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Malnutrition Detection using Convolutional Neural Network

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Abstract — **Malnutrition is directly or indirectly responsible for the deaths of children younger than 5 years in many countries. Identification of malnourished children will help to prevent the risk of death and can reduce physical and health issues by taking necessary measures or treatment. The proposed system uses a Convolutional Neural Network (CNN), a Deep Learning algorithm that takes input, analyzes the images, and differentiates one from the other. The architecture we used here is AlexNet for the training process and Transfer Learning. The system takes the image of a child as the input and classifies the image into a malnourished or normal child by comparing the image with the trained model. The objective of the system is to detect malnutrition in children that can help people and healthcare providers to reduce the effects caused by malnutrition by automation implementation instead of a manual process.**

Keywords* — *Malnutrition, Convolutional Neural Network, Alexnet.

I. INTRODUCTION

Malnutrition is a condition that occurs due to fewer intakes or over intake of nutrients. This can lead to health issues such as diabetes, heart disease, eye problems, and stunted growth. Malnutrition is directly or indirectly responsible for the deaths of children younger than 5 years in many countries. According to the World Health Organization's (WHO) 2020 edition, stunting has affected 21.3% or 144 million children under 5 years of age globally. Wasting has affected or threatened the lives of 6.9% or 47 million children under the same age group. About 5.6% or 38.3 million children under the age of 5 years were overweight around the world [1]. Yet, while there has been an improvement, it has been slow and patchy as shown in the Fig 1. Undernutrition leads to physical health issues and growth issues. According to UNICEF's The State of the World's Children 2019 report [2], globally out of 3 children at least 1 is not growing well due to malnutrition, and 1 out of 2 children is suffering from hidden hunger.

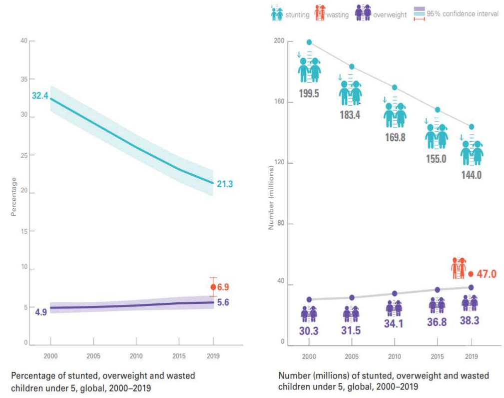

Fig. 1. Percentage and Number (millions) of stunted, wasted and overweighed under age 5 globally between the years 2000-2019. Source: UNICEF, WHO, World Bank Group joint malnutrition estimates, 2020 edition

Approximately 45% of deaths of children under the age of five years are due to undernutrition [3]. The National Family Health Survey 2005-06 (NFHS-3) reported that in India, 48.0% of children under age 5 years were stunted, 19.8% were wasted, 6.4% were severely wasted and 42.5% were underweight[4]. The National Family Health Survey 2015-16 (NFHS-4) reported that 38.4% were stunted, 21.0% were wasted, 7.5% were severely wasted and 35.8% were underweight [5]. Over the decade there was a slight decline in stunted and underweight children but wasted remains alarming. Children were suffered more with malnutrition and the detection of malnutrition will help to prevent the risk of death and can reduce physical or growth issues by taking necessary measures.

Detection of malnutrition in children can help people and healthcare providers to take preventive measures and can reduce the effect caused by malnutrition on children. To detect the malnutrition in children, a type of artificial neural network called convolutional neural network (CNN) is used. The architecture we used here is AlexNet, which is a convolutional neural network that is a powerful model capable of achieving high accuracies on challenging datasets.

II. RELATED WORK

A disease detection concept has detailed by using the human images and analyzing the data from the color of the image. This might not work in every case as some people might look lean and are not malnourished [6]. Tensor Flow algorithm is used to train the dataset which supports various features. The data obtained from semi structured interviews were analyzed using frame analysis and MaxQDA software. The gathering of data required much amount of time and improper data might lead to incorrect results [7]. The nutritional status of the population is characterized using height, weight, and MUAC based anthropometric indicators. The study also revealed that the removal of data based on SMART flag cut-off points improves the data quality of anthropometric surveys. The quality improvement measures are described rather than identifying the children affected with malnutrition [8].

The white paper [9] detailed the role of CNS in the prevention and treatment of malnourished patients who were hospitalized. The accurate documentation of the malnourished patients will help in the appropriate coding, funding reimbursement, and treatment [10]. A decompositional analysis was conducted using two waves (2004-2005 and 2011-2012) data from Indian Human Development. The z-scores of Weight-for-Height (WHZ), Height-for-Age (HAZ), Weight-for-Age (WAZ), and the composite index of Anthropometric Failure were used for undernutrition measures. The analysis provided the up-to-date profile of the nutritional status of India's children using the z-scores [11].

A system was developed to show the dashboard representation of malnutrition. The final output is the graphical representation of the data in the form of a pie chart or bar graph which contains the data that is maintained in the database and is displayed based on the selected. It represents the data in the form of pie chart or bar graph which might not help to treat the malnourished children but can help us to take preventive measures to decrease the rate of malnourished children [12]. Malnutrition among under-five children is one of the major concerns in India. This review has identified the determinants and strategies that are required to prevent malnutrition under age of five years children in India. Prevention measures are explained and [13]. A system was developed using ID3, Random forest tree algorithm to generate a general result about the nutritional status of the children. Random forest tree algorithm is beneficial to train the data. However, it is comparatively slow to create predictions out of trained data [14].

In 2011 a complete nutrition data about children under five years were collected. Based on this data, a predictive model is developed using PART pruned rule induction which helps program managers and government to identify the children who are at risk. [15]. A Rule-based classification technique with a Multi-Agent System was used to detect malnutrition in children. The final decision is made based on the number of rules used and shows that there is connectivity between the number of rules and the optimality of final decision. It requires lot of manual intervention like generating rules out of facts and also depletes time while we generate rules for complex data or system [16]. The study says that weight-height based case-detection technique performs worse in identifying malnutrition. MUAC is the best case-detection method and helps to identify severely malnourished children for their admission into community based therapeutic care programs. MUAC is the best method to measure each and every child to know about their nutritional status [17]. The study resulted that 21.7% of children fewer than three years of being affected with undernutrition in rural Western China in 2005 and stated that childhood malnutrition is a large health challenge. This work depicts the overall rate of malnourished children under three years but not techniques to identify malnourished children [18].

III. SCOPE OF THE STUDY

Identifying malnourished children less than five years age is very important as it causes more problems in children than any other age group as they may lead to growth (both physical and mental) impediment and vulnerability to rehashed diseases. The main aim of the project is to detect the children affected with malnutrition with the help of their images and simple parameters (gender, age, weight and height).

IV. METHODOLOGY

A. Dataset

The dataset contains malnutrition and normal children images in different folders labeled as Malnutrition and Normal without any filters or size restrictions.

B. Graphical User Interface (GUI)

A GUI is created in Matlab for taking inputs from the user as shown in Fig 2, for performing operations and for displaying the results.

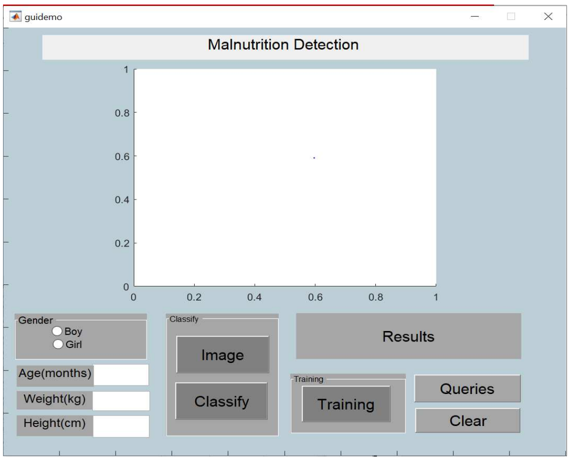

Fig. 2. Graphical User Interface for Malnutrition Detection

Input: 1. Child image, 2. Gender, 3. Age (in months), 4. Weight (in kg), 5. Height (in cm).

Processing: Training using Alexnet and transfer learning. Classification using image result and parametric conditions of weight-for-age, weight-for-height, and height-for-age.

Output: Displays the result in string form in Results textbox. Queries button displays frequently asked questions on malnutrition.

C. Training and transfer learning

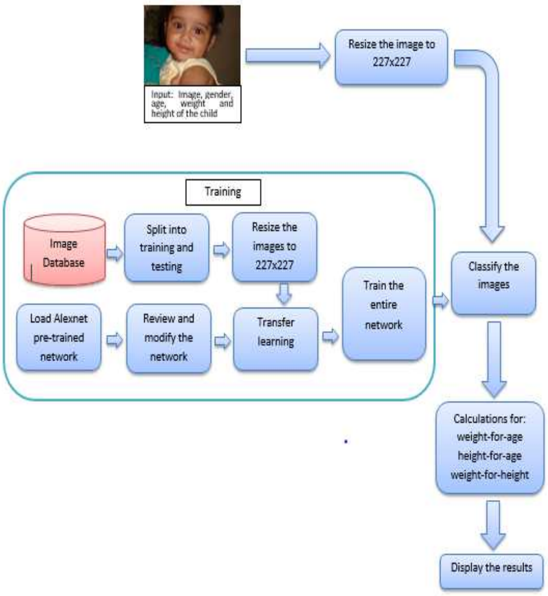

Fig. 3. Architecture for Malnutrition Detection

1	'data'	Image Input	227x227x3 images with 'zerocenter' normalization
2	'conv1'	Convolution	96 11x11x3 convolutions with stride [4 4] and padding [0 0 0 0]
3	'relu1'	ReLU	ReLU
4	'norm1'	Cross Channel Normalization	cross channel normalization with 5 channels per element
5	'pool1'	Max Pooling	3x3 max pooling with stride [2 2] and padding [0 0 0 0]
6	'conv2'	Convolution	256 5x5x48 convolutions with stride [1 1] and padding [2 2 2 2]
7	'relu2'	ReLU	ReLU
8	'norm2'	Cross Channel Normalization	cross channel normalization with 5 channels per element
9	'pool2'	Max Pooling	3x3 max pooling with stride [2 2] and padding [0 0 0 0]
10	'conv3'	Convolution	384 3x3x256 convolutions with stride [1 1] and padding [1 1 1 1]
11	'relu3'	ReLU	ReLU
12	'conv4'	Convolution	384 3x3x192 convolutions with stride [1 1] and padding [1 1 1 1]
13	'relu4'	ReLU	ReLU
14	'conv5'	Convolution	256 3x3x192 convolutions with stride [1 1] and padding [1 1 1 1]
15	'relu5'	ReLU	ReLU
16	'pool5'	Max Pooling	3x3 max pooling with stride [2 2] and padding [0 0 0 0]
17	'fc6'	Fully Connected	4096 fully connected layer
18	'relu6'	ReLU	ReLU
19	'drop6'	Dropout	50% dropout
20	'fc7'	Fully Connected	4096 fully connected layer
21	'relu7'	ReLU	ReLU
22	'drop7'	Dropout	50% dropout
23	''	Fully Connected	2 fully connected layer
24	'prob'	Softmax	softmax
25	''	Classification Output	crossentropyex

Fig. 4. Modified Alexnet network

Load the dataset: The dataset consists of malnutrition and normal/healthy children. The very first step in this module is to load the data folders and subfolders.

Split the dataset: The dataset splits into training and testing images randomly and creates two data stores for training and testing data.

Load and modify pre-trained network: AlexNet is a convolutional neural network which is trained on more than one million images from the ImageNet database and can classify images into 1000 object categories, such as a keyboard, mouse, pencil, and many animals. As a result, the model has learned rich feature representations for a wide range of images. AlexNet architecture consists of eight layers. They are five convolutional layers, some of them are followed by max-pooling layers and three fully connected layers. Using a non-saturating Rectified Linear Unit (ReLU) activation function improves training performance. It is a powerful model capable of achieving high accuracies on challenging datasets. This step loads the pre-trained Alexnet neural network. After loading, an appropriate learning rate, epochs, and mini-batch values are given to the Alexnet architecture and final layers are modified (Fig. 4) according to the new dataset categories that are two (malnutrition and normal).

Transfer learning: To perform the classification on a new set of images, the pertained network is used as a starting point to learn the task then the final layers are replaced by the new small set of images. Fine-tuning a network with transfer learning is generally a lot quicker and simpler than training a network with randomly initialized weights from scratch. This step performs Transfer learning with the modified pre-trained network and mentioned parameters. Then, it trains the entire network to classify the images, here the images for training requires with the dimension of 227×227, a function is used so all the images get resized to 227×227 for training by using resize function.

D. Classification

This module classifies the input image into either malnutrition or normal. It loads the pre-trained Alexnet model, and then it reads the input image and resizes the image to 227×227 as the pre-trained model requires the image size to be the same as the input size of the network and label the image. According to WHO, children who fall under -2 standard deviation (SD) of the WHO Child Growth Standards median for z-scores of weight-for-age, height-for-age, and weight-for-height indicate that they suffer from malnutrition. With the help of these standards and user input for age, weight, and height, the classifier classifies the children into three categories: 1. malnutrition, 2. risk of malnutrition, and 3. Normal.

V. EXPERIMENTAL RESULTS

The proposed system used 500 images of children under five years, 250 images of malnourished children and 250 images of healthy/normal children. 90% of data is used for training and 10% for testing. The input image for classification and all the images in the dataset resized to the dimensions of 227x227x3 for training and testing process.

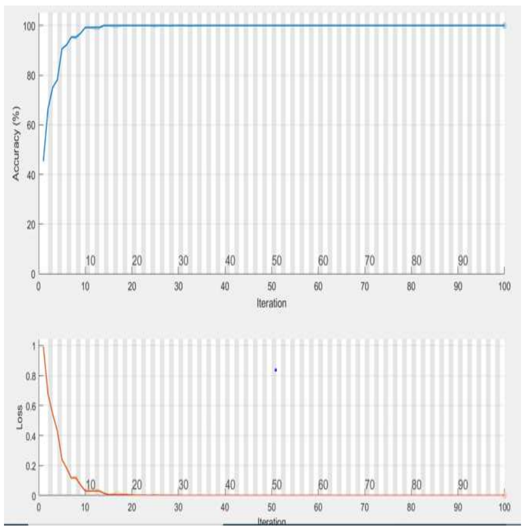

Fig. 5. Training progress of the network

The training progress (Fig 5) involves transferred layers and the new layers of the network.

Accuracy is used to find out the performance. It is equal to number of correct predictions. Accuracy changes for every iteration. The accuracy value at each iteration is plotted in graph. The structure of graph shows the increase in accuracy value which means the model learns about the model and loss is reduced. Lower the loss higher the accuracy of the model. If prediction of model is accurate and predicts as expected the loss is lesser or zero. If the prediction of model is not accurate or not as expected, loss value is higher.

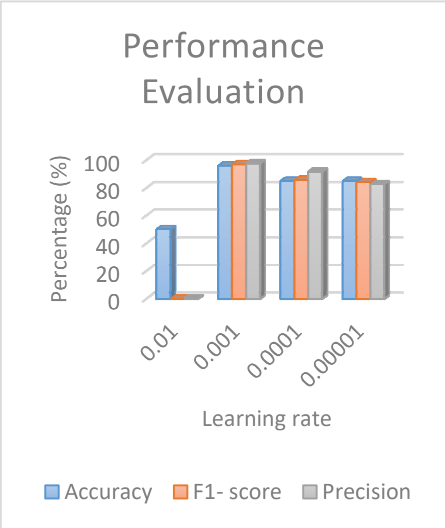

Fig. 6. Performance evaluation for different learning rates

After successful training, we tested the proposed model and it is observed that the model achieved 96% of accuracy for the learning rate of 0.001 as shown in Fig 6. The final results were classified into 3 categories based upon image classification and z-scores of WAZ, WHZ, HAZ: (i) Malnutrition - if the image and z-scores classifications were predicted as malnutrition, the final result shows that the child is malnourished as shown in Fig 7(a), (ii) Risk of nutrition - if either the image or z-scores classification is predicted as malnutrition, the final results shows that the child is at the risk of malnutrition as shown in Fig 7(b), (iii) Normal – if both the image and z-scores classifications were predicted as normal, the final result shows that the child is not malnourished or normal as shown in Fig 7(c).

Fig 7 (a)

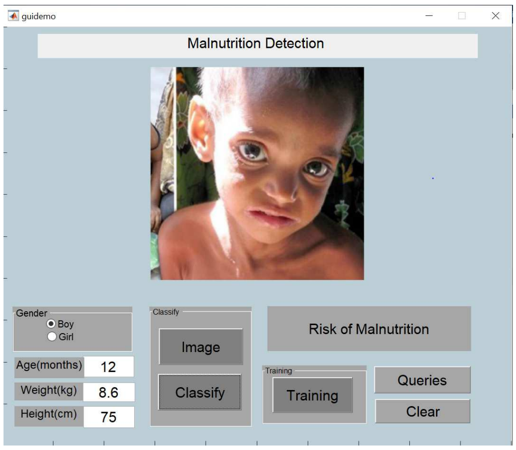

Fig 7 (b)

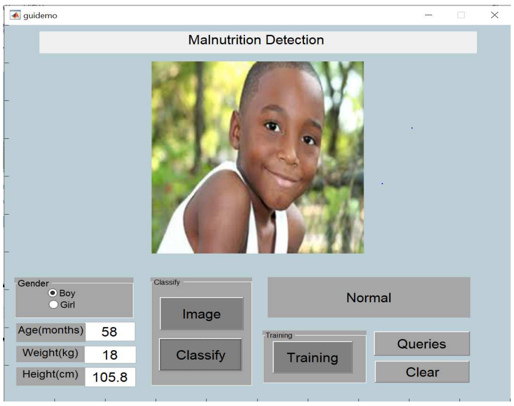

Fig 7 (c)

Fig. 7. The child is detected as (a) malnutrition (b) risk of malnutrition and (c) normal using image and simple inputs

VI. CONCLUSION AND FUTURE WORK

Malnutrition is extravagantly high and has affected many countries in the world by one or more forms. Detecting or predicting malnutrition will help the government or health services to take preventive measures. Conventional Neural Network (CNN or ConvNet) algorithm is used to detect the children affected with malnutrition under age five. Images of children are used as input. Alexnet is a CNN used to find patterns in images to recognize faces and objects and performs classification tasks. By using parametric conditions, Alexnet architecture, and with the help of the extracted features, the system predicts whether children are affected by malnutrition or not. It also categorizes the children who are at the risk of malnutrition. In the next phase of study, we would apply the CNN algorithm to detect the type of malnutrition which affected the children. As the treatment differs for each type, it would be helpful to the parents and healthcare providers.

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