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Non-Invasive Detection of Anemia Using AI Techniques

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***Abstract*— According to the World Health Organization (WHO), anemia, a disorder that poses a risk to one's health because it results from a lack of red blood cells or Haemoglobin in the blood, affects one-fourth of the world's population. Therefore, it is crucial to have an automated, quick, and accurate anemia diagnosis system. A first visual examination of the anterior conjunctiva of the eye by the doctor to rule out anemia is frequently followed by an intrusive blood test. In this study, we developed a system for the noninvasive, automated visual approach of anemia identification. To treat this disease, non-invasive techniques for tracking and recognizing potential anemia risks, as well as smartphone-based devices to carry out this duty, are promising. Since the main goal of our work was not to write a review, we took into consideration certain well-known studies that were conducted on this subject. The most prevalent nutritional deficit, iron deficiency anemia, results in thousands of deaths each year and, regrettably, increases morbidity and mortality in young children and pregnant women. Since 2002, iron deficiency anemia has been regarded as one of the major causes of the world's disease burden. In addition, a sizable population survey revealed that, regardless of gender, about 10% of the elderly were anemic. With an estimated summary proportion of 4% for all other grades, mild anemic cases make up the bulk of cases. Between the ages of 17 and 49, the proportion of male anemic patients is at its lowest and for women it's seen between the age of 50 and 64 years.**

Keywords*— *CNN Algorithm, Non-Invasive Anemia, Signal Conditioning, Conjunctiva Image, IR rays.

I. INTRODUCTION

Anemia also called as **Erythrocytopenia** is decrease in total amount of RBC's/haemoglobin in blood**.** In the current global environment, anaemia is a significant global public health concern. WHO reports that around 1.6 billion people, or 30% of the world's population, suffer from anaemia. This sensitive category for anaemia includes pregnant women, pre-schoolers, and teenagers. The most prevalent form of malnutrition, iron-deficiency anaemia, is classified as the ninth most common sickness among young women in underdeveloped nations. Red blood cells (RBCs) contain iron and protein-containing haemoglobin, which oversees transporting oxygen from the lungs to various body parts and carbon dioxide from various body parts to the lungs. Below lists the usual range of haemoglobin in human blood: Women 12–16 g/dL, Men 14–18 g/dL, New-born 14–20 g/dL. More than 115,000 maternal deaths and 591,000 perinatal deaths worldwide occur each year due to anaemia in Asia and Africa. In India, the National Family Health Survey conducted in 1998–1999 found that 46% of women in urban areas and 54% of women in rural areas experienced anaemia during pregnancy. A peripheral smear, reticulocyte count, total blood cell technique, and serum iron indices can all be used to identify anaemia. The approaches stated above are intrusive techniques. They need a sample of blood to check for anaemia. Another method of identifying anaemia is by looking for symptoms that include paleness in the tongue, palms, and nails, as well as other clinical disorders. The sensitivity of anaemia detection through clinical condition observation ranges from 19 to 70 percent. These technologies merely collect data, store it in a database, and retrieve it in the future, with no extraction of important information that might aid medical practitioners in better managing bovine disease.

The technique of Convolutional Neural Networks is probably the most well-known, simple, and well-understood in AI techniques. In this paper, we propose an approach where we have used CNN and a hardware tool which extracts visual information from the images. This paper is organised as a section. (I) Related Works, (II) Problem Description, (III) Experimental Setup, (IV) Results and Discussion, and (V) Conclusion.

II. RELATED WORKS

Using Artificial Intelligence Techniques and Anemia Detection System many research papers have been published on the disease prediction. Different AI methods are used for prediction and obtaining dissimilar outcomes for different models.

In their report "Detection of Anemia from Image of the Anterior Conjunctiva of Eye by Image Processing and Thresholding," Azwad Tamir, Chowdhury S. Jahan, Mohammad S Saif describe that using MATLAB and a smart phone, this project offered a novel method for identifying anemia. The developing nations received most of the attention since they can use it to get results more quickly and affordably. The goal was to create a non-invasive method of identifying anemia from a photo of the subject's eyes' anterior conjunctival pallor taken with a suitable smartphone with a suitable camera [1]. Another system was created and, in their paper, "Estimate of Anemia with New Non-Invasive Systems A Moment of Reflection" Giovanni Dimauro, Serena DeRuvo, Federica Di Terlizzi, Angelo Ruggieri, Vincenzo Volpe , Lucio Colizzi and Francesco Girardi and here, a new method for identifying anemia was developed using images of the nailbed, fingertip, and anterior conjunctiva. The fingertips and nail bed were also given attention since they may be more accurately identified than the conjunctiva and are also contributing variables [2].

The goal was to create a non-invasive method of identifying anemia by taking a snapshot of the subject's fingernails, nailbed, and anterior conjunctival pallor in their eyes using a smartphone with an appropriate camera.

Sohini Roychowdhury, Donny Sun, Matthew Bihis, Johnny Ren, Paul Hage, Humairat H. Rahman in their work on “Computer Aided Detection of Anemia-like Pallor” they used a new model for detection of anemia using pallor sites of tongue and conjunctiva using screening process. The proposed pallor screening system will detect anemia with good accuracy levels [3].

"A non-invasive approach for estimation of hemoglobin analyzing blood flow in palm," by Bikash Santra, Dipti Prasad Mukherjee, Dipankar Chakrabarti propose a machine vision using the redness of the skin on the palm as a cost-effective, non-invasive, portable way to quantify Haemoglobin. By monitoring and documenting animal diet and behavior on a regular basis, this gadget can detect sickness. Another IoT-based solution has been developed [4]. In their paper " Non-invasive hemoglobin measurement using embedded platform," Caje Pinto, Jivan Parab, Gourish Naik employed Arduino based Embedded System and IoT. Using the Photoplethysmography (PPG) concept, they have developed a finger probe using five LEDs on a multi-chip with wavelengths of 670 nm, 770 nm, 810 nm, 850 nm, and 950 nm, and a single silicon photo detector with an integrated trans-impedance amplifier. Another IoT-based solution has been developed [5]. A New Method and a Non-Invasive Device to Estimate Anemia Based on Digital Images of the Conjunctiva in their work on “A New Method and a Non-Invasive Device to Estimate Anemia Based on Digital Images of the Conjunctiva" proposed a non-invasive method of estimating Haemoglobin based on image analysis of a particular conjunctival area. [6].

Yunendah Nur Fuadah, Sofia Sa’idah, Inung Wijayanto, Raditiana Patmasari, Rita Magdalena in their work on “Non-Invasive Anemia Detection in Pregnant Women Based on Digital Image Processing and K-Nearest Neighbor” suggests a digital image processing-based non-invasive computer-aided diagnosis approach for identifying anemia. Analyzing the conjunctival picture of the eye is the technique. This study divides the conjunctival picture into anemic and non-anemic circumstances using the first-order statistic feature extraction method and K-Nearest Neighbor (K-NN). The RGB, Hue, Saturation, and Value (HSV), and grayscale colour spaces are used in the feature extraction process. Using the most ideal parameters on the green layer of RGB with K = 5 and the Euclidean distance equation, the system had an accuracy of 71.25 percent. [7].

In this article Ahmed Z. Jamal, Biju M. John, “Efficacy of Noninvasive Hemoglobin Measurement by Pulse Co‐oximetry in Neonates,” have addressed test in a tertiary hospital in Southern India, a cross-sectional study was conducted in the postnatal ward and newborn critical care unit. Neonatal patients who were admitted and hemodynamically stable (n = 100) had their SpHb estimated using a Masimo Radical 7 Pulse Cooximeter at the same time as their Hb was taken. The link between SpHb and LabHb was then determined by analyzing the matched data. [8].

III. PROBLEM DESCRIPTION

A disease is a type of ailment that affects the body's ability to operate. The prevalence of anemia is higher in developing nations, because of low socioeconomic status and indigent access to the health care services. Anemia detection if done in invasive way, natives find it unsafe. Non-invasive method of detecting Anemia in patients is the objective of the project.

A. CNN Algorithm

The spatial correlations in the input data are used by Convolutional Neural Networks (CNN) to make use of them. Some input neurons are connected by each concurrent layer of the neural network. The term "local receptive field" refers to this area. On-site neurons are the main focus of the receptive field. Convolutional, ReLU, pooling, and fully connected layers make up CNN's four layers.

CNN Algorithm Steps

i. Get or prepare the dataset needed.

ii. Prepare the dataset for training which involves paths, categories creation and resizing.

iii. This stage entails creating training data, where training is an array containing image pixel values and the index where the image is in a list.

iv. The next step is to assign labels and features; this shape of both lists will be used for classification using neural networks.

v. The subsequent steps involve normalizing X, transforming labels to categorial data, and splitting X and Y for use by CNN.

vi. The last step involves defining, compiling, and training the CNN model.

1) Convolution

As we've mentioned, these networks use convolution that is defined as:

$$g(x,y) = w * f(x,y) = \sum_{s=s_{min}}^{s_{max}} \sum_{t=t_{min}}^{t_{max}} w(s,t) f(x+s, y+t)$$

where f(x, y) is the input image and w are the filter or kernel. More intuitively, we can imagine this process looking at the illustration below:

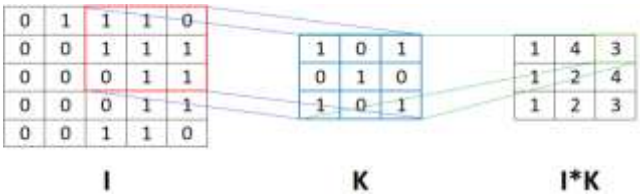

Fig. 1. Convolution matrix

The matrix I to which convolution with the filter K is applied is visible in the image above. The entire matrix I is traversed by the filter K, and element-wise multiplication is then done between the corresponding matrix I elements and the filter K. The outcome of this element-by-element multiplication is then added together to form a single integer.

2) Illustration of CNN Architecture

The ReLU activation function is typically employed after the convolutional layer, which is worth highlighting in closing. The pooling layer, which applies filters in a manner like that of the convolutional layer but simply calculates the maximal or average item rather than convolution, frequently comes next. Below is an illustration of a convolutional layer, ReLU, and maximum pooling:

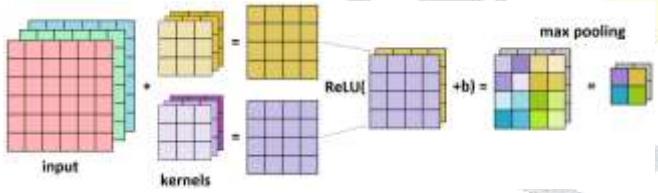

Fig. 2. Simple CNN Architecture

3) Types of layers

i. *Convolution layer (CONV):* The convolution layer (CONV) employs filters that carry out convolution operations as it scans the input II in terms of its dimensions. The filter size FF and stride SS are some of its hyperparameters. The output of OO is referred to as a feature map or activation map.

ii. *Pooling (POOL):* Following a convolution layer, which performs some spatial invariance, the pooling layer (POOL) is a down sampling procedure. In instance, the maximum and average values are taken into consideration in special types of pooling called max and average pooling.

iii. *Fully Connected (FC):* Each input is coupled to every neuron in the fully connected layer (FC), which functions on a flattened input. FC layers can be used to improve goals like class scores and are typically seen toward the end of CNN systems.

IV. Experimental Setup

Figure 3 depicts the software system's overall design. The procedure starts with the acquisition of an image of the patient's eye, followed by preprocessing to identify the Region of Interest and change the RGB image into an HSV and grayscale colour space. First-order statistical measurement is used in the feature extraction procedure. The following step involves applying the Convolutional Neural Network (CNN) approach to categorize anemia and non-anemia disorders.

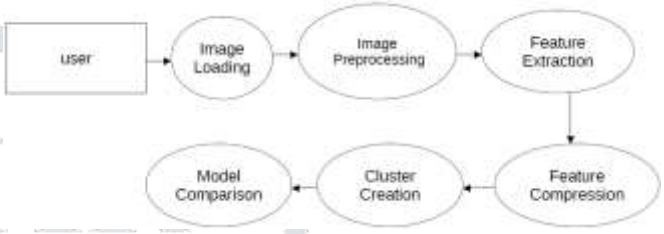

Fig. 3. General Process

A. Python IDE

Python is a general-purpose, interpreted programming language released for the first time in 1991 and created by Guido van Rossum. Python's design philosophy places a strong emphasis on code readability and makes considerable use of whitespace. Its language constructs and object-oriented methodology are designed to aid programmers in creating clean, comprehensible code for both little and big projects.

B. Tensorflow

A free and open-source software library called TensorFlow is used for differentiable programming and dataflow across a variety of activities. It is a symbolic math library that is also utilised by neural network applications in machine learning. Google uses it for both research and production. Stateful dataflow graphs are used to represent TensorFlow calculations. The actions that these neural networks carry out on multidimensional data arrays, known as tensors, are where the name TensorFlow originates. Only five of the 1,500 GitHub repositories that cited TensorFlow, according to Jeff Dean at the Google I/O Conference in June 2016, were from Google.

C. Augmentor

A Python library called Augmentor is intended to help with the augmentation and artificial synthesis of image data for machine learning tasks. Although it is primarily a tool for data augmentation, it will also have some simple image pre-processing features.

D. Data Flow

1) Image Loading/Collection/Aquisition

The process of collecting digital conjunctival photographs of the eye is called image acquisition. Using a smartphone camera with a 13 MP RGB colour space sensor, the conjunctival images for this investigation were taken from 80 pregnant women. The conjunctiva image, the participants' ages, and the intrusive measurement via blood analysis—which served as the condition's "ground truth"—were all acquired. No participant's personal information was included in the data that was collected. The procedure begins with the index finger gently tugging the lower eyelid, followed by focussing the camera on the conjunctiva of the eyelid. Figure 2 (a) depicts an example of a normal condition, while Figure 2 (b) depicts an anaemic situation (b).

Fig. 4. (a) Normal condition (b) Anemic Condition

2) Image Pre-processing

At this point, the conjunctival region of the eye is manually cropped to provide the Region of Interest (ROI). The chosen area is concentrated on the palpebral conjunctiva, as seen in Figure 3. The photos were then downsized to 172 X 172 pixels, and the RGB colour space image was transformed into HSV and Grayscale images. The palpebral conjunctiva's size determines the ROI's dimension. The area of the conjunctiva that lines the interior of the eyelid—both the upper and lower eyelids—is known as the palpebral conjunctiva. The bulbar conjunctiva, in contrast, is the front portion of the sclera (background) (the white part of the eye).

3) Feature Extraction

A procedure to obtain the value or characteristic of the input image is called feature extraction. In this work, the first-order statistics are computed as part of the extraction process. The mean, variance, skewness, kurtosis, and entropy are the first order parameters. The layers R, G, and B of the RGB colour space, H, S, and V of the HSV colour space, and grayscale are where extraction is done. The properties of the image histogram are used to guide the adoption of the first-order feature extraction approach. The histogram displays the likelihood that a given degree of grey pixel values will appear in an image.

4) Feature Compression

Convolutional neural networks (CNNs) have achieved success in a wide range of machine vision tasks, but their millions of weights, which take the shape of thousands of convolutional filters, make them challenging for interpretation by humans or for scientific comprehension. The compression is based on removing the filters that have the lowest Classification Accuracy Reduction (CAR) importance index or those that contribute the least to classification accuracy. So, in this paper we have compressed various images to reduce the size but not compromising on the quality of images taken.

5) Cluster Creation

One type of unsupervised machine learning is clustering, which groups a set of objects—in this case, images—according to some pattern in the data collection itself. Images that land in the same cluster ought to resemble one another more than those that land in different clusters. Similar featured images are clustered so that the algorithm can be applied and output the results.

6) Model Comparison

The model is then optimized by changing the values of number of layers and nodes and the model with better accuracy and validation accuracy is used. Various models, algorithms were referred and compared where the best choice was made i.e., CNN model

TABLE I. Sample Test Cases

Test Case ID	Test Case Name	Test Case Description	Test Steps				Test Status P/F
			Step	I/P Given	Expected O/P	Actual O/P	
TC - 01	Uploading the wrong input	User loads the wrong input to the system	Select the wrong input image and load it for output	Wrong Image	File extension is not supported	File extension is not supported	P
TC - 02	Uploading the correct sample input image	User loads the correct image	Selects the correct image	Anemic image	Detection of anemia or not	Detection of anemia or not	P

TABLE II. Integration Test Cases

Test Case ID	Test Case Name	Test Case Description	Test Steps				Test Status P/F
			Step	I/P Given	Expected O/P	Actual O/P	
TC - 01	Dataset with incorrect data	User loads the dataset with incorrect data inside	Loads the dataset	Dataset	Wrong results	Wrong results	P
TC - 02	Dataset with no data	User loads the dataset with no image	Loads the dataset with no data	Dataset	No results	No results	P

TABLE III. System Test Cases

Test Case ID	Test Case Name	Test Case Description	Test Steps				Test Status P/F
			Step	I/P Given	Expected O/P	Actual O/P	
TC - 01	Feature Extraction from RGB image	Features will be extracted from the image after RGB conversion	Extraction of features from image	RGB image	Features Extractions	Features Extractions	P

Along with software CNN model, for better accuracy and precision, we have proposed a hardware setup which using an embedded system based on Arduino, can estimate the amount of total haemoglobin in human blood.

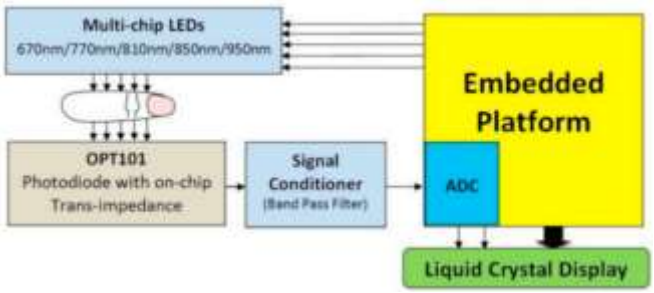

Fig. 5. Haemoglobin meter

The major goal of this article is to construct a finger probe with several LEDs on a single chip and a photo detector, to implement signal conditioning circuit to reduce noise from the PPG signal, and to develop an internal algorithm to compute total haemoglobin with formula-based equations using three wavelength LEDs and five wavelength LEDs. The main goal in this situation is to calculate the total haemoglobin count with an inaccuracy of less than lgm/dL. Fig. 4 depicts the proposed hardware meter's whole design.

The portion comprises of the Finger Probe with Multi-Chip LEDs at wavelengths of 670 nm, 770 nm, 810 nm, 850 nm, and 950 nm; OPT101 with an on-chip photo detector and Trans-impedance amplifier; Signal Conditioning (Band Pass Filter); Liquid Crystal Display (LCD); and the Embedded System. The Arduino Uno was used to control and switch on each of the five LEDs one at a time in the following order: = 670 nm, 770 nm, 810 nm, 850 nm, and 950 nm. When a finger is inserted within the finger probe, the illumination goes through the finger. Light transmission out of the finger varies due to variations in light absorption caused by changes in blood volume in the finger brought on by heartbeat. The OPT101, which transforms the transmitted light into voltage, detects variations in the transmitted signal (PPG signal). The PPG signal has a millivolt order and is accompanied by noise. An active bandpass filter (0.72 Hz to 2.82 Hz) with the proper strength was used to separate the PPG signal from noise because the frequency of the human heart is approximately 1-2 Hz. The Arduino Uno's 10-bit ADC was then used to digitise the boosted PPG signal. The algorithm was carried out once the information was processed by the controller using three and five wavelengths.

V. Results And Discussion

The probabilities of identifying the disease based on the input dataset images are the results. In this study, artificial intelligence (AI) algorithms were used to determine whether anemia was present in photos representing data samples. Python is used to segment photos from a variety of sources, and it is 91 percent accurate. In comparison to the outdated laboratory testing procedure, the CNN model for anemic diagnosis is more affordable and time efficient. Shape-based features discovery provides the highest accuracy, at 97.8%, when compared to other techniques for detecting areas of interest. Given that we employed CNN, we suggest that this method provides greater accuracy.

VI. Conclusion

The goal of this study is to first classify the condition into Anemic or non-Anemic using the CNN algorithm and. The procedure entails utilising an android application that we developed to take a photograph of the conjunctival pallor of the eye using the camera of a smartphone with appropriate controls in adequate lighting. The photograph is then uploaded to a computer using any available method, including the internet. To detect whether the person is anaemic or not, a computer programme first analyses the image to extract the RGB spectrum of the anterior conjunctival pallor and compares it to a predetermined threshold value.

Future research will focus on the analysis of additional data sets obtained under well controlled imaging circumstances. Since the data sets being analysed in this work contain a wide range of imaging condition variabilities, the experimental analysis's findings are more generalizable yet have a restricted ability to classify. Future work will focus on comparing the automated pallor severity grade calculated from facial pallor site photos to the patient's real haemoglobin level for pre-clinical assessments.

VII. References

[1] Detection of Anemia from Image of the Anterior Conjunctiva of the Eye by Image Processing and Thresholding by Azwad Tamir, Chowdhury S. Jahan, Mohammad S Saif, Sums U. Zaman, Mazharul Islam, Asir Intisar Khan, IEEE 2017.

[2] Estimate of Anemia with New Non-Invasive Systems A Moment of Reflection by Giovanni Dimauro, Serena De Ruvo, Federica Di Terlizzi, Angelo Ruggieri, Vincenzo Volpe , Lucio Colizzi and Francesco Girardi, MDPI 2020.

[3] Computer Aided Detection of Anemia-like Pallor by Sohini Roychowdhury, Donny Sun, Matthew Bihis, Johnny Ren, Paul Hage, Humairat H. Rahman, IEEE 2017.

[4] A non-invasive approach for estimation of hemoglobin analyzing blood flow in palm by Bikash Santra, Dipti Prasad Mukherjee, Dipankar Chakrabarti, Electronics and Communication Sciences Unit, Indian Statistical Institute, Kolkata, India 2017.

[5] A New Method and a Non-Invasive Device to Estimate Anemia Bases on Digital Images of the conjunctiva by Giovanni Dimauro Danilo Caivano, Francesco Girardi, IEEE 2018.

[6] Non-Invasive Anemia Detection in Pregnant Women Based on Digital Image Processing and K-Nearest Neighbor by Yunendah Nur Fuadah, Sofia Sa'idah, Inung Wijayanto, Raditiana Patmasari, Rita Magdalena, IEEE 2020.

[7] Non-invasive hemoglobin measurement using embedded platform by Caje Pinto Jivan Parab, Gourish NaikJournal, Elsivier 2020.

[8] Efficacy of Noninvasive Hemoglobin Measurement by Pulse Co-oximetry in Neonates by Ahmed Z. Jamal, Biju M. John, Journal of Clinical Neonatology 2020.

[9] World Health Organization, "Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity," Vitamin and Mineral Nutrition Information System (WHO/NMH/NHD/MNM/11.1), World Health Organization, Geneva, Switzerland, 2011.

[10] World Health Organization, The Global Prevalence of Anaemia in 2011, World Health Organization, Geneva, Switzerland, 2018.

[11] C. Camaschella, "New insights into iron deficiency and iron deficiency anemia," Blood Reviews, vol. 31, no. 4, pp. 225–233, 2017.

[12] L. I. Dini, P. Riono, and N. Sulistiyowati, "Effect of Unintended Pregnancy towards Mothers' Behaviour during Prenatal and Postnatal in Indonesia (An Analysis of IDHS 2012)," Jurnal Kesehatan Reproduksi, vol. VOL 7 NO 2, no. 2, pp. 119–133, 2016. [Online]. Available: https://media.neliti.com/media/publications/108270- ID-pengaruh-status-kehamilan-tidak-diingink.pdf.

[13] A Systematic Mapping Study on Research in Anemia Assessment with Non-Invasive Devices by Giovanni Dimauro, Danilo CaivanoORCID, Pierangelo Di Pilato,Alessandro Dipalma and Mauro Giuseppe Camporeale, MDPI 2020.

[14] Semantic Segmentation of Conjunctiva Region for Non-Invasive Anemia Detection Applications by Sivachandar Kasiviswanathan, Thulasi Bai Vijayan, Lorenzo Simone ORCID and Giovanni Dimauro, ORCID, MDPI 2020.

[15] Accuracy of noninvasive hemoglobin and invasive point-of-care hemoglobin testing compared with a laboratory analyzer by N. Shah,E. A. Osea,G. J. Martinez, ISLH 2014.

[16] Digital Camera-Based Spectrometry for the Development of Point-of-Care Anemia Detection on Ultra-Low Volume Whole Blood Sample by Animesh Halder, Probir Kumar Sarkar, Poulomi Pal, Subhananda Chakrabarti, IEEE 2017.

[17] Graphene-Based Biosensor for Early Detection of Iron Deficiency by Oluwadamilola Oshin ,Dmitry Kireev, ORCID, Hanna Hlukhova Francis Idachaba, Deji Akinwande and Aderemi Atayero RCID, MDPI 2020.