

A Comprehensive Approach to Vitamin Deficiency Detection through Image Analysis of Skin, Tongue, Eyes and Nail Images using Convolutional Neural Networks

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Abstract: *This research presents a free artificial intelligence-based smartphone application designed to detect vitamin deficiencies among individuals by utilising images of specific parts of the body. Current approaches for detecting vitamin deficiencies requires an expensive laboratory analysis. Several vitamin deficiencies can exhibit one or more easily identified signs and indicators that manifest in various parts of the human body. Through the examination of images of their eyes, lips, tongue, and nails, users of the application can determine whether they may be lacking in any vitamin without having to give blood samples. Using nutritional micro-correction, the program then suggests a list of sources of nutrients for tackling the identified deficiency and its expected consequences. Through collecting and validating visual data of individuals, medical professionals can also help the platform improve its detection and accuracy capabilities. Allowing more advanced picture analysis and feature extraction skills that could eventually outperform human medical condition diagnosis. In addition to helping individuals solve a global issue that affects millions of people due to a lack of nutritional understanding, our software will eventually assist medical professionals in making more accurate diagnoses.*

Keywords: Vitamins Deficiency, AI, Image Processing, CNN, Nutrients

I. INTRODUCTION

Innovations in technology in the last few years have opened the door for innovative ideas in the healthcare industry. Early identification of nutritional deficiencies especially those related to vitamins, which can have a significant impact on human health is one such area of research. This paper provides a novel technique for detecting vitamin deficiencies through analysing skin, lips, tongue, and fingernail images using Convolutional Neural Networks (CNNs). Several physiological processes depend on vitamins, and deficiencies in these nutrients can result in a variety of health problems. Blood tests are frequently used in traditional ways of identifying these deficiencies, but they can be disruptive time-consuming, and less accessible. Our suggested method makes use of CNNs to examine simple pictures of important areas that are affected by vitamin deficiencies, such as the skin, lips, tongue, and fingernails. Through the conduct of this study, we are hoping to promote the development of healthcare technologies by providing a practical and easily accessible means for people to keep an eye on their nutritional condition. With the use of Convolutional Neural Networks (CNNs) using images of the tongue, lips, skin, and fingernail we hope to offer an accurate and complete analysis of nutritional status.

II. LITERATURE SURVEY

Diaa Addeen Abuhani, Jowaria Khan, Hana Sulieman [1] 2023, Its main objective is to identify diseases based on their features, which suggests a limited range that could exclude illnesses with symptoms that are less obvious or well-defined. The absence of precise information regarding the technological stack employed to implement the expert system in the text poses a difficulty in comprehending the underlying frameworks and tools. Lack of information regarding the technology stack could make it more difficult to duplicate or expand the system, which could limit its ability to adapt to

changes or developments in the future. Though the text mentions the validation testing findings, it doesn't go into detail on the specific procedure that was employed. The robustness of the validation procedure may be questioned in light of this paucity of information. While consistency between findings from manual calculations and those generated by the system is mentioned in the conclusion, it is not made clear how extensive the testing was or how different the examples were.

Justice Williams Asare, P. Appiahene, Emmanuel Timmy Donkoh, Giovanni Dimauro [2] 2023, This study compares photos of the fingernail colour, the palpable palm, and the conjunctiva of the eyes to identify iron-deficiency anaemia using machine learning models. Three steps make up the study: gathering datasets, preparing datasets, and creating models to detect anaemia. A variety of machine learning methods, such as CNN, SVM, k-NN, Naïve Bayes, and decision trees, are tested; CNN achieves the greatest accuracy of 99.12%. The outcomes show that a non-invasive method based on machine learning is a useful tool for detecting anaemia. The study only compares how well several machine learning algorithms identify anaemia using pictures of the fingernail colour, the sensitive palm, and the conjunctiva of the eyes. It does not take into account additional possible signs or diagnostic techniques for identifying anaemia. The size, diversity, and representativeness of the dataset that was utilised to train and evaluate the machine learning models are not fully disclosed. The results' ability to be applied generally may be impacted by this informational gap.

Suma Uday [3] 2023, Some people have trouble maintaining optimal serum 25-hydroxyvitamin D (25OHD) levels due to limited dietary sources of vitamin D. These people include those who live in high latitudes, people with dark skin, people who avoid the sun for health or cosmetic reasons, and people who wear full body clothing out of religious conviction. A lack of vitamin D has been connected to infections including tuberculosis, multiple sclerosis, Crohn's disease, and autoimmune diseases like type 1 diabetes mellitus (T1DM). The article by Harvey JN suggests reducing the occurrence of type 1 diabetes by fortifying meals with vitamin D. Due in large part to the observational character of most studies and the global prevalence of vitamin D insufficiency, it is difficult to establish causation in autoimmune disorders. The cause of type 1 diabetes is largely influenced by environmental variables, such as vaccination programmes, enterovirus exposure, seasonal illnesses, childhood obesity, and the bacteria in the gut. Research assessing vitamin D receptor variants in type 1 diabetes has been limited and inconsistent, with inconsistent findings. These studies frequently underrepresent ethnic minority groups, who are particularly affected by vitamin D deficiency.

Katarzyna Kosz, Klaudia Remjasz, Aleksandra Kuchnicka, Julia Kuchnicka [4] 2022, The review of medical literature gathered from PubMed between 2008 and 2021 served as the basis for this work. The causes, signs, and diagnosis of vitamin D toxicity (VDT) were the main areas of study. The manifestation of VDT, which is mostly linked to hypercalcemia and can be asymptomatic or potentially fatal, is covered in this work. The authors highlight the inappropriate usage of vitamin D supplements and their broad availability. Clinical characteristics, high 25(OH)D concentration, suppressed parathormone, and typically normal level 1,25(OH)D are used to diagnose VDT. The causes of VDT are also highlighted in the research, including improper vitamin D dosage and mistakes made during food manufacturing's formulation and fortification processes. Renal manifestations, neuropsychiatric symptoms, cardiovascular symptoms, gastrointestinal issues, hearing impairment.

Gerald Litwack [5] 2022, The article covers a wide range of vitamin and nutrition-related subjects, such as vitamin D deficiency, fat-soluble and water-soluble vitamins, balanced diets, and nutrient intake. Certain vitamins, including thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, pyridoxal, and pyridoxamine, as well as cobalamin, biotin, folic acid, ascorbic acid, beta-carotene, alpha-tocopherol, and vitamin K, are covered in this chapter. A summary, a list of references, review multiple-choice questions, and a case-based issue are also included in the paper. The goal of this chapter is to give a thorough introduction to vitamins, their purposes, and the significance of a diet that is balanced.

James Ming Chen [6] 2022, When faced with a variety of clinical signs that are unrelated to an infectious disease, fish doctors should consider the possibility of a nutritional disease. Disorders of mineral nutrition in cultured fish can occur, and while they are relatively uncommon when using formulated fish feeds. Trace minerals are components of hormones and enzymes and play a role in the development of the skeleton, colloidal system maintenance, and acid-base equilibrium homeostasis. Fish that experience disturbances in their mineral nutrition or balance may develop biochemical, structural, or functional diseases, depending on the severity and length of the shortage. Poor development, poor feed conversion, and general skin darkening are caused by high amounts of minerals.

Žane Temova Rakuša, Robert Roškar, Neal Hickey, Silvano Geremia [7] 2022, As a way to prevent and treat deficiency, vitamin B12 is an essential micronutrient that is frequently combined with food supplements and medications. The paper just gives an overview of the available data and does not go into great detail about the content-related quality of vitamin B12 products on the market. The possible interactions between vitamin B12 and other substances or drugs are not discussed in the text, despite the fact that these interactions may be important to understanding the vitamin's overall stability and effectiveness. The impact of manufacturing procedures and storage circumstances on the stability of vitamin B12 in foods, food supplements, and medications is not thoroughly examined in this research. The potential health advantages or disadvantages of using various kinds of vitamin B12 supplements are not covered in the paper.

Christopher J. Cifelli, Sanjiv Agarwal, Victor L. Fulgoni III [8] 2022, The study looked at the relationship between dairy consumption and US population markers of folate, vitamin B6, and vitamin B12 status. The National Health and Nutrition Examination Survey (NHANES), which is a nationally representative sample, provided the data for the study from 2001 to 2018. After controlling for demographic factors, the study examined the associations between biomarkers of folate, vitamin B6, and vitamin B12 and dairy intake (total dairy, milk, yoghurt, and cheese). Serum and RBC folate, serum vitamin B6, and serum B12 were all favourably correlated with higher consumption of dairy products, milk, and yoghurt. Additionally, a lower likelihood of insufficient or deficient levels of these vitamins was linked to higher dairy intake. According to the research, promoting dairy consumption may enhance micronutrient status.

Anastasia Vasiliki Mitsopoulou¹, Emmanuela Magriplis¹, George Michas [9] 2021, In order to evaluate the micronutrient intake of Greek adults, the Hellenic National Nutrition and Health Survey (HNNHS) used 24-hour recalls to gather food consumption data from 2389 individuals. The probability technique was utilised to assess the adequacy of iron intake in females of reproductive age, and the estimated average requirement (EAR) cut-point method was employed to assess nutritional adequacy. According to the study, nearly everyone had vitamin D intakes below EAR, and a sizable portion of the population also had inadequate intakes of potassium, vitamins A, E, K, and C. Intake of calcium and magnesium was below EAR in certain age and gender categories. Fifty percent of females, including those who were reproductive age, had folate intakes below EAR. More than half of the population consumed more sodium than was considered safe, and a food contribution analysis showed that the majority of vitamins came from low-quality foods like fast food. According to the study's findings, a sizable section of Greek adults consume inadequate amounts of nutrients and make poor dietary choices, which underlines the necessity for public health policy makers to create plans to enhance dietary quality.

Rafael G González-Acuña, Héctor A Chaparro-Romo, Israel Melendez-Montoya [10] 2021, It goes over the main ideas and methods of these algorithms, including non-maximum suppression, feature extraction networks, and anchor boxes. The paper provides insights into the accuracy, speed, and robustness of several algorithms by comparing their performance on benchmark datasets. It also addresses the obstacles and potential paths in object detection research, such as the requirement for real-time detection, occlusion handling, and enhancing detection precision in complex situations. The computational difficulty and resource needs of the discussed algorithms are not thoroughly explored in this study. There is little discussion of the algorithms' performance in real-world circumstances, and their evaluation is mostly dependent on benchmark datasets. The difficulties and restrictions unique to object detection in particular fields or applications such as autonomous driving or medical imaging are not discussed in the paper. The clarity and simplicity of the object identification algorithms important factors in some applications are not discussed.

alla Pogozheva Pogozheva, Погожева Алла Владимировна, Kodentsova Vm, Коденцова Вера Митрофановна [11] 2020, Majority Russian adults and children, regardless of where they live, suffer from a year-round deficiency in many vitamins, calcium, magnesium, zinc, iodine, and other minerals in their diets. When switching to food from a common table, individuals with food intolerances and allergies, people on elimination diets (vegetarians, vegans, etc.), people receiving drug therapy, people experiencing increased physical and psychological stress, the elderly, people keeping long-term religious fasts, pregnant and lactating women, people with food intolerances and allergies, people on diets that are enriched with dietary fibre, and obese people (who have their weight reduced by the caloric content of their diet). Vitamin supplementation of the diet. Adding vitamins and minerals to the diet is an established and empirically supported strategy for enhancing micronutrient status. Using vitamin and mineral supplements is an excellent choice if mass-market foods are not required to be fortified. A full range of vitamins and microelements, the shortage of which is

typical for a particular age group, and at dosages that are close to the body's physiological requirements, are the selection criteria for supplements.

Ankita Srivastava, Sanjiv Choudhary [12] 2020, This paper shows how important it is to identify knuckle pigmentation as a prior to vitamin B12 deficiency so that therapy can begin early and prevent irreversible neurological consequences. Vitamin B12 deficiency is commonly associated with haematological and neurological symptoms, although it can also cause pigmentary changes, such as pigmentation on the knuckles. In this instance, a thorough investigation revealed no systemic alterations, highlighting the importance of cutaneous indicators in the early identification and management of vitamin B12 insufficiency. The patient was instructed to keep taking iron, folic acid, and vitamin B12 orally. Vitamin B12 insufficiency can cause haematological and neurological problems, some of which might result in lifelong disability, if it is not identified and treated in a timely manner. The impact of manufacturing processes and storage circumstances on the stability of vitamin B12 in foods, food supplements, and medications is not thoroughly examined in this research. The possible advantages or disadvantages of taking various kinds of vitamin B12 supplementation are not covered in the research.

Nina Sevani, Iwan Aang Soenandi, Fajar Saputra [13] 2020, draws attention to the shortcomings of the current approaches in terms of responding to alterations in symptoms. Explains the new method of using backpropagation (BPN) in an Artificial Neural Network (ANN) for detection. Outlines the 17 different vitamin and mineral kinds and the 107 physical symptoms that make up the output features. Outlines the input, hidden, and output layers of a neural network architecture with 107-50-17 neurons. Explains how trial and error experiments using 623 epochs, 0.0517 error rate, and 0.1 learning rate were used to establish the ideal values. Reports an accuracy level of 73% and presents the performance indicators utilised (precision, recall, F-score). When applied to populations with different dietary practices, genetic predispositions, and environmental circumstances, the model's performance may differ. It might not translate well to a variety of global demographics. It's possible that the suggested model won't offer real-time vitamin and mineral level monitoring. Delays in detection could prove to be a constraint for conditions that demand quick action. Interactions between various vitamin and mineral deficits may not be taken into consideration by the model.

Kianna Louise Guintu, Angeli Landicho, Madeleine Navarrete, Jersey Marice Padilla [14] 2020, Nails may act as indicators for nutritional status and, depending on their state, can reveal various diseases and deficiencies. By using nail image processing, the researchers hope to create a stand-alone gadget that can identify signs of iron insufficiency. The gadget takes pictures of fingernails with a webcam and utilises image processing algorithms to determine how healthy they are. In identifying nail abnormalities associated with iron shortage, the device had an overall predictive performance of 91.3%, with a precision of 87.5% and sensitivity of 95.45%. In order to make the gadget portable and self-sufficient in terms of power, the programme and model were moved to a Raspberry Pi. The gadget demonstrated 100% consistency in identifying nail symptoms of iron insufficiency, with an accuracy of 85.71% recorded.

According to Ahmed Saif Eldeen, Mohamed AitGacem, Saifeddin Alghlayini, Wessam Shehieb and Mustahsan Mir [15] 2020, by the help of artificial intelligence (AI) and picture analysis of the tongue, lips, eyes, and nails, the Android application Vita-Cam is being unveiled. That is a major step towards enabling people to self-diagnose specific vitamin deficiencies. By utilising Machine Learning and a Fuzzy Logic method for decision-making, the programme is able to precisely extract features from photos, identify the sorts of deficiencies, and provide recommendations for compensation. However, due to restricted access to photos and profiles of instances with vitamin deficiencies, the application's efficacy might be limited in the absence of actual patient testing. Furthermore, the use of pictures alone in diagnosis raises questions regarding the possibility of misinterpreting or ignoring subtle symptoms that call for a more thorough medical evaluation. These shortcomings highlight the necessity of continual improvement and verification, underscoring the significance of working in conjunction with the medical community to guarantee the precision and dependability of the application.

Imelda Angeles-Agdeppa, Ye Sun¹, Liya Denney¹, Keith V. Tanda [16] 2019, Examine research that address the general nutritional status of the adult Filipino population. Evaluate important results, trends, and patterns pertaining to dietary practices and nutrient deficits. Examine the literature on eating habits in the Philippines and other countries in Southeast Asia. Determine the basic foods, general dietary habits, and how these affect adults' nutritional intake. Analyse past Philippine National Nutrition Surveys to learn about changes in eating practices and nutritional status over time. To determine trends and changes, compare the results with the survey conducted in 2013. Seek out research on the

effects of diets high in rice on nutrient intake. Examine how the use of rice as a staple has increased. Examine studies that examine the consumption of particular nutrients in Southeast Asian nations, including iron, calcium, vitamin C, and others. To find geographic tendencies, compare the findings with the current investigation. Examine the literature on the socioeconomic, cultural, and environmental aspects of Philippine diet choices. Comprehending these variables can offer a framework for the noted eating habits.

Ian Darnton-Hill [17] 2019, Study papers and documents that highlight the importance of vitamins and the global burden of micronutrient deficiencies. Examine the prevalence of deficits and their effects on public health in low- and middle-income nations. Analyse the literature in particular to learn about the incidence and effects of vitamin A insufficiency in children. List the public health initiatives and interventions that have been used to address this particular deficiency. Study studies on many life periods, including pregnancy, childhood, adolescence, and old age, to comprehend the range of dangers associated with vitamin deficiencies. Determine particular guidelines for reducing these hazards at each stage of life. Recognise the complex interactions that exist between different vitamins and minerals as well as the difficulties in treating several deficits at once. Comprehensive techniques may be necessary due to the interconnectivity of nutrient demands. Acknowledge the impact of cultural and socioeconomic factors on eating patterns and the success of interventions. To guarantee cultural relevance and acceptance, strategies need to be customised for local circumstances. Underline how crucial it is to take interventions' long-term sustainability into account. Sustained improvement may not always follow short-term progress, therefore continuous work is crucial. Being aware of any potential gaps in the availability and precision of micronutrient status data, particularly in environments with limited resources. Methods for data collecting and monitoring may need to be improved.

Mutammimul Ula, Mursyidah, Yana Hendriana, Richki Hardi [18] 2016, The complexity of related concerns including food, health, and disease is increasing as the world's population rises to an expected 5 billion. A system to support patients, healthcare providers, and individuals in the field is desperately needed in light of the growing health concerns. For ease of use, the prototype has been purposefully kept basic, enabling users to modify and modify the system for a variety of conditions. Limited technological Mention: The expert system's technological stack isn't discussed in length in the text. Without precise details on the tools and frameworks used, this could make it difficult to replicate or expand the system. The system's application to diseases with distinct and easily observable symptoms may be limited due to its concentration on detecting diseases based on their characteristics. It could have trouble with intricate or subtle situations that call for greater understanding. The Text makes the assumption that readers are able to recognise and precisely describe symptoms. However, the efficacy of the system can be harmed if users are unaware of the symptoms. Tung Duc Nguyen, Kazuki Mori, Ruck Thawonmas [19] 2016, The research paper describes a novel method for applying deep learning techniques more specifically, a pre-trained convolutional neural network meant for image classification to colourize monochrome photos. The suggested technique adds colours to a grayscale image by separating the content and style of many photos and combining them. By using their method to colourize pictures of ukiyo-e, a style of Japanese painting, the authors show how successful it is and get some interesting results. The study indicates that this technique has a lot of potential for computer-assisted art and that image colorization is one of its many possible uses.

Divya Seshadri, Dipankar De [20] 2012, The connection between nutritional deficits and nail health is the main topic of the paper. It seeks to detect particular anomalies of the nails that may indicate various nutritional deficits. The significance of identifying these nail alterations as preliminary indicators of underlying nutritional issues is emphasised by the authors. The impact of several nutrients, such as vitamins, minerals, and essential fatty acids, on nail health is covered in this paper. It also looks into the possible processes by which malnutrition may have an impact on the development and structure of nails. The authors stress the importance of additional study in this field to enhance the precision of diagnoses and create focused interventions for people suffering from nutritional deficits. Limited sample size and participant variety could limit how broadly applicable the results can be. Insufficient extended monitoring to evaluate the advancement and improvement of nail defects in reaction to dietary therapies. The association between dietary inadequacies and nail health is the main emphasis of the research, however nail abnormalities may also be caused by descent, underlying medical disorders, and environmental factors.

III. CONCLUSION

An Artificial Intelligence-powered software has been developed that can diagnose certain vitamin deficiencies based on pictures of the user's tongue, skin, lips, eyes, and nails. The application utilised a Fuzzy Logic decision-making technique to determine the type of deficiency and machine learning to extract certain features and characteristics from the pictures. Following the identification of the visual symptoms related to each deficiency by pathological study, a large number of identified pictures with segmented symptoms for each organ separately, at a minimum resolution. Associate professors in oral medicine and oral and facial surgery confirmed the validity and acceptability of the approach. The test resulted in the accurate diagnosis that matched the symptoms. However, the application was not tested on patients directly because of the restricted access to pictures and case histories of individuals with vitamin deficiencies. The software is a novel method that enables quick self-diagnosis without requiring a blood sample. By adding more data and receiving direct input from experts, researchers, and medical practitioners with database access alone, the accuracy of the diagnosis can be greatly increased. The capabilities of the suggested method can be expanded beyond vitamin deficiencies to include early identification of other health issues using more resources.

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