

Analysis of iron deficiency anemia in Pregnant women using Modular neural network (MNN)

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Abstract— In this paper a new classification algorithm is proposed for the Classification of five types of abnormal Red Blood Cells (RBCs) called Poikilocytes in Iron deficient blood smears in pregnant women . In order to develop algorithm 160 five type of abnormal Red Blood Cells images have been considered, With a view to extract features from the images after image processing, an algorithm proposes WHT transformed coefficients. The Efficient classifiers based on Modular Neural network(MNN) Neural Network. A separate Cross-Validation dataset is used for proper evaluation of the proposed classification algorithm with respect to important performance measures, such as MSE and classification accuracy. The Average Classification Accuracy of GFF Neural Network comprising of one hidden layers with 28 PE's organized in a typical topology is found to be superior (94.22 %) for Training and cross-validation. Finally, optimal algorithm has been developed on the basis of the best classifier performance. The algorithm will provide an effective alternative classification method of five types of abnormal Red Blood Cells (RBCs) in Iron deficient blood smears in pregnant women.

Keywords— Neural solution, MatLab, Microsoft excel, all five types of abnormal Red Blood Cells (RBCs)

I. INTRODUCTION

Red blood cells (erythrocytes) are cells, which morphology determines their functional possibilities. Ability of erythrocytes to transport oxygen is defined by interaction of erythrocyte surface square with oxygen rich media and its possibility to deformation while passing thin capillaries. So, the shape of biconcave disk (maximum surface squire under the volume and deformability) corresponds to normal erythrocytes. Investigations, carried out by electron microscopy and digital holographic interference microscopy [11] techniques, have shown that erythrocytes underwent morphological changes not only in hematological diseases but in diseases of different geneses and under influence of outward physical and chemical factors. Erythrocyte morphology investigation is of great interest, because they take part in the processes of homeostasis of the whole organism. So, erythrocytes are the most suitable medical objects for estimation of the whole organism state and its biological response on physical and chemical factors influence.

Iron deficiency is one of the most prevalent nutritional problems in the world and is reported by the World Health Organization (WHO) to affect 4 – 5 billion people .Pregnant women are at high risk for iron deficiency anemia (IDA) due to the increased physiological demands for iron imposed by pregnancy. Anemia remains at epidemic levels among pregnant women . (12). It is a serious obstacle not only to a healthy and productive life of the mother, but also to the proper growth and development of her infant (13). Maternal severe anemia, whether caused by iron-deficiency or not, increases the risk for maternal mortality and morbidity (14) and is associated with a high risk of adverse birth outcomes (12). Given the availability of proven interventions to treat and to prevent anemia, the persistent high prevalence represents a lack of political will and failure of the public health sector to develop effective programs to address this problem. Currently, the Ministry of Health (MOH) has a policy to treat anemic pregnant women with iron supplements. In addition, Female Community Health Volunteers (FCHVs) are to distribute iron and de-worming tablets to all pregnant women. Yet, anemia prevalence in world unacceptably high . This could be due to the presence of other factors that limit the woman's response to iron supplementation. Maternal anemia programs are most effective when they address the multiple causes of anemia through integrated interventions (13). Therefore, knowing the various causes of anemia in pregnant women is the first step in designing tailored intervention strategies. Succeeding in improving maternal anemia would subsequently decrease the burden of adverse pregnancy outcomes.

Iron deficiency is a highly prevalent form of under nutrition, affecting around one-fourth of the world's women and children, and is one of the most common causes of anemia. Iron deficiency is one of the most prevalent nutrient deficiencies in the world, affecting an estimated two billion people. Children and Young children and women are the most commonly and severely affected because of the high iron demands. However, where diets are based mostly on staple foods with little meat intake, or people are exposed to infections that cause blood, iron deficiency may occur throughout the life span. Although much is known about iron metabolism, the health consequences of iron deficiency continue to be a subject of research and debate. This is partly because in many regions of the world iron supplements are the standard of care for individuals with anaemia. Most trials of iron supplementation have measured hemoglobin Concentra- 164 Comparative Quantification of Health Risks as the primary outcome. There is surprisingly little evidence to either support or refute a causal link between iron deficiency and these important adverse health outcomes. As processes like this comparative risk assessment (CRA) bring to light the overall weakness of evidence either supporting or refuting the relationship, new research priorities may emerge.

So Anemia is considered as the most prevalent Hematological disorder and is mainly caused by the lack of Iron in the body. Iron Deficiency Anemia or simply Iron Deficiency Anemia is traditionally determined by Complete Blood Count test (CBC). It would be a sensible and reasonable idea to use image processing techniques for the diagnosis of Iron Deficiency Anemia. In an iron deficient blood smear, the shape and the size of red blood cells change significantly. Shape variation of cells is called **Poikilocytosis** and size variation is known as **Anisocytosis**. Based on the shape of the outer boundary of a cell, six different types of blood cells can be categorized in an iron deficient blood smear including round cells(Discocyte), Dacrocytes, Schistocytes and Elliptocytes, Degmacyte,. Samples of these six blood types are illustrated in Fig.1 Dacrocytes are tear drop like cells and Elliptocytes are similar to ellipses. Round cells have circular outer boundary and include normal blood cells.

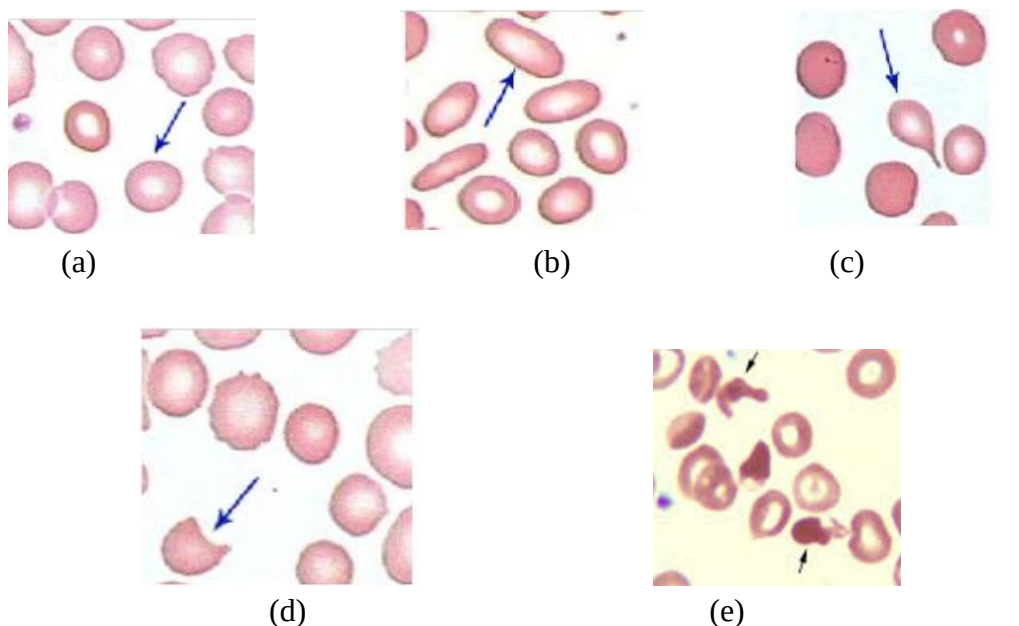


Figure.1(a) Round cell(Discocyte) (b)Elliptocyte (c)Dacrocyte (d) Schistocyte (e)Degmacyte

These Poikilocyte cells (Dacrocytes, Elliptocytes and Schistocytes, Degmacyte, Discocyte) have different shapes which can be used as features for their classification. In this Project work, collecting data and preparing cell images for feature extraction, Dacrocyte cells, Elliptocyte cells, Schistocyte cells Degmacyte cells, Discocyte cells and round cells are classified.

Iron Deficiency Anemia is considered as the most common type of haematological disorder and nutritional deficiency worldwide, it is caused by the deficiency of iron in body leading to reduction in the number of erythrocytes. Iron IS necessary to synthesize erythrocytes, which help to store and carry oxygen via blood. Iron is received in the liver as ferritin and discharges as demand to form new erythrocyte in the bone marrow.

When erythrocyte completes its lifetime in the blood circulation (after 100-120 days), they are reabsorbed by the spleen. Iron is maintained by the balance between absorption and body losses and Image daily to maintain equilibrium. Grievous and protracted iron deficiency anemia may increase the risk of evaluative complicacy that affects heart and lungs as a consequence of which tachycardia (abnormally fast heart beat) or heart failure and dysfunction of iron inclusive cellular enzymes may occur. It can cause reduced impact motor and work capacity in adults and mental development in adolescents and children. There are few evidences that prove iron deficiency anemia causes fatigue in adult women and affects realization in adolescent girls. Deficiency generates in stages. In the first stage, iron necessity increase intake, causing onward depletion of bone marrow iron stores. As depository decrease, absorption of dietary iron increase in quid pro quo. During later stages, deficiency makes worse erythrocyte agglutination, finally causing anemia. Iron Deficiency Anemia is traditionally determined by complete blood cell count test. It would be a sane and proper opinion to use digital image processing techniques for the diagnosis of iron deficiency anemia. In an iron deficient blood smear microscopic images, the shape and size variation of erythrocyte is observed. Shape venations of cells is called Poikilocyte and size variation is called Anisocytosis.

Iron metabolism during pregnancy:

Pregnancy causes important changes in iron metabolism that include cessation of menstruation, expansion of red cell mass, deposition of iron in fetus and placenta and increased intestinal absorption of dietary iron.

Increased erythropoiesis:

Iron requirements during pregnancy depend on iron metabolism that varies with gestation. During the first trimester of pregnancy, iron requirements decrease as a result of cessation of menses. At around week 16 of gestation, maternal blood volume expands so that iron requirements are increased. Although expansion of maternal blood volume peaks at weeks 20 to 25 of gestation, the need for iron increases almost linearly until the end of pregnancy. In the third trimester, fetal erythropoiesis and iron uptake increases. The mechanisms responsible for the increase of erythropoiesis during pregnancy have not been fully elucidated. Erythropoietin (EPO), the hormone that stimulates erythropoiesis, and human placental hormones including lactogen, estrogen and progesterone are elevated and are thought to influence red cell mass expansion (14). Total hemoglobin (Hb) mass expansion during pregnancy is proportionally smaller than the expansion of plasma volume causing dilutional or physiological anemia. This gap between the rate of plasma volume expansion and that of red blood cell mass becomes greater as pregnancy progresses causing a fall in Hb and hematocrit (15).

Increased in iron absorption:

In the first trimester of pregnancy, intestinal iron absorption is lower than that of nonpregnant women because of the decreased iron needs. Absorption of iron increases after the first trimester to meet the needs of the increased erythropoiesis. Non-heme iron absorption at 12 weeks of pregnancy was 0.7% and increased to 4.5% and 13.5% at 24 18 and 36 weeks, respectively, in healthy Swedish women (16). Using stable isotope methods, Barrett et al (17) found much higher absorption rates in non-iron-deficient pregnant women at the same interval of pregnancy relative to absorption rates 16 – 24 weeks after delivery and suggested that iron requirements can be met with diet alone. However, these high absorption rates should be confirmed by other studies before they are generally accepted.

Anemia and iron deficiency

Anemia is characterized by a reduction in Hb concentrations and therefore a decrease in the oxygen-carrying capacity of the blood. It is defined by WHO as Hb < 11.0g/dl for pregnant women. Iron is stored mainly in the liver. Stores are used when insufficient iron is absorbed; this occurs when dietary intake of iron is inadequate or when bioavailability is low. IDA occurs in stages :

- 1) *Depleted iron stores.* During this stage the Hb remains above the anemia cutoff value and serum iron is normal, but the body iron stores are absent. A low serum ferritin (< 12 µg/L), generally, is indicative of depleted iron stores. Caution should be applied when interpreting ferritin in developing countries, where poor health is common, because concentration increases in the presence of inflammation or infections (20).
- 2) *Iron-deficient erythropoiesis.* In this stage, also called iron deficiency without anemia, Hb concentration remains above the anemia cutoff value, but the transport of iron is reduced and iron-deficiency erythropoiesis develops. This stage is characterized by increased free protoporphyrin in red blood cells, low serum iron and an increase in the soluble transferrin receptor concentrations.
- 3) *Iron deficiency anemia.* This is the most severe form of iron deficiency and is characterized by absence of iron stores and decreased transport of iron. Iron supply for Hb synthesis is inadequate and consequently, Hb falls below the established cutoff levels. To diagnose IDA, measurements of iron deficiency, as well as Hb, are needed.

Prevalence of anemia and iron deficiency during pregnancy:

There are more than 2 billion people in the world with anemia – one third of the world's population. Pregnant women and children less than 2 years old are the most vulnerable. Anemia is one of the most frequent complications related to pregnancy. Its prevalence is highest in developing countries; it ranges between 37 – 75% for Asia, 35 – 72% for Africa, and 37 – 52% for Latin America and on average 55% of pregnant women suffer from anemia. In industrialized countries, less than 20% suffer from anemia, a rate that still indicates public health significance (21). This reflects the difficulty of meeting the iron needs of pregnancy even in areas where diets are relatively high in iron. Severe anemia is also common particularly in developing countries. Nonetheless, the risk of developing anemia is 2 to 7 times greater in developing countries than industrialized countries. Anemia prevalence is also usually higher in rural areas than urban areas (21). Anemia in developing countries is not only common but can also be severe. Estimates of Hb level < 7.0 g/dl ranged between 2 – 7% and those of Hb < 8.0 g/dl between 15 – 20% (22). Iron deficiency causes 50% of the anemia worldwide, and is the primary cause of anemia. It is estimated that 80% of women at term who do not consume iron supplements have Hb concentrations lower than 11.0 g/dl (23). In a study conducted in Nepal, iron deficiency was present in 81% of pregnant women defined by erythrocyte protoporphyrin > 70 $\mu\text{mol/mol}$ heme or serum ferritin < 10 $\mu\text{g/L}$ (22). In India, as many as 86% of anemic women were reported to have high sTfR (12). In a recent study in Bangladesh (24), high sTfR was observed in 25% of the pregnant women. Interpretation of iron status indicators measured during pregnancy should be done with caution because they are altered by gestational age and infection (15). This will be discussed in more details in subsequent sections.

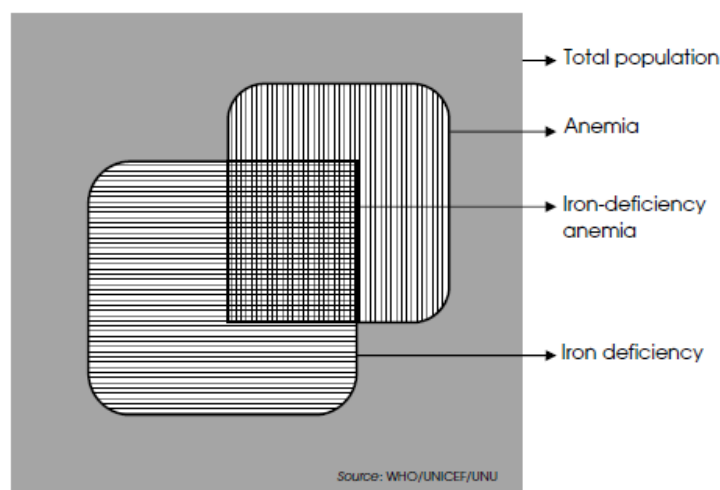


Figure 2 Relationship between iron deficiency, iron-deficiency anemia and anemia in a population. More people are affected by iron deficiency than have iron deficiency anemia. While anemia can be caused by factors other than iron deficiency, most people with anemia in developing countries are also iron deficient.

Anemia is caused by either a low production of red blood cells or by destruction or shortened lifespan of red blood cells. In developed countries iron deficiency is the major cause of anemia during pregnancy as evident by the positive impact of iron supplementation on Hb. In developing countries, many factors, in addition to iron deficiency, could co-occur and contribute the high prevalence of anemia. These factors include other nutritional deficiencies, malaria, hookworm infestation and other infections

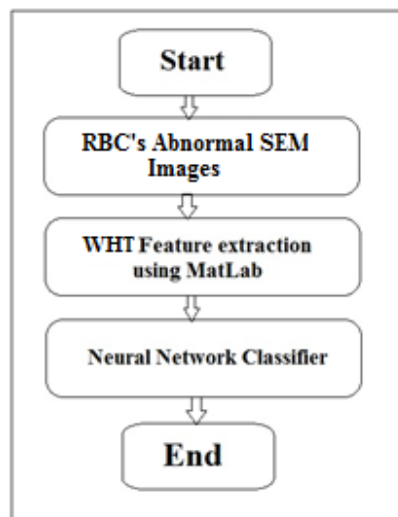
Poor intake and/or bioavailability of dietary iron

Poor intake of iron, especially heme iron from animal sources, is very common in developing countries where the traditional diet could be vegetarian and largely comprised of cereal- and pulse-based foods(26) While non-heme iron consumption from plant foods could be high, bioavailability is likely low and absorption is adversely affected by the presence of inhibitors (phytates and tannins) and enhancers (vitamin C) of iron absorption (27). The availability of enhancers of iron absorption is affected by seasonality in many developing countries, including Nepal, further compromising the bioavailability of iron. The decreased intake and bioavailability of iron coupled with the increased demand for iron during pregnancy places pregnant women at a higher risk for iron deficiency.

Hookworm and other helminth infections

Intestinal helminth infections are common in developing countries with a poor water supply and sanitation. Every year, more than 1000 million persons are infected with *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworm (28,29). Two species of hookworm, *Ancylostoma duodenale* and *Necator americanus*, are endemic in human populations. The mechanism by which hookworm contribute to IDA is chronic blood loss. Hookworms are contracted when the parasite enters the skin, generally through the feet as people walk barefoot on feces-contaminated soils (30). Both the worm load and the fecal egg count are correlated with the amount of blood loss, and therefore, severity of IDA. Infection is especially disastrous to iron status during pregnancy because of the already increased demand for iron. A moderate hookworm infection nearly doubles the iron requirements for a woman. The WHO recommends using anti-helminthic drugs, such as albendazole, during second or third trimester of pregnancy as a component of strategies aimed at improving IDA (31).

II. RESEARCH METHODOLOGY



As per methodology work to study iron deficiency Using Neural Network Approaches.. Data acquisition for the proposed classifier designed for the classification of five different types of blood cells can be categorized in an iron deficient blood smear including round cells(Discocyte), Dacrocytes, Schistocytes and Elliptocytes, Degmacyte. Image data will be Collected from the different- different Pathology labs .The most important un correlated features as well as coefficient from the images will be extracted .In order to extract features, statistical techniques, image processing techniques, transformed domain will be used.

1) Neural Networks

Following Neural Networks are tested:

A. Neural network

Modular Neural Network (MNN):

Modular NN (MNN) Modular Neural Network is in fact a modular feedforward neural network which is a special category of MLP NN. It does not have full interconnectivity between their layers. Therefore, a smaller number of connection weights may be required for the same size MLP network with regard to the same number of processing elements. In view of these facts, the training time is accelerated. There have been many ways in order to segment a MNN into different modules. MNN processes its inputs with the help of numerous parallel connected MLPs and the outputs of these MLP are recombined to produce the results. This neural network is comprised of different sub modules and according to a specific topology; some structure is created within the topology in order to boost specialization of function in each sub-module.

The following topology depicted in Fig.3.4 of the MNN has produced the best classification results.

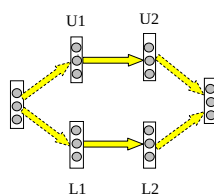


Figure 3Topology of a Modular Neural Network

This topology is recommended on the basis of experimental evidences, testing and performance measures.

B. Learning rule used

Quick propagation (QP):

Quick propagation (QP) is a heuristic modification of the standard back propagation algorithm. Fahlman introduced QP in 1998. QP is not essentially faster than back propagation even though for some application it may prove faster. QP is more susceptible to instability and may stick to local minimum than back propagation. QP changes the network weights after each case. It is a batch update algorithm. It computes the average gradient of the error surface across all the cases before updating the weights at the end of an epoch.

QP works with the assumption that the error surface is locally quadratic, with the axes of hyper-ellipsoid error surface associated with the weights. If this is true, then the minimum of the error surface can be found after only a couple of epochs. Certainly, the assumption is not generally valid, but if it is close to true, the algorithm can converge to the minimum very quickly. On the first epoch, the weights are changed using same rule as the back propagation, based upon the local gradient and the learning rate. On successive epochs, the quadratic assumption is used to obtain the minimum.

The basic QP formula has a number of limitations. If the error surface is not concave, the algorithm can deviate from the desired value. If gradient changes a little or not at all, Then the changes can be extremely large. If the zero error is encountered, a weight will stop changing permanently. On the first epoch, QP updates weights similar to back propagation. Subsequently, weight changes are calculated using the quick propagation equation.

$$\Delta w(t) = \frac{s(t)}{s(t-1)-s(t)} \Delta w(t-1) \quad \dots (1)$$

The system is numerically unstable if $s(t)$ is very close, equal or greater than $s(t-1)$. Since (t) is expressed along the direction of weight gradient, such conditions can only occur if the slope becomes constant, or becomes steeper. In such cases, the weight update formula is

$$\Delta w(t) = \varepsilon \alpha \Delta w(t-1) \quad \dots (2)$$

Where α denotes on acceleration constant

III. RESULT

All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified. The MNN neural network has been simulated for 160 five different types of blood cells images of pregnant female out of which 144 images were used for training purpose and 16 images were used for cross validation.

The Best Neural network with maximum accuracy is shown below:

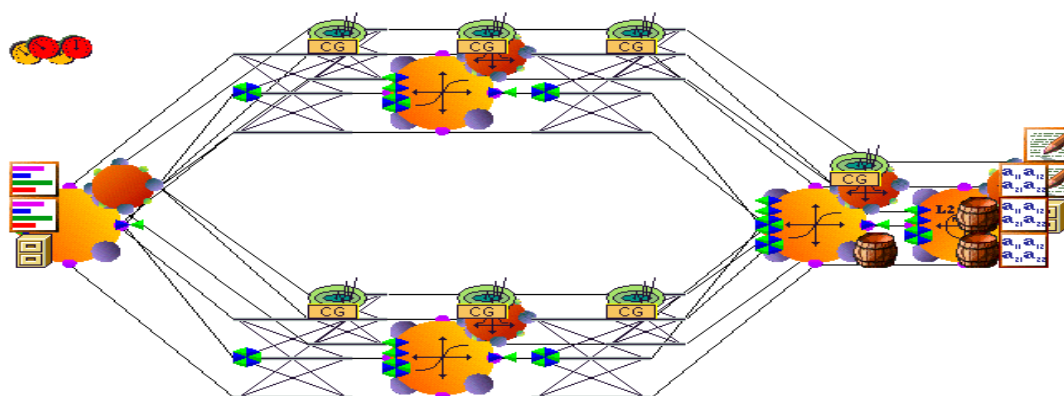


Figure 4. The Best Neural network with maximum accuracy (MNN-CG)

Training Report of the Best Classifier:

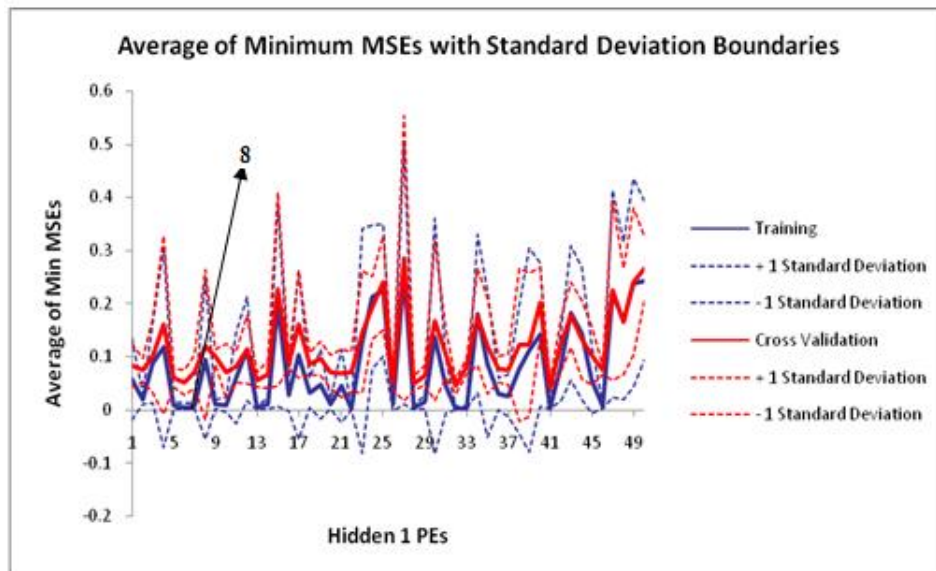


Table 1. Training and cross validation Report of the Best Classifier MNN-CG

<i>Best Networks</i>	<i>Training</i>	<i>Cross Validation</i>
Hidden 1 PEs	32	8
Run #	3	2
Epoch #	789	997
Minimum MSE	0.001096258	0.01420744
Final MSE	0.001096258	0.014631963

Test on Cross validation (CV):

Table 2. Confusion matrix table of Cross validation (CV)

Output / Desired	<i>SCHISTOCYTE</i>	<i>DEGMACYTE</i>	<i>DACROCYTE</i>	<i>ELLIPTOCYTE</i>	<i>DISCOCYTE</i>
<i>SCHISTOCYTE</i>	1	0	0	0	0
<i>DEGMACYTE</i>	0	3	0	0	0
<i>DACROCYTE</i>	1	0	4	0	0
<i>ELLIPTOCYTE</i>	0	0	0	5	0
<i>DISCOCYTE</i>	0	0	0	0	4

Table 3: Performance Measures for cross validation

<i>Performance</i>	<i>SCHISTOCYTE</i>	<i>DEGMACYTE</i>	<i>DACROCYTE</i>	<i>ELLIPTOCYTE</i>	<i>DISCOCYTE</i>
MSE	0.01813191	0.001596218	0.056589033	0.065586921	0.001829062
NMSE	0.183585584	0.011492768	0.327407979	0.326925573	0.010582431
MAE	0.074168926	0.035697473	0.11150378	0.1048382	0.039241025
Min Abs Error	0.00110985	0.002027132	0.007918895	0.000301095	0.00952198
Max Abs Error	0.519956602	0.078083848	0.70564276	1.034550285	0.065671019
r	0.959800218	0.996357527	0.854821605	0.859390234	0.997168013
Percent Correct	50	100	100	100	100

Test on Training:

Table 4: Confusion matrix table of Training

Output / Desired	<i>SCHISTOCYTE</i>	<i>DEGMACYTE</i>	<i>DACROCYTE</i>	<i>ELLIPTOCYTE</i>	<i>DISCOCYTE</i>
<i>SCHISTOCYTE</i>	14	1	0	0	0
<i>DEGMACYTE</i>	0	26	0	0	0
<i>DACROCYTE</i>	0	0	27	0	0
<i>ELLIPTOCYTE</i>	0	0	0	38	0
<i>DISCOCYTE</i>	0	0	0	0	36

Table 5: Performance Measures for training

Performance	<i>SCHISTOCYTE</i>	<i>DEGMACYTE</i>	<i>DACROCYTE</i>	<i>ELLIPTOCYTE</i>	<i>DISCOCYTE</i>
MSE	0.002432524	0.011081671	0.001338093	0.001828186	0.004683109
NMSE	0.027371326	0.071964837	0.008689635	0.00932782	0.024745863
MAE	0.044671399	0.051983302	0.030688984	0.036435559	0.047467923
Min Abs Error	6.33212E-05	0.001246309	0.000256609	9.61995E-05	0.000163608
Max Abs Error	0.133076612	1.053876206	0.091913151	0.085218719	0.286715086
R	0.991403867	0.964647418	0.996004268	0.999047395	0.988653954
Percent Correct	100	96.2962963	100	100	100

IV. CONCLUSIONS

A From the results obtained in WHT domain it concludes that the MNN Neural Network with CG (Conjugate gradient) and hidden layer 1 with processing element 8 gives best results of 99.25% in Training while in Cross Validation it gives 90% so overall accuracy is 94.62%.

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