REVIEW OF VITAMIN DEFICIENCY DETECTION METHODS USING DEEP LEARNING

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Abstract: Deep Learning is one of the emerging fields in today's world. It has shown its application in many fields, especially in medical field, in helping to get over with the disadvantages of the ancient methods. Vitamins are organic components that are required by human body and needed to be supplied from diet because body cannot synthesize vitamins itself. The deficiency of vitamins can cause severe changes in our body. But people are very less aware about it and the issues caused by it. By the development of AI-based applications, that helps to detect the vitamin deficiency in human body and providing food recommendation, awareness can be created among people. The deficiency of certain vitamins can cause distinguishable changes in our body. This paper reviews about the various Deep Learning methods which can be used to detect the vitamin deficiency, and also summarizes about the current enhancements, applications and the research works in this field**.**

Index Terms **- Vitamins, Deficiency, Detection, Convolutional Neural Networks, Deep Learning.**

I. INTRODUCTION

Even though vitamins are required by the body in very less amount, it's deficiency can cause severe changes in our body or it may even lead to life- threatening conditions. Now-a-days, it has become very common and is a major issue to be addressed. It was observed that, people who are vitamin deficient exhibits reduced educational outcomes, reduced work productivity and are more prone to other diseases and health conditions. If people could be made more aware and if they follow a good diet, the issues caused by vitamin deficiency could be reduced to an extend.

II. RESEARCH ELABORATION

This section summarizes the research woks done based on vitamin deficiency detection methods and food recommendation systems.

Diabetic Retinopathy(DR) is a medical condition which, if not diagnosed in an earlier stage, can lead to blindness. Lifeng Qiao, Ying Zu, Hui Zhou, in their paper, cited that, Convolutional Neural Networks are more widely used as a Deep Learning method in medical image analysis and they are highly effective. The earliest and detectable sign of DR is Micro Aneurysms (MA), which are small red round dots, and are of less than 125μm in size. The Prognosis of MA is mentioned by training effectively the Deep Convolution Neural Network(DCNN) for semantic segmentation of fundus images [1].

The paper, "Detecting Clinical Signs of Anaemia from Digital Images of the Palpebral Conjunctiva*",* discusses about the examination of the palpebral conjunctiva and suggest a method for diagnostic support. Conjunctiva images were taken with the help of affordable and user friendly device, that optimized the properties of independence from ambient light. The obtained results guarantee the reliability of the system and it can be used as a personal monitoring tool [2].

The paper, "A deep learning algorithm for detection of oral cavity squamous cell carcinoma from photographic images: A retrospective study" deals with oral cancer detection. Oral cancer, is a disease that can be life threatening if not diagnosed in an earlier stage. Oral cancer, being easily visualizable, can be detected and on applying certain techniques of deep learning and computer vision, we can easily perform the diagnosis at an earlier stage. The training of model was done using data set which included 44,409 oral images from 11 hospitals. The deep learning algorithm was developed using the cascaded Convolutional Neural Network to detect Oral Cavity Squamous Cell Carcinoma (OCSCC) from photographic images. Image preprocessing techniques like scaling, rotation, horizontal flipping and adjustment of the saturation and exposure were performed. The final result are obtained and overall accuracy, sensitivity and specificity are calculated [3].

"AI (artificial intelligence) in histopathology – from image analysis to automated diagnosis" discusses how a virtual slide does the calculation and related presentation of an image information. Virtual slide is the presentation of microscopic images' in a digital matrix form, as a whole. The system has been computed and tested for diseases of several organs. Based on image analysis, classification was done so as to differentiate between cancerous and non-affected cells. The system specificity was computed to be in a range between 95% and 100 %. Even the images that were difficult to diagnose were also correctly classified [4].

The work by S. Jeyalakshmi and R. Radha, reviews on various image processing techniques for diagnosing nutrient deficiency in plants. The diagnostic system using digital image processing focused on diagnosing macro nutrient deficiencies: Nitrogen, Phosphorous and Potassium and others. Only very few works have been taken place for diagnosing micronutrient deficiency symptoms[5].

"Machine Learning Based Nutrient Deficiency Detection in Crops" discusses the strategies of cultivating various plants for food production and about raising of domesticated animals. There are number of reasons for decreasing of crop yield. One of the reason is nutrient deficiency. It's very difficult for the farmers to identify the particular deficient vitamin and to know which fertilizer to be used. This paper describes about the design of an automatic robotic vehicle that helps in detecting the particular nutrient that is deficient in crops. This is done by capturing the image of leaves. Convolutional Neural Networks (CNN) is used to process the captured images. The newly captured images are compared with the already available dataset. The system checks whether the

image matches with any one of the existing images in the dataset, and based on the analysis, provides result of nutrient deficiency, in terms of the percentage[6].

Meng-Leong How and Yong Jiet Chan reported about malnutrition, and how Artificial Intelligence(AI) can be used to simulate the possible dynamics between malnutrition and health. The analysis is done on the basis of the collected set of data. One of the limitations seen in this paper is that the exploratory character of predictive analytics using Bayesian Network analysis makes the simulated counterfactual findings suggestive rather than definitive. This paper focused on the global system-level view of analyzing the data[7].

"An Expert System for Early Diagnose of Vitamins and Minerals Deficiency On The Body", defines an expert system for detecting vitamin and mineral deficiency. Expert systems provide problem solutions and also involves in decision making activities, just as a human expert does. Artificial Intelligence can help to diagnose vitamin deficiency and provide food recommendations. Expert system has various applications including classification, diagnosis, generation of options. Disease detections were done using expert system by using certainty factor of uncertainty. Expert system have been built for diagnosis of dengue fever. The method for handling uncertainty was also described. Based on the symptoms of vitamin deficiency the certainty factor value for each user is being calculated and once the values are obtained, based on the rules, we can predict which vitamin is deficient [8].

Dony Novaliendry, Cheng-Hong Yang and A. Y. Denno Guara Labukti, in their work, described about vitamin deficiency detection methods using an expert system, that chooses the best way of solving a problem, and comes out with a decision. Application of expert system diagnosis, uses forward chaining method, that is driven by the data where initially the input information is observed and then try to describe the conclusions [9].

Deficiency of vitamins and minerals can be performed in an early stages with the help of an expert system. Detection is done by knowing the exact symptoms. The work, "Vitamins and Minerals Diagnosis System Using Neural Network" discusses about an application that helps in achieving a better health status. The training of the neural network is based on the already available datasets[10].

The main objective of this study performed by G. Sambasivam, J. Amudhavel, G. Sathya is to identify the best Machine Learning model in the prediction of Vitamin D Deficiency (VDD severity). The prediction accuracy was calculated and compared with the training and testing set. Evaluated the Machine Learning models and performance measures like precision, recall, F1-measure, and accuracy. These parameters were used in the severity prediction and techniques used for feature selection. McNemar's statistical significance test is used to validate the empirical results. From McNemar's test, it is undoubtedly RF scores high in prediction when compared to different models and the Pearson's correlation coefficient and error measures result concluded the same. Efficient VDD prediction can be done with high accuracy using the machine learning methods. The results of this research work proved that the machine learning models especially the random forest classifier accurately predict the severity of Vitamin D deficiency. In particular, the Random forest classifier achieved the highest accuracy (96%) and outperforms well than other classifiers. This machine learning classifier will have a greater opportunity in the real-world medical domain which would assist experts to efficiently identify the severity of VDD. The major advantage of this study is that it has explored a new approach for the prediction of VDD severity using the Random Forest model and it has evaluated the results of the machine learning models using various performance measures accurately among the adolescents. Random forest method was found to be the best one[11].

Huaping Zhou, Raushan Myrzashova and Rui Zheng, in their work, discussed about the diabetes prediction model. Diabetes is simply high blood sugar. When affected with diabetes, insulin production may not occur properly, or if produced also, it cannot be used properly. Now-a-days, Deep Neural Network perform excellent in the field of medical diagnosis and detection. Deep Neural Networks uses sigmoid, soft max, tanx, ReLU, soft plus and other activation functions and add nonlinear factors to improve the expression ability of the model. Deep Neural Network has basically three layers : the input layer, the hidden layer and the output layer. Different neural network models are present like convolutional neural network and recurrent neural network.

For image processing and speech recognition we used convolutional neural network model commonly. Natural Language Processing and hand writing recognition are done using the Recurrent Neural Network. Activation Functions have properties like nonlinearity, differentiability and monotonicity. The deep neuron networks usually uses dropout technique that helps in avoiding data over fitting by eliminating the features which are repeating or eliminates the features which are not required. The weights are initialized with a random value and the input is fed into the neural network. The PIMA indians diabetes data and the diabetes type data set from the data world repository are being used. The steps followed include data preprocessing, building and training the DL model, adding dropout regularization to fight over fitting and hyper parameter tuning. Finally Loss and accuracy is visualized. The model creation and training is done on the deep learning studio using deep cognition AI. Deep learning studio is a special tool for AI developers to build, train and deploy the models [12].

Nina Sevani, Iwan Aang Soenandi and Fajar Saputra, used the back propagation method to detect vitamin deficiency. Back propagation is a mechanism which is used in Neural Networks to handle errors. It is a repeated process, where fine tuning is performed based on the feedback which is obtained from the previous states and the weight of each neuron is adjusted so as to minimize the error. Other than the rule-based and the certainty factor methods, here we apply back propagation artificial neuron network to find the vitamin deficiencies. This was adopted as it had more accuracy than other methods. The dataset is acquired and the validation is performed using the proposed architecture. The main three steps in back propagation are feed forward, back propagation of errors and the weight adjustment based on the error rate.

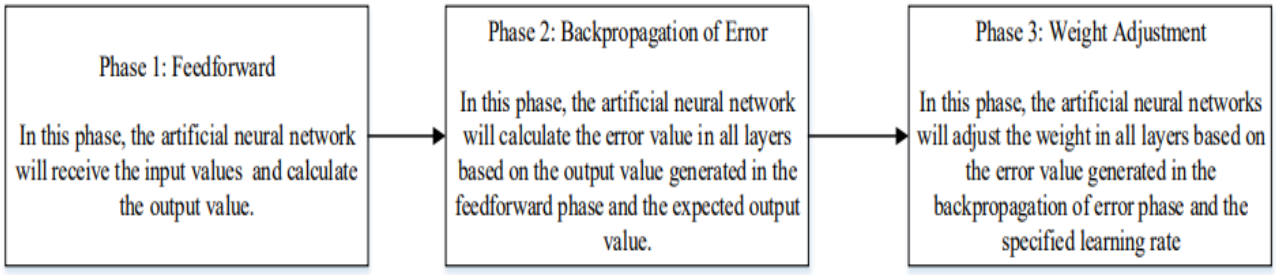

Figure 1: Architecture of Artificial Neural Network

The architecture of the artificial neural network which provided the least mean square error on the trial and error was chosen. Trial and error method is a very commonly used method for finding the error in a particular system and also to find solutions to the issue. It is a repeated process and the process is continued till we get an error free and desired output. Each parameters used in the artificial neural network are also selected by doing this trial and error mechanism. Parameters include the learning rate, epoch limit, selection of activation function. Once artificial neural network is built, the values like precision, recall, f-score and accuracy are detected using confusion metrics which are vital in detecting the vitamin and mineral deficiency. The model accuracy evaluation is done based on the match and mismatch classification between the output of the artificial neural network. This method have generated an accuracy of 73 percentage [13].

The paper, "Non-Invasive Blood Glucose Estimation using Handheld Near Infra-Red Device", reported that, non-invasive blood glucose measurement would ease everyday life of diabetic patients and may cut the cost involved in their treatments. Non-invasive blood glucose measurement is done using NIR (near infrared) spectroscopic device. Data collection included NIR spectra data and blood glucose levels. With these samples, a predictive model is developed using Interval Partial Least Square (IPLS) regression method. The determination coefficient (R2) obtained for calibration/training and testing dataset are respectively 0.9 and 0.91 [14].

"NIR-Spectroscopic Classification of Blood Glucose Level using Machine Learning Approach", was a work based on Diabetes Mellitus (DM) or diabetes, one of the metabolic diseases exhibiting high blood glucose level over a prolonged period. Machine Learning techniques are utilized to analyze NIR spectroscopic response data for predicting blood glucose levels. The NIR spectrums of the samples were obtained using Neo-Spectra-Micro development kit and Blood glucose samples were prepared in a controlled environment. Two methods were used: one, the Random Forest algorithm (RF) followed by Support Vector Machine (SVM) and second, a combination of Principle Component Analysis (PCA) and SVM [15].

Recommendation systems are information filtering systems which analyze the preferences of a user and would give suggestions based on it. The paper, "An overview of recommender systems in the healthy food domain", describes about various recommendation techniques for individuals as well as for groups. The collaborative filtering recommendation system is a method where the rating is taken from the user and the system finds the neighbors who have the same interest and based on the items selected by the neighbor, recommendations are given to the user. The approaches being implemented here include item-based, user-based, model-based approach and metrics factorization. Content based recommendation systems take personalized recommendations. It exploits the information about the available item descriptions and search users' profile on what items he likes or commonly uses. This can be achieved by certain approaches like information retrieval or machine learning algorithms. Hybrid recommended system use the advantage of A to fix the disadvantages of B. These are the recommendation systems for individuals. Some of the recommendations systems for groups include aggregation strategies, group formation, group recommendation approaches, and group decision making. The food recommendations are generally performed considering the user preferences and nutritional needs of the user [16]. The paper, "Yum-Me: A Personalized Nutrient-Based Meal Recommender System", describes about a personalized nutrient-based meal recommender system. Individuals' nutritional expectations, dietary restrictions, and fine-grained food preferences are being considered while designing the product. It is a visual quiz-based user interface [17].

III. TERMINOLOGI ES

3.1Convolutional Neural Network

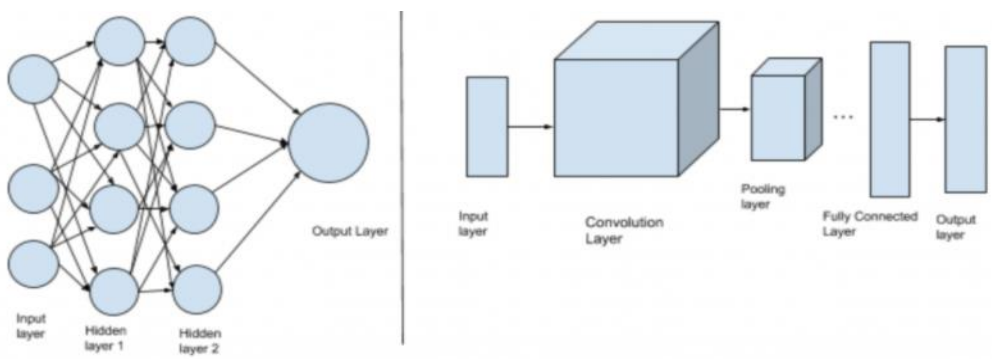

Figure 2: RNN and CNN

The main difference between the Convolutional Neural Network (CNN) and Regular Neural Network (RNN) is that, CNN does not require another process for feature extraction, whereas RNN requires. For Image Processing and image classification activities, we generally use CNNs. It have an input layer, convolutional layer, pooling layer and the fully connected layer (which is the Regular Neural Network) and finally the output layer.

The feature extraction is performed in the convolutional layer and a filter is being used which slides over the image from top to bottom from left to right thereby reducing the size of the image. Dimensionality reduction is performed by the pooling layer. All the basic neural network structures are associated with weight and biases.

3.2 Transfer Learning

Applying Deep Learning model that is trained on one machine, to another machine will result in performance drop. Here we apply the concept of unsupervised learning which is a branch of transfer learning and does not require any label data.

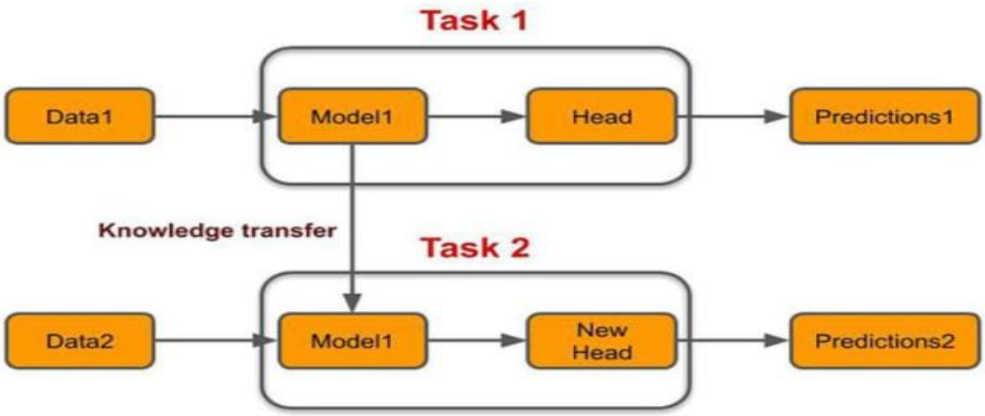

Figure 3: Transfer Learning

3.3Deep Learning(DL) and Machine Learning(ML)

Machine learning is an Artificial Intelligence(AI) system that can self learn based on algorithm. Deep Learning is Machine Learning applied to large dataset. AI can make a machine able to think without human intervention and it can take decision on it's own.

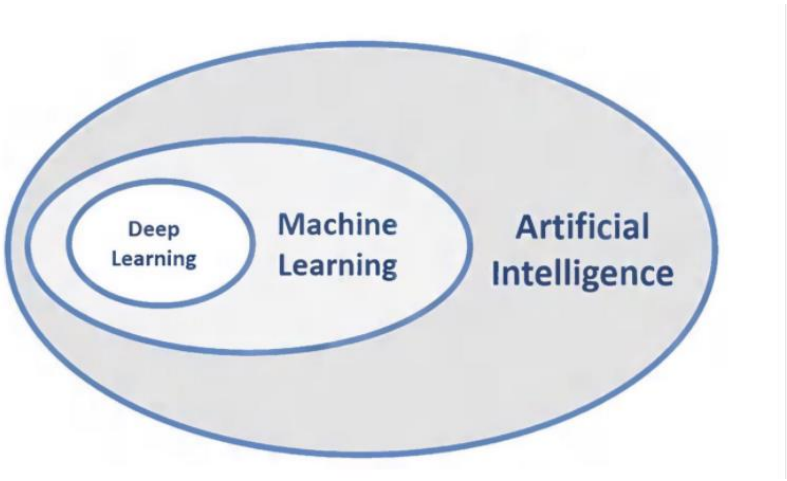

Figure 4: AI, ML and DL

3.4Deep Reinforcement Learning (RL)

It works on the basis of previous experiences and the examples that it had worked on. It uses this knowledge to solve the problem. It works on trial and error environment. Many reinforcement learning techniques have been proposed including Q-learning, State-Action-Reward-State-Action (SARSA) and action-critic learning. We can use Reinforcement Learning in health management applications. Challenges of deep reinforcement learning is that, as it's not trained upon by any specific or fixed data set, it can result in unstable performance.

3.5Convolution Filter

Convolution is basically, how the input is modified by a filter. The filter slides from left to right across the image from top to bottom. 2D convolution is usually used for black and white images. 3D convolution are used for color images.

The output image size is then reduced than that of the input image. Convolution in 3D is just like two-dimensional except that we are doing 2D convolution three times.

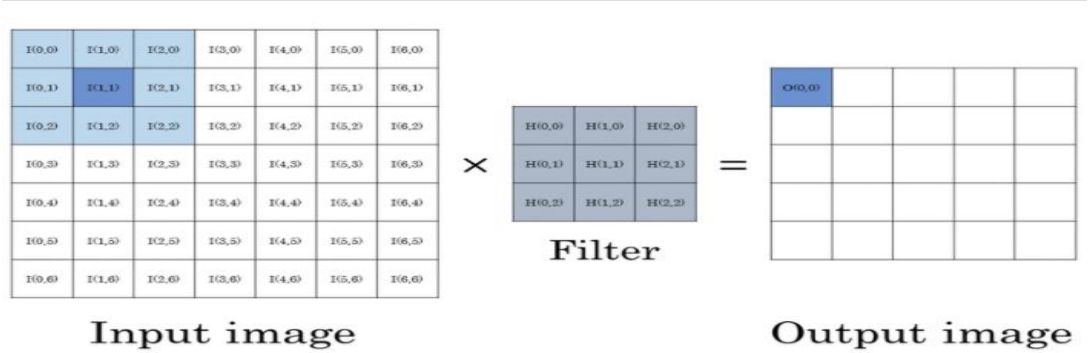

Figure 5: 3×3 convolution filter

3.6Deep Learning

Deep Learning gain more attention by the introduction of Deep Convolutional Neural Network. The success of deep learning is mainly due to availability of large data set which is required to train the Deep Learning model and the emergence of fast and self trained freely available software libraries. Deep Learning has been successful in speech recognition, machine translation and Natural Language Processing (NLP). The speech recognition system that we have on smart phone are the first widely available application of Deep Learning. This is done by training model with large data set. Image Processing and recommendation systems are the other successful domains of Deep Learning. Interpretability is one of the main challenge that is faced in this field.
Supervised learning is training data by giving labeled input. Unsupervised learning does not require any labeled data. Semi-supervised learning uses the available and labeled data to improve the performance of supervised learning tasks. Reinforcement learning functions are based on feedback.

IV. CONCLUSION

In this paper, various Deep Learning methods for detection of vitamin deficiency was discussed. Discussions on food recommendation systems were also included. Fields of health management, diabetes prediction, vitamin D deficiency detection were discussed. It was observed that random forest classifiers acquire more accuracy. Dropout technique is used to reduce over fitting problem.

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