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Vitamin Deficiency Detection Using Image Processing

Mr. Harshavardhan J R[1], Vaishnavi M[2], K R Sahana[3], Sneha A S[4], Sanjana G[5]
[1]Associate Professor, [2, 3, 4, 5]Students, Dept of CSE KSIT College of Engineering, Bangalore, Affiliated to VTU

Abstract: This research paper introduces an innovative Web application that utilizes Artificial Intelligence (AI) to identify vitamin deficiencies in individuals by analyzing images of specific body organs. This novel approach eliminates the need for costly laboratory tests, enabling users to detect potential vitamin deficiencies without requiring blood samples. Users can easily capture photos of their eyes, lips, tongue, and nails, and the application will analyze these images to identify possible deficiencies. Furthermore, the application provides a list of recommended nutritional sources to address the identified deficiency and outlines potential associated complications.

The AI software has been meticulously trained to accurately distinguish and classify vitamin deficiencies by analyzing images of these specific body parts, which exhibit distinct symptoms when the body experiences nutritional deficits. Additionally, healthcare professionals can contribute to and validate visual data from their patients, enhancing the application's accuracy and expanding its detection capabilities. This application serves as a valuable tool in addressing the global issue of insufficient nutritional awareness, ultimately assisting healthcare workers in delivering more precise diagnoses.

Vitamins are essential components of our diet, and their deficiency can lead to a range of health problems. The primary objective of this AI system is to identify vitamin deficiencies at an early stage, helping to prevent severe consequences such as infectious diseases, anemia, maternal mortality, and impaired cognitive and physical development.

Keywords: Vitamin Deficiency, Early Detection, Machine Learning, Image Processing, Convolutional Neural Networks, and customized recommendations.

I. INTRODUCTION

Vitamin deficiencies pose a significant global health challenge, impacting various aspects of our well-being. Health issues often arise from inadequate intake of essential minerals and nutrients. Accurately monitoring our nutritional needs can be complex, especially when individuals are unaware of potential deficiencies without seeking guidance from healthcare professionals. On a global scale, more than 2 billion people grapple with vitamin deficiencies. For instance, over 1.2 billion individuals suffer from Zinc deficiency, leading to around half a million annual deaths. Similarly, over 100,000 people succumb to Anemia caused by iron deficiency.The easy accessibility of cheap processed junk foods has made nutrient-rich foods financially inaccessible for many, transforming them into symbols of luxury rather than dietary essentials. Research has shown that even the soil itself lacks essential micronutrients. In 2003, researchers conducted a comparative analysis of data on vegetable nutrient content from 50 years ago and the present, revealing significant declines in the mineral content of cabbage, lettuce, spinach, and tomatoes, regressing from 400 milligrams to less than 50 milligrams. This trend highlights a concerning decrease in nutrient availability. Even with what might appear to be a perfect diet, it's likely that something crucial is missing. Approximately 50% of Americans lack sufficient vitamin A, vitamin C, and magnesium, while 70% of elderly Americans and 90% of Americans of color experience a deficiency of vitamin Recently, a survey involving 100 university students was conducted to gauge their awareness of vitamin deficiencies, with 67% responding negatively. Although the sample size is limited and does not represent the entire population, it provides an estimate of the current state of public awareness. Vitamin deficiency is a global concern affecting more than 2 billion individuals. According to the World Health Organization (WHO), one in three children is deficient in essential vitamins. Approximately 33% of children under the age of five experience a deficiency in vitamin A, leading to compromised immunity and night blindness. Vitamin deficiencies affect individuals of all age groups and often co-occur with mineral deficiencies such as zinc, iron, and iodine. Vulnerable groups, particularly pregnant women and children, are particularly susceptible to vitamin deficiencies due to their elevated nutritional requirements and heightened vulnerability to these deficiencies. The most common deficiencies involve vitamins A, B, folate, and D. Supplementation programs have been successful in reducing the prevalence of diseases like scurvy and pellagra.

II. LITERATURE SURVEY

In this section, we examine the existing body of literature related to the application of vitamin deficiency.

A perspective from North India on the endemic nature of vitamin B12 deficiency in the Indian population is presented in the publication [1]. Analyses were conducted on information gathered from a diagnostic laboratory and an endocrine practice's electronic medical records (EMR). Used statistical analysis: "Jamovi" was an open-source programme used for statistical analysis. In tier 3 cities, 47.19% of the population (n = 267) had vitamin B12 insufficiency (levels < 200 pg/ml). A database containing 11913 patients was searched for reports of vitamin B12 levels from an urban endocrine practise. In individuals with pre-diabetes (n = 92), those with endocrine disorders other than diabetes and pre-diabetes (n = 285), and those with diabetes (n = 378), the prevalence of vitamin B12 insufficiency was 31.23%. Populations in Tier 3 cities have far lower levels of vitamin B12.

The importance of employing image processing to identify vitamin deficiencies is explored in Paper [2]. A meticulous investigation into medicine and pathology was undertaken in order to establish a connection between recognised signs and symptoms and the corresponding vitamin deficits on a particular range of visually discernible characteristics that are known to be brought on by the incapacity to obtain the required quantity of vital nutritional components. The tongue, lips, nails, and eyes were among the body parts that were picked since it is well recognised in medicine that deficiencies in any one of the important vitamins can cause changes in the texture, shape, colour, or appearance of those areas. In order to prepare the images for machine learning analysis, a database of gathered photos displaying these symptoms has been built. The use of cloud computing services allowed for the achievement of accurate neural training iteration results in a shorter amount of time than would have been necessary for such a large amount of data using conventional methods. This is because training a reliable image feature extraction classifier requires a large number of pictures containing symptoms, and access to current photos of real patients is currently not possible. Since the chosen symptoms are recognised as early warning signs of vitamin deficiencies, they have been utilised to confirm the accuracy and precision of feature extraction and diagnosis. Angular Cheilitis (cracked lips), Beau's lines (vertical ridges in nails), strawberry tongue (red colour), and red eye were the symptoms that were displayed in this case.

An automated method for diagnosing nutritional deficiencies using skin imaging data is covered in depth in Paper [3]. The researchers achieve great accuracy in identifying iron and vitamin B12 deficits by using a CNN architecture for feature extraction and classification. But rather than examining the possibilities of image processing methods other than CNNs, the study concentrates on a small number of shortcomings. Paper[4] describes a machine learning method for utilising facial image analysis to identify vitamin D deficiency. They utilise a variety of image processing methods, such as feature extraction and segmentation, and then a support vector machine classifier. The study highlights the potential of image-based analysis for nutritional assessments by demonstrating promising results in correctly identifying individuals with vitamin D deficiency.

Using deep learning and tongue image analysis, a non-invasive technique for identifying vitamin B12 deficiency is presented in Paper [5]. They create a deep convolutional neural network architecture and use a sizable dataset of tongue pictures to train it. The study successfully distinguishes between people in good health and those who are deficient in vitamin B12. There are many opportunities for image-based nutritional deficiency detection, as evidenced by the focus on tongue images as a possible biomarker.

An integrated system for automated analysis of children's nutritional deficiencies is presented in Paper [6], which integrates computer vision, machine learning, and clinical data. In order to detect vitamin A, iron, and zinc deficiencies, the system uses a multi-class classifier and image processing techniques to extract features from facial images. Promising results in identifying deficiencies are shown by the study, highlighting the significance of an integrated approach.

III. OBJECTIVES

1) Early Detection: Provide a system that identify vitamin deficiencies in people before they cause major health problems
2) Precise Diagnosis: Guarantee a high degree of precision in determining the particular vitamin deficiency (e.g., vitamin B12, vitamin C, vitamin D) in order to offer tailored therapy suggestions.
3) Non-Invasive Testing: To evaluate vitamin levels, develop a minimally invasive or non-invasive technique that eliminates the need for blood tests and other invasive procedures.
4) Efficient Screening: Provide a cost-effective screening procedure accessible to a broad spectrum of people, including those in environments with low resources.
5) Tailored Treatment Plans: Depending on individual inadequacies, provide tailored recommendations for food modifications, supplements, or lifestyle changes.
6) Data Integration: Integrate data from various sources, such as medical records, dietary information, and biomarkers, to enhance the accuracy of deficiency detection.

7) Real-Time Monitoring: Enable continuous or periodic monitoring of vitamin levels to track progress and adjust treatment plans accordingly.
8) Machine Learning Models: Develop robust machine learning models that can learn from large datasets to improve accuracy and generalizability.
9) User-Friendly Interface: Create a user-friendly interface for healthcare professionals and individuals to input data and receive results.
10) Ethical and Privacy Compliance: Ensure the project complies with ethical standards and data privacy regulations to protect sensitive health information.
11) Education and Awareness: Include an educational component to raise awareness about the importance of maintaining adequate vitamin levels for overall health.

IV. PROPOSED SYSTEM

The system consists of a varied dataset comprising people in healthy states and those with documented vitamin deficits. To improve image quality, pictures of pertinent body components are taken and preprocessed. To extract features, a CNN model that has already been trained is used to identify patterns in images that correspond to certain defects. Afterward, a classifier is trained using machine learning methods on the extracted features. Using testing data, the trained model is assessed and its performance is contrasted with other approaches. Scalability and user interface design are taken into account while implementing and deploying the suggested system for real-world applications. The system's capabilities are being investigated for future enhancements and extensions. In addition, the system offers dietary recommendation tools and a BMI calculator to monitor and enhance each user's health.

V. METHODOLOGY

1) Symptom Analysis and Literature Initially, a comprehensive investigation was undertaken to establish a connection between identifiable symptoms and corresponding deficiencies in vitamins within a selected range of visually distinctive attributes known to be linked to the insufficient intake of crucial nutritional elements. Specific body parts were deliberately chosen, as they are medically recognized to exhibit changes in texture, shape, color, or appearance when one or more essential vitamins are insufficient. These parts include the tongue, lips, nails, and eyes. A comprehensive database containing collected images showcasing these symptoms has been compiled to facilitate their analysis using Machine Learning techniques.
2) AI and NLP Natural language processing (NLP) is an integral component of artificial intelligence (AI), where computational techniques are applied to analyze and generate text and speech. In the medical domain, patient records typically contain a wealth of critical information that healthcare professionals must extract. This information encompasses medications, immunization records, and laboratory test results. NLP tasks can be categorized into low-level tasks and high-level tasks, with some tasks having direct applications and others serving as subtasks that contribute to solving broader objectives. Low-level tasks often feed into high-level tasks.
3) Fuzzy membership function and defuzzification, through multiple iterations of the Convolutional Neural Network (CNN) is used for analyzing a multitude of photos encompassing the specified attributes in the earlier-mentioned study, the confidence levels of each extracted feature are obtained and utilized in a Mamdani-based Fuzzy Logic Membership Function developed using MATLAB. The Fuzzy Logic rules are formulated based on the intensity and prevalence of the scrutinized visual attributes, whereby a higher certainty is assigned to the deficiency identified in one variable when it is more frequently detected in the other variables, and vice versa. Subsequently, a distinct code will extract the Defuzzification results to present a roster of recommended and modifiable nutritional sources for the identified deficient vitamins.

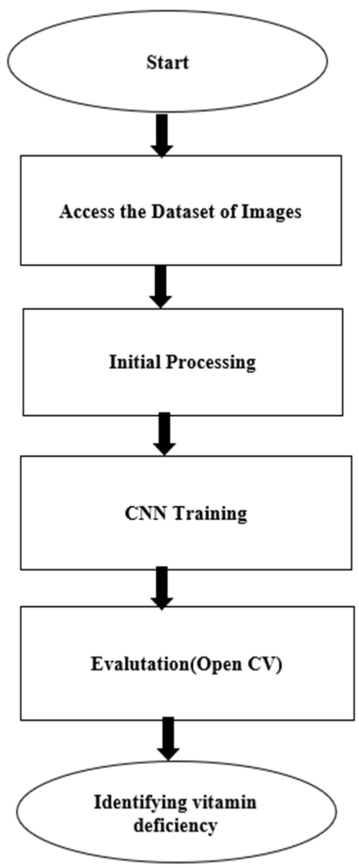
VI. IMPLEMENTATION

In order to find nutrients using image processing and neural networks, a model that can analyse individual images must be developed recognising the symptoms of malnutrition. Its model's performance plays a critical role in precisely identifying and classifying different kinds of deficiencies, like inadequate intake of vitamins A, B, C, D, or E. Putting this into practise model, a dataset of photos of people who are deficient in certain nutrients and those who are not is gathered. This dataset is used by the neural network as training data. Preprocessing is done on the images to improve aspects linked to shortcomings and standardise the information. Next, a neural network with convolutions (CNN) uses the previously processed images for training and design.
The CNN is made up of several layers that extract pertinent characteristics from the input photos and create estimates of the shortcomings. It trains the model with the proper loss function and optimised with algorithms for gradient descent.

When the model is trained, is assessed by means of an independent test dataset to determine its precision and effectiveness. Metrics for evaluation like accuracy are employed to assess the model's capacity for accurately categorise dietary deficits. By feeding images of the affected individuals into the trained neural network, the implemented model can be used to detect nutrient deficiencies in people in real time.Those who are at risk of nutrient deficiencies can then benefit from early detection and intervention thanks to the model's predictions.

Fig 1.1 Sample Data Set

VII. ARCHITECTURE



VIII. CONCLUSION

A Web application has been developed, offering the capability to diagnose a range of selected vitamin deficiencies in users based on photos of their tongue, lips, eyes, and nails, employing Artificial Intelligence. The application combines Machine Learning to extract pertinent features and attributes from these images and deploys a Fuzzy Logic decision-making algorithm to specify the particular type of deficiency. The classifier is incorporated into a user-friendly interface for offline use. The Defuzzification Rules of the Fuzzy Membership Functions have been fine-tuned based on symptom commonality and probability, allowing administrators to enhance detection accuracy. Furthermore, the decision-making algorithm presents a list of recommended nutrients, compensational medications, and supplementary products. This innovative approach has been validated by associate professors in oral medicine and oral and maxillofacial surgery, confirming its validity and acceptability. Nevertheless, it represents a novel approach that facilitates self-diagnosis quickly, without the need for blood samples. The application is not intended to replace medical consultations but rather serves as a tool to enhance public awareness of nutritional deficiencies and aid in obtaining a suitable diet, thus mitigating the risk of health complications arising from untreated vitamin deficiencies.

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