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Convolution Neural Learning Based Blood Group Identification

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ABSTRACT

Determining of blood types is very important during emergency situation before administering a blood transfusion. Presently, these tests are performed manually by technicians, which can lead to human errors. Determination of the blood types in a short period of time and without human errors is very much essential. A method is developed based on processing of images acquired during the slide test. The image processing techniques such as thresholding and morphological operations are used. The images of the slide test are obtained from the pathological laboratory are processed and the occurrence of agglutination are evaluated. Thus the developed automated method determines the blood type using image processing techniques. The developed method is useful in emergency situation to determine the blood group without human error. Domain of image processing is progressing a lot and has achieved tremendous milestones. Image processing is helping in many ways for the researchers to achieve their goals especially in security and medical fields. Detection of blood group in disaster or remote areas where expert is unavailable is challenge. Successful results have been obtained and accuracy of the proposed system is optimal.

Keywords: ABO Antigens, Blood Group, CNN, Convolution Layer and Molecular Genetics

INTRODUCTION

Determining of blood types is very important during emergency situation before administering a blood transfusion. Presently, these tests are performed manually by technicians, which can lead to human errors. Determination of the blood types in a short period of time and without human errors is very much essential. A method is developed based on processing of images acquired during the slide test. The image processing techniques such as thresholding and morphological operations are used. The images of the slide test are obtained from the pathological laboratory are processed and the occurrence of agglutination are evaluated. Thus the developed automated method determines the blood type using image processing techniques. The developed method is useful in emergency situation to determine the blood group without human error.

Blood is a vital intravascular fluid circulates throughout heart and blood vessels, and classified as connective tissue. Blood is composed of two portions (can be observed after separation by centrifuge), solid portion constitutes (45%), consists of white blood cells, red blood cell and platelets. Fluid portion of plasma constitutes about (55%).

A blood group could be defined as, ‘an inherited character of the red cell surface, detected by a specific alloantibody’. Do blood groups have to be present on red cells? This is the usual meaning, though platelet- and neutrophil-specific antigens might also be called blood groups. Blood group antigens may be:

- Proteins
- Glycoproteins, with the antibody recognizing primarily the polypeptide backbone.
- Glycoproteins, with the antibody recognizing the carbohydrate moiety.
- Glycolipids, with the antibody recognizing the carbohydrate portion.

LITERATURE SURVEY

In routine clinical analysis, there is a wide range of established procedures and practices for blood typing, where nearly all of them deal with the formation of agglutinates. Red cells from the specimen are reacted with reagent antisera (anti-A and anti-B).Agglutination of red cells indicates presence of corresponding antigen (agglutinogen) on the red cells.

ABO Blood Group System Background:
Karl Landsteiner discovered the ABO blood group system in 1900, which incited the beginning of modern blood banking and transfusion medicine. Landsteiner performed a series of experiments demonstrating serological

incompatibilities between individuals. In 1901, using his blood and the blood of his colleagues, he mixed the serum of some individuals with other people's cells. 3 Inadvertently, he was the first person to perform forward and reverse grouping. This series of experiments led him to discover three of the four ABO groups: A, B, and O. Shortly after Landsteiner's initial discovery, his associates, Alfred von Decastello and Adriano Sturli, discovered the fourth blood group, AB. In later studies, Landsteiner correlated the presence of the ABO antigens on red cells and the reciprocal agglutinating antibodies in the serum of the same individual i.e. an antigens on red blood cells, anti-B in the serum). This discovery was labeled Landsteiner's Law or Landsteiner's Rule. This rule is the basis for all transfusion therapy as well as a guideline for determining the compatibility of donor and recipients. ABO grouping is one of the primary tests performed in the blood bank.

Bernstein discovered the group inheritance pattern of multiple alleles at one locus in 1924. This discovery explained the inheritance of ABO blood groups. Additionally, it was established that an individual inherits one ABO gene from each parent. These genes produce the antigens present on the surface of an individual's red cells. Like Landsteiner's discoveries, Bernstein's determination of inheritance patterns of the ABO group has played a major role in the knowledge base for all blood group systems.

In 1930, O. Thompson postulated a four-allele system of inheritance. This proposed system was based on the discovery of Emil Frieherr von Dungern and Ludwig Hirtzfeld in 1911 that the group 'A' antigen can be divided into two subgroups, A1 and A2. Thompson expanded this premise and proposed the four allelic genes: A1, A2, B, and O. His expansion of Landsteiner's original findings enhanced the ability to provide safe blood for transfusion.

Biochemical nature of ABO antigens:
A and B antigens are oligosaccharides. The most abundant structures on red cells carrying ABO activity are the N-linked oligosaccharides of red cell surface 4 glycoproteins, predominantly the red cell anion exchanger (AE1, the Diego blood group antigen, or band 3) and the glucose transporter (GLUT1), although some other glycoproteins are also involved. ABO-active oligosaccharides are also present on glycolipids. Oligosaccharides are chains of monosaccharide sugars: Dglucose (Glc); D- galactose (Gal); D-mannose (Man); N-acetyl-D-glucosamine (GlcNAc); N-acetyl-D- galactosamine (GalNAc); L-fucose (Fuc). An oligosaccharide is A-active when the terminal monosaccharide is GalNAc, in α1→3 linkage to a Gal residue that also has Fuc in α1→2 linkage, whereas an oligosaccharide is B-active when the terminal monosaccharide is Gal, in α1→3 linkage to the α 1,2-fucosylated Gal residue . GalNAc and Gal are the immunodominant sugars of A and B antigens, respectively. Group O red cells lack both GalNAc and Gal from the α1,2-fucosylated Gal residue , so express neither A nor B. The A and B trisaccharides may be attached to several different core oligosaccharide chains, but in red cells the fucosylated Gal residue is usually in α1→4 linkage to GlcNAc .This is called a type 2 core structure. Less abundant core structures, called type 3 and type 4, are only present on glycolipids and may also be involved A and B activity. Type 3 and type 4 structures express A antigen on A1 phenotype red cells, but not on A2 cells, which may account for the qualitative differences between A1 and A2[12][15][17].

Biosynthesis of ABO antigens and ABO molecular genetics:
Oligosaccharides are built up by the stepwise addition of mono saccharides. The addition of each monosaccharide requires a specific transferase, an enzyme that catalyses the transfer of the monosaccharide from its donor substrate, a nucleotide molecule carrying the relevant monosaccharide, to its acceptor substrate, the non reducing end of the growing oligosaccharide chain. A-transferase, the product of the A allele, is a GalN Actransferase, which catalyses the transfer of GalNAc from UDP-GalNAc (donor) to the fucosylated Gal residue (acceptor). B-transferase, 5 the product of the B allele, is a Gal- transferase, which catalyses the transfer of Gal from UDP-Gal to the fucosylated Gal residue of the acceptor .The O allele produces no active enzyme, and so the fucosylated Gal residue remains unsubstituted (and expresses H antigen). The genetic basis for oligosaccharide blood groups is fundamentally different from that of the protein blood groups. Protein antigens are encoded directly by the blood group genes, but the genes governing carbohydrate polymorphism encode the transferase enzymes that catalyse the biosynthesis of the blood group antigens. A and B alleles of the ABO gene.

ABO Antigens:
Agglutination tests are used to detect A and B antigens on red cells. Reagent antibodies frequently produce weaker reactions with red cells from newborns than with red cells from adults. Although A and B antigens can be detected on the red cells of 5- to 6-week-old embryos, A and B antigens are not fully developed at birth, presumably because the branching carbohydrate structures develop gradually. By 2 to 4 years of age, A and B antigen expression is fully developed and remains fairly constant throughout life.

ABO Subgroups:
ABO subgroups are phenotypes that differ in the amount of antigen carried on red cells and, for secretors, soluble antigen present in the saliva. Subgroups of A are more commonly encountered than subgroups of B. The two principal subgroups of A are A1 and A2. Red cells from A1 and A2 persons both react strongly with reagent anti-A in direct

agglutination tests. The serologic distinction between Al and A2 cells can be determined by testing with anti-A1 lectin . There is both a qualitative and quantitative difference between A1 and A2. The A1-transferase is more efficient at converting H substance into A 6 antigen and is capable of making the repetitive Type 3A structures. There are about 10.5 × 105 A antigen sites on adult A1 red cells, and about 2.21 × 105A antigen sites on adult A2 red cells. Approximately 80% of group A or group AB individuals have red cells that are agglutinated by anti-A1 and thus are classified as A1 or A1B. The remaining 20%, whose red cells are strongly agglutinated by anti A but not by anti-A1, are called A2 or A2B. Routine testing with anti-A1 is unnecessary for donors or recipients. Subgroups weaker than A2 occur infrequently and, in general, are characterized by decreasing numbers of A antigen sites on the red cells and a reciprocal increasable in H antigen activity. Subgroups are most often recognized when there is a discrepancy between the red cell (forward) and serum (reverse) grouping.

Generally, classification of weak A subgroups (A3, Ax, Am, Ael) is based on:

1. Degree of red cell agglutination by anti-A and anti-A1.
2. Degree of red cell agglutination by human and some monoclonal anti-A,B.
3. Degree of red cell agglutination by anti-H (Ulex europaeus).
4. Presence or absence of anti-A1 in the serum.
5. Presence of A and H substances in the saliva of secretors.
6. Adsorption/elution studies.
7. Family (pedigree) studies.

The serologic classification of A (and B) subgroups was developed using human polyclonal anti-A, anti-B, and anti-A, B reagents. These reagents have been replaced by murine monoclonal reagents, and the reactivity is dependent upon which clone(s) is selected by the manufacturer. There are, however, some characteristics that should be noted. A3 red cells give a characteristic mixed-field pattern when tested with anti-A from group B or O donors. Ax red cells are characteristically not agglutinated by human anti-A from group B persons but are 7 agglutinated by anti-A, B from group O persons. Ax red cells may react with some monoclonal anti-A reagents, depending on which monoclonal antibody is selected for the reagent. Ael red cells are not agglutinated by anti-A or anti- A, B of any origin, and the presence of A antigen is demonstrable only by adsorption and elution studies. Subgroups of B are even less common than subgroups of A. Molecular studies have confirmed that A and B subgroups are heterogeneous, and the serologic classification does not consistently correlate with genomic analysis; multiple alleles yield the same weakened phenotype, and, in some instances, more than one phenotype has the same allele .

ABO Antibodies:
Antibodies directed against ABO antigens [17][16][21]are the most important antibodies in transfusion medicine. This is a profound, but true statement. For this reason, ABO antibodies require detailed description. The ABO blood group presents a unique situation in Immunohematology. It is the only example of a blood group where each individual produces antibodies to antigens not present on the red cells. These ABO antibodies were originally thought to be natural antibodies formed with no apparent antigenic stimulus. Since the antibodies are not stimulated by exposure to red cells, they may also be considered non-red cell stimulated antibodies. However, some form of an antigenic stimulus must exist. The proposed mechanism is environmental. These “naturally occurring” substances resemble A and B antigens and stimulate the production of complementary antibodies to the antigens that are not present on the red cell surface.

Newborns have no ABO antibodies. When newborns are tested, only a forward group is performed. Newborns may exhibit passive ABO antibodies that have crossed the placental barrier. Reverse grouping of a newborn or umbilical cord serum indicates the blood group of the mother. The child will begin antibody 8 production, and have a detectable titer, at three to six months of age. ABO antibody production peaks at age five to ten years of age and continues in immunocompetent individuals throughout life.

Clinical Significance of ABO Antibodies:
ABO antibodies are capable of causing both Hemolytic Disease of the Fetus and Newborn (HDFN) and Hemolytic Transfusion Reactions (HTR). These issues explain the clinical significance of “naturally occurring” antibodies. HDFN usually presents itself with a maternal antibody of an IgG isotype that corresponds to an antigen on the surface of the baby’s red cells. The most common scenario is a group ‘O’ mother and a group ‘A’ baby. ABO hemolytic disease may affect a woman’s first pregnancy. This is in contrast to Rh HDFN where the antigenic stimulation usually occurs in the first pregnancy and subsequent antigen-positive newborns are affected. Hemolytic transfusion reaction occurs when a recipient is transfused with red cells that are an ABO group incompatible with the antibodies in his or her serum. Because of the complement-binding ability of the ABO antibodies, this is always a life-threatening situation. As the recipient antibodies react with the incompatible red cells, complement is activated and in vivo hemolysis, agglutination, and red blood cell destruction occurs. ABO compatibility is also significant in solid organ transplantation. For most organs, an ideal scenario for transplant is an ABO compatible solid organ[8][9][11]. Post-

transfusion antibody titer, and pheresis to reduce the titer of the incompatible antibody, will assist in achieving a positive outcome when an ABO incompatible organ is transplanted.

Drawbacks of Existing System:

- Manual tests can feature the risk of human error associated with then procedureas well as with the reading and interpretation of results.
- To determine the blood type ABO and Rh, using the techniques available, it is necessary to use some reagents. These reagents are composed by antibodies, specifically anti-A, anti-B, anti-AB, and anti-D, which in contact with patient's blood can either produce or not a reaction.
- Problem that arises in some of the current systems is the human intervention inthe reading and interpretation of the results.

PROPOSED METHODOLOGY

Our project mitigates the drawbacks of the manual procedure of Blood Group Detection. First, the patient's thumb will be placed on the hole, present on the top of the IOT Pi camera. It contains Laser light and camera device is turned on to fire laser light onto the skin surface. When illuminating at certain frequencies, light is absorbed by the haemoglobin in the red cells, and light gets scattered after hitting on the edges of the antigenic determinants having specific structure/shape. The pattern of this light scattering is captured by keeping the optical device ON for certain specified time to capture the after-effects of scattering – Multiple images are taken by the device in a succession to trace/track scattered light. The recorded pattern gives an estimate of the type of antigens in the blood cells – which provide an estimate of the blood type.

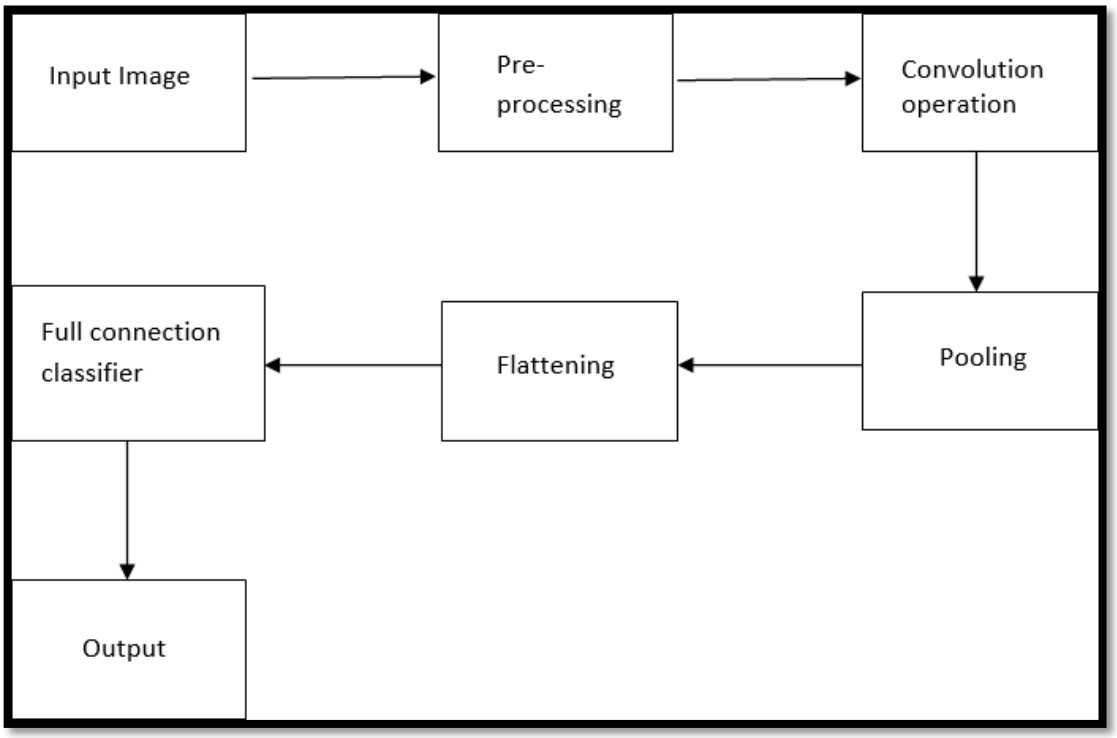

Fig 1 Block diagram of proposed system

Step 1: Input
Input image is taken from the laboratory using pi cam or from kaggle dataset. Input image is an image of blood cell.

Step 2:Pre-processing
In pre-processing unit image which is taken as input is pre-processed by thresholding and morphological operations. First the image is converted into rgb to gray scale and then thresholding is applied which changes image into matrix form which consists of pixel values and then morphological operation formscluster of pixels where it has to process.

Step 3: Convolution Operation
The first building block in our plan of attack is convolution operation. In this step, we will touch on feature detectors,

which basically serve as the neural network's filters. We will also discuss feature maps, learning the parameters of such maps, how patterns are detected, the layers of detection, and how the findings are mapped out. In Fig 2, Fig 3 input image is convolved with feature detector which is also called as filter. Feature map is formed from the convolution operation between input image and feature detector, tis convolution operation takes place by convolving feature detector with 3x3 matrix of input image andthen it moves to the next 3x3 section.

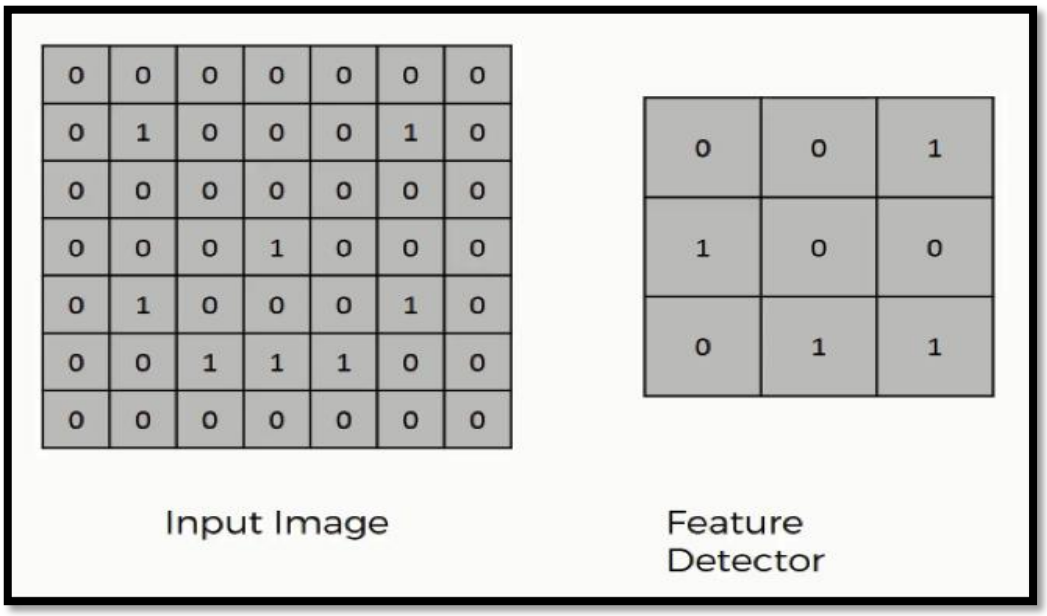

Fig 2 Convolution operation of pre-processed image

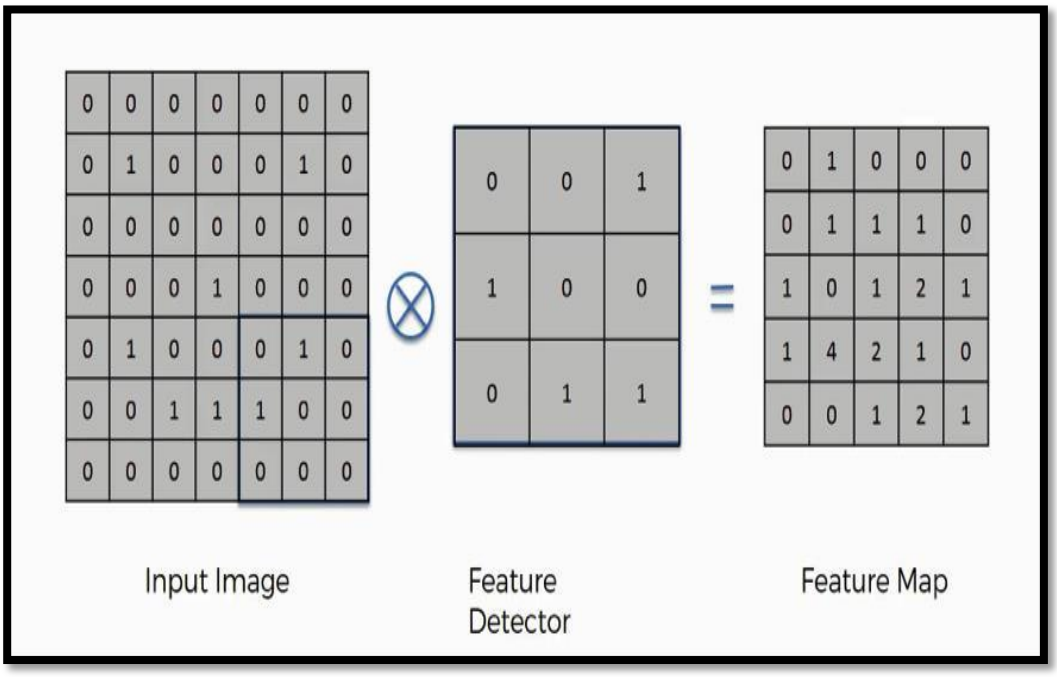

Fig 3 Feature Map

Step 4: Pooling

Formed feature map is then fed to pooling section which undergoes max pooling. In this max pooling we select matrix size of 2x2 and stride as 2 then this 2x2 matrix selec- tion is done in feature map and selects maximum pixel value from the matrix and then it forwards with 2 steps and repeat the process. Fig 4 represents pooling process of input image.

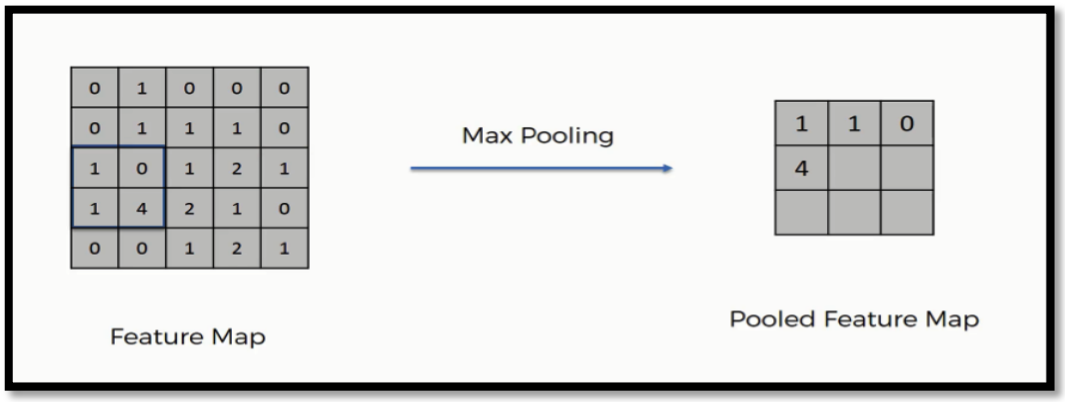

Fig 4 Pooled Featured Map

Step 5: Flattening

This will be a brief breakdown of the flattening process and how we move from pooled to flattened layers; in Fig 5 it sets all the pixel values in one bit order to the classifier section.

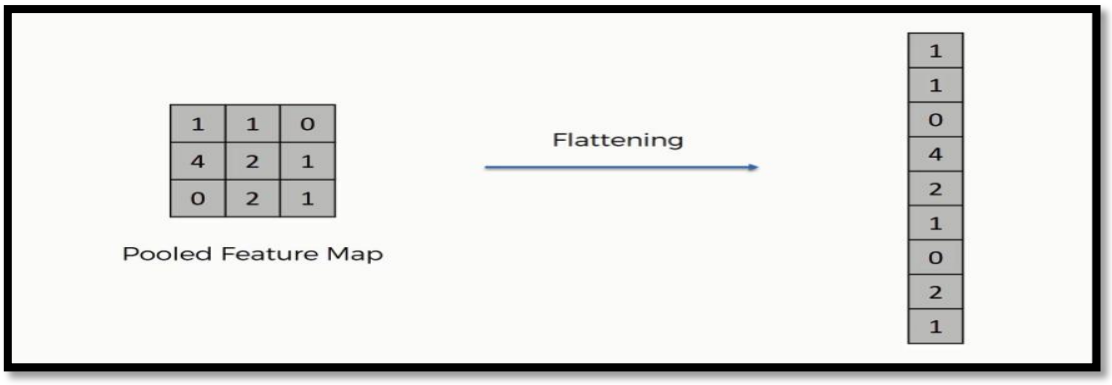

Fig 5 Flattening

Step 6: Full Connection

Each image has different features and model weights are assigned to the given input image and while training the system these values are set by the user by observing different images. According to the model weights during testing processit describes and predicts which blood group it is.

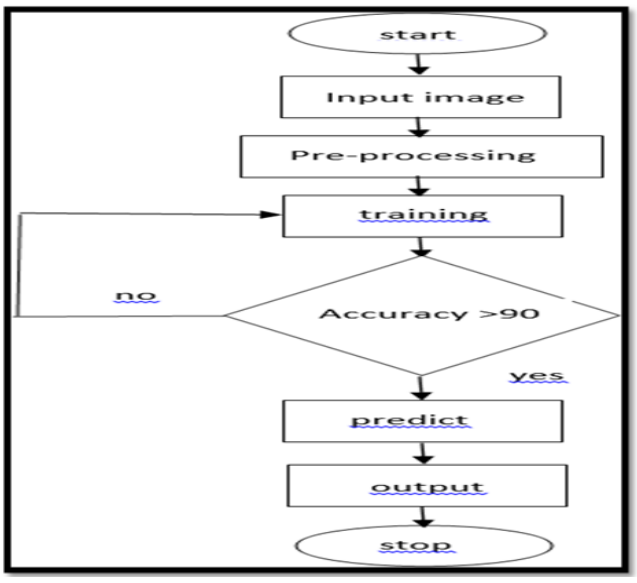

Fig 6 Training of proposed system

Experimental Setup

This proposed technique is implemented in python with PC specification RAM, HDD, CPU speed etc (available in lab) as a developmentsystem. Matplotlib is a Python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms. Matplotlib tries to make easy things easy and hard things possible. You can generateplots, histograms, power spectra, bar charts, error charts, scatter plots, etc., with just a few lines of code. Scikit-learn provide a range of supervised and unsupervised learning algorithms via a consistent interface in Python. It is licensed under a permissive simplified BSD license and is distributed under many Linux distributions, encouraging academic and commercial use. The library is built upon the SciPy. NumPy is the fundamental package for scientific computing in Python[10][13][114]. It is a Python library that provides a multidimensional array object, various derived objects (such as masked arrays and matrices), and an assortment of routines for fast operations on arrays, including mathematical, logical, shape manipulation, sorting, selecting, I/O, discrete Fourier transforms, basic linear algebra, basic statistical operations, randomsimulation etc. Pandas are a Python package providing fast, flexible, and expressive data structuresdesigned to make working with "relational" or "labelled" data both easy and intuitive. It aims to be the fundamental high-level building block for doing practical, real world data analysis in Python. Additionally, it has the broader goal of becoming the most powerful and flexible open source data analysis / manipulation tool available in any language.

RESULTS AND DISCUSSIONS

Gray scale image of input blood cell image

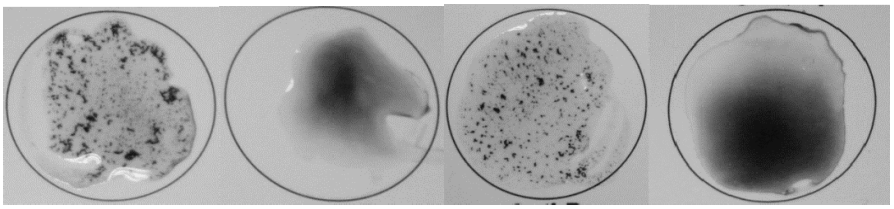

Fig 7 gray scale image

Morphological image of input blood cell

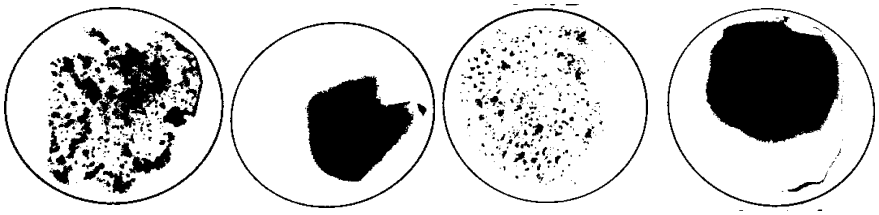

Fig 8 Morphological image

Above images are the gray scale and morphological images Fig 7 and Fig 8respectively of input image

Output image of proposed system

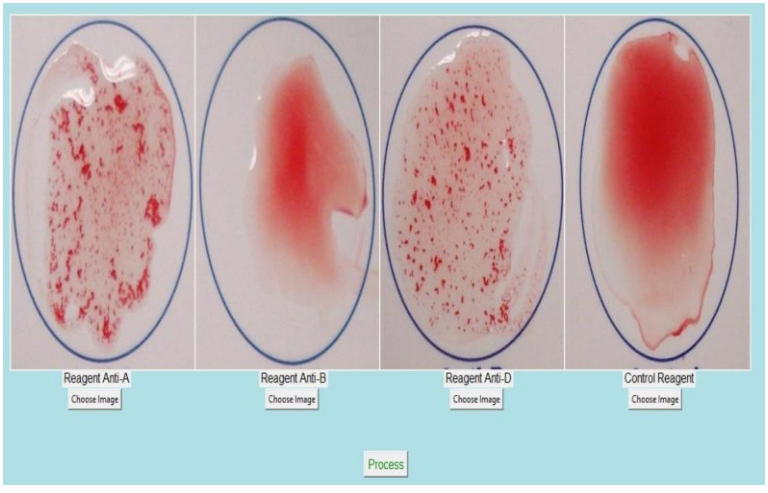

Fig 9 states the reaction of reagents added to the taken blood are observed.
Fig 9 Reaction of Reagents

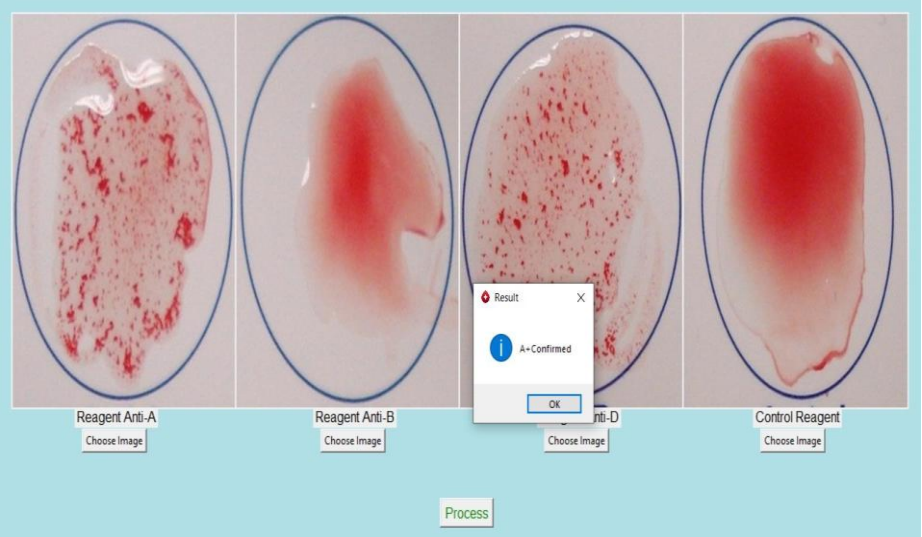

Fig 10 states the output of the blood group detection and it is a A+.

Fig 10 Output Image

CONCLUSION AND FUTURE WORK

This report has discussed the development of a blood group detection system. The objectives of this project were to develop the necessary software using machine learning which will minimize the human error .By giving the images taken by IOT[18][19][20] Pi camera as input using image processing technique and using previous data set our system recognizes the blood group. Using this approach blood group is detected with 83% success rate. Detection of blood group is always more accurate, efficient and fast in digital procedures than manually collecting the blood sample and performing the tests whichtake more time and sometimes it may also lead to human errors.

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