# Development of a Blood Type Analyzer using Computer Vision and Machine Learning Techniques: A Review

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***Abstract*—In emergency cases, when the available time for blood transfusions is limited, blood type O (universal donor) is administered. However, sometimes, this can cause a transfusion reaction that can lead to the death of the patient receiving the transfusion. The equipment available on the market is not adequate for emergency scenarios (not portable and slow results). This paper presents the steps taken into consideration in the development of a blood type analyzer using computer vision and machine learning algorithms suitable for emergency situations (small size, lightweight, easy transportation, ease of use, fast results, high reliability and low cost). Several prototypes have been developed with the final version performing real world scenario experiments in hospitals for validation. With this system, it will be possible to contribute to the reduction of casualties in blood transfusions associated to human error or blood incompatibilities.**

***Keywords-blood types; computer vision; machine learning; prototype.***

## I. INTRODUCTION

Blood transfusions are a daily necessity in hospitals and their success depends on various procedures and their execution without errors. A key procedure is the correct identification of the blood type of the patient requiring the blood transfusion, since an error in this procedure leads to incorrect administration of the required blood unit. This procedure becomes more complicated when it comes to emergency situations due to the lack of time and the need to perform the tests in the laboratory. This scenario occurs because automated systems available on the market are bulky and cannot be transported. Additional time is needed for laboratory trips and manual solutions have the possibility of human error in the procedure, while reading and interpreting the results. In urgent situations, the procedure calls for the use of a blood type considered the universal donor (O negative) for the transfusion to be performed. However, because the universal donor is scarce and can induce transfusion reactions, blood transfusions based on the universal blood donor principle should be reserved for emergency situations only. In this sense, the ideal scenario would be to administer the compatible and corresponding blood even in emergency situations and it is necessary to develop a new solution that enables it [1]-[5].

To make it possible even in emergency situations to perform the tests and identify the patient's blood type, avoiding the use of the universal donor, some prototypes were developed that aim to automate the tests and obtain fast results in a portable way. The different prototypes developed are based on the automation of the procedures of an already validated manual test, the slide test, and the use of a camera that captures the images after performing the procedures to obtain test results. The plate test consists of mixing one drop of four different reagents with the blood, separately. Each of the reagents, Anti-A, Anti-B, Anti-AB and Anti-D will identify the presence or absence of a specific antigen found in red blood cells. The identification of the antigens is done through the occurrence of an agglutination reaction that causes the development of agglomerates in the blood [6][7]. These agglomerates are visible to the naked eye, but in this case, they will be detected automatically using the test image and the use of Computer Vision and Machine Learning algorithms. This will allow to reduce or even eliminate the human errors occurrence in blood type identification, enabling to administrate a compatible blood type since the first blood unit, avoiding causalities.

This paper is organized in 5 sections. Section II, describes the functions used to classify the human blood type. Section III shows some results obtained for 40 tests. Section IV presents several prototypes developed in this project and finally, Section V, presents some remarks obtained in this project and indicates some future work considerations.

## II. BLOOD TYPE DETECTION ALGORITHMS

As described in [8] several algorithms of Computer Vision were used (below sequence of actions 1-5), to identify the occurrence of the agglutination reaction from the analyzed images. An example of an analyzed image is presented in Figure 1.

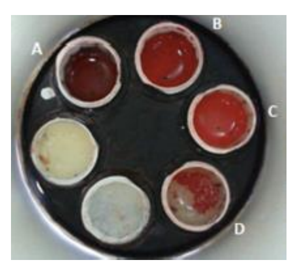


Figure 1. Example of an image of the test of type of blood with an HDD camera (O+ type) [edited from [8])

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However, to make the identification of the reaction even more robust, Support Vector Machines (SVMs) (sequence of action number 6 above), were introduced so that, based on experience and consequent learning, blood type identification could be obtained even in the weakest reactions [8]. The following sequence of actions was considered: 1 - Image Acquisition; 2 - Color Plane Extraction; 3 - Pattern Matching; 4 - Geometric Matching; 5 - Features Extraction; and 6 - Support Vector Machines. The 5th action (features extraction) considers obtaining from the analyzed images the Standard Deviation, the Histogram, Histogram of Gradients (HoG) and Fast Fourier Transform (FFT) results, which are presented in the next section (Table I).

## III. RESULTS

The different characteristics extracted allowed to obtain better or worse effectiveness. The effectiveness of each of them is represented in Table I for 40 tests carried out, corresponding to 124 samples (4 samples per test) [8].

TABLE I. RESULTS OF SVMS WITH THE DIFFERENT FEATURES EXTRACTED FROM THE IMAGE [8]

| Features | Support Vector Machines Results |
|---|---|
| Standard Deviation | 1 |
| Histogram | 1 |
| HoG | 0.7917 |
| FFT | 0.8718 |

## IV. DEVELOPED PROTOTYPES

The development of the different prototypes and plates test (where the reagents were placed with the blood) allowed to improve their capabilities, including speed of test, visualization of the reactions, efficacy of detection and the diminution of its dimensions facilitating the portability of the future product [9] [10], Figure 2.


Figure 2. Prototypes and plate tests. (1): with recycled material [9]. (2) with electronics included [10]. (3) with a screen and small dimensions.

As can be seen in Figure 2, throughout the development of the different prototypes, changes were made, which resulted in a final prototype much closer to the intended final device in which the test plate is sealed and there is only a single blood insertion site. This last prototype carries out tests between 3 to 5 minutes, in an efficient and portable way, and ready to be tested in a hospital setting.

## V. FINAL COMMENTS

This project describes a solution developed for detecting human blood types using computer vision and machine learning algorithms. The success of this solution will allow to reduce human errors, minimize the necessity of using the universal donor in blood transfusions being able to be used in emergency scenarios. Several prototypes have been developed, with the last one currently being subject to real world tests in hospitals for validation.

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