Faster Region-Based Convolutional Neural Networks, and Mask Region-Based Convolutional Neural Networks. These models were provided with an image, a model name, and a confidence score in order to carry out object detection. It has been determined and calculated how each of the major performance evolution characteristics changed over time. Several backbone networks were used throughout the modelling and training processes for the Mask R-CNN model.

In Chapter 4, one of the ailments with the greatest rate of robust growth is diabetes. There are many stages of DR, from mild to severe, and finally PDR. If the problem is not identified at an early stage, it may result in floaters, blurry vision, and ultimately blindness. These photos must be manually diagnosed, which takes a lot of time and effort and needs highly qualified professionals. In the study, automated DR and its different stages, detection techniques and machine vision have been introduced. An innovative technique for precise bleeding identification from retinal fundus pictures has been used in this work. To identify and categorize haemorrhages, the DCNN with HHMO-LSTM-based hybrid meta-heuristic approaches is presented. Parameters are determined for both training and testing using metrics including accuracy, specificity, sensitivity, F-measure, and precision. The proposed method has a 95% accuracy when evaluated using hospital photos and the Kaggle collection. The outcomes demonstrate that the improved deep learning model outperforms the state of technology.

2. FUTURE WORK AND CONSTRAINTS OF THE ALGORITHM

Chapter 2

In the future, the authors intend to work on heart rate data for different physical activities, tabulate how the resting heart rate varies, and collect seasonal data to find anomalies and correlations.

Chapter 3

In the future, we intend to work on counting the number of gallstones and also to predict the form of gallstone (slurry or fully calcified form) and to use instance-level segmentation. The algorithmic constraints of object detection algorithms used in the work are:

- Single Shot Multibox Detector (SSD) relies on a predefined set of anchor boxes of different scales and aspect ratios at each feature map location. This limits its ability to handle objects with highly variable shapes and sizes, effectively.
- Faster R-CNN is a two-stage detection model, which makes it computationally more complex compared to SSD. It requires two separate networks (RPN and Fast R-CNN) and can be slower during inference.
- Mask R-CNN requires more memory and computational resources than both SSD and Faster R-CNN due to the mask prediction branch.

- Achieving high-quality instance segmentation masks with Mask R-CNN can be challenging and may require careful tuning and more training data.
- Mask R-CNN includes an additional mask loss term in addition to the classification and bounding box regression losses, making it more challenging to train.

Chapter 4

CNN-LSTM models are powerful for a wide range of sequence-based tasks, they come with computational, data, and modeling challenges that need to be carefully considered during development and deployment. The constraints are as follows:

- Like any deep learning model, CNN-LSTM networks are prone to overfitting, particularly when the dataset is small or when the model is complex.
- Effective regularization techniques, such as dropout and L2 regularization, are often necessary to mitigate overfitting.
- Tuning the hyperparameters of CNN-LSTM models, such as the number of convolutional layers, LSTM units, learning rates, and batch sizes, can be time-consuming and requires expertise.
- Proper data preprocessing, including sequence padding, normalization, and handling missing data, is crucial for the success of CNN-LSTM models. Preprocessing can be task-specific and require domain knowledge.
- Extracting interpretable features from CNN-LSTM models can be challenging,

SUBJECT INDEX

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