

Android App for Classifying pH Indicator Strips

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Abstract—PH level is a quality parameter used in several areas such as agriculture, chemistry and health. There are different ways to measure pH, including the use of indicator strips, whose chemical properties provide a change in the color of the paper depending on the acidity level of the substance in which it is immersed. This paper presents the construction of a mobile Android application capable of identifying pH on an test strip using image processing.

Keywords—pH, Image Processing, pH Indicator Paper.

I. INTRODUCTION

PH (hydrogenation potential) is a numerical scale defined by Sorensen in 1909 which represents the amount of hydrogen ions contained in a substance [1]. The hydrogen ion concentration $[H^+]$ is directly proportional to the acidity of the substance. There are several ways to measure the pH level. One of the most affordable and inexpensive is by using a pH test strip, whose chemical properties cause a change in the color of its components due to the acidity of the substance in which it was immersed. This type of analysis depends mainly on the visual ability of the observer. However, color interpretation can be compromised as a result of eye fatigue, caused by repetitive activities. Other factors such as age and genetic diseases can also affect the quality of vision and consequently the accuracy in judging information.

In this context, digital image processing can be used as a tool to aid detection, recognition and interpretation of colors, areas and objects. Preprocessing activities, such as the application of filters for noise elimination, can be considered as low level processing methods, while segmentation and interpretation of the objects can be considered as high level processing and high level vision [2].

The advantages provided by image processing become more accessible when combined with the use of mobile devices. Most of these devices are equipped with sensors like camera and GPS, as well as robust processing units, thus allowing the execution of complex tasks and ensuring mobility to users. According to the International Mobile Data Corporation, 82.8% of all mobile devices sold in 2015 use Android as their operating system [3].

This article presents an algorithm capable of identifying the pH level measured with an indicator strip using digital image processing. The software was developed for mobile devices that have Android as their operating system.

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II. APPROACH

This paper aims to improve earlier works that used similar procedures [4]. Major enhancements of this study are the use of Android operating system combined with better hardware configurations devices, along with the OpenCV image processing library. The pH test strips used in this research also differs in size and number of reagents, whose color combination indicates the pH level.

An overview of the image processing steps of this research is shown in Figure 1.

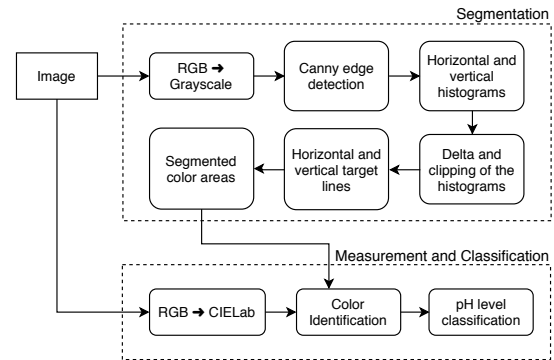


Fig. 1: Block diagram of pH image processing steps.

The mobile app was developed for Android 4.1 and later versions using Android Studio IDE, and installed on smart-phone devices through an APK file generated by the IDE. The image to be processed could be captured by the camera app or picked from gallery.

Pictures with 4160×3120 resolution, as the one shown in Figure 2a, were taken for each sample, where the upper part contains the reference chart (with its information text hidden) and the bottom part has the sample taken with its tip on the left side. Before processing, a proportional scaling to 1024×768 pixels was applied in order to optimize the processing time while preserving the algorithm accuracy.

A. Segmentation

In order to apply the Canny edge detection filter [5], the image was first converted to grayscale. Then, a technique for obtaining the horizontal and vertical histograms [4] was applied to the edge detection output image. The result of the histograms of Figure 2a is shown in Figure 2b, where the horizontal histogram is displayed in blue and the vertical histograms are displayed in red.

After that, a delta operation was used in both histograms along with a clipping filter, i.e. if the difference between the

frequency values of position $i + 1$ and i (delta) was less than a level $l = 10$, the frequency value of position i was set to zero. Then, the highest frequency values of each group were selected. Consequently, the blue and red lines in the Figure 2c were obtained from the horizontal and vertical histograms respectively. Finally, the combination of the horizontal and vertical lines were used to identify the colored areas of the image, as shown in Figure 2d, which was subsequently used as a mask for color determination.

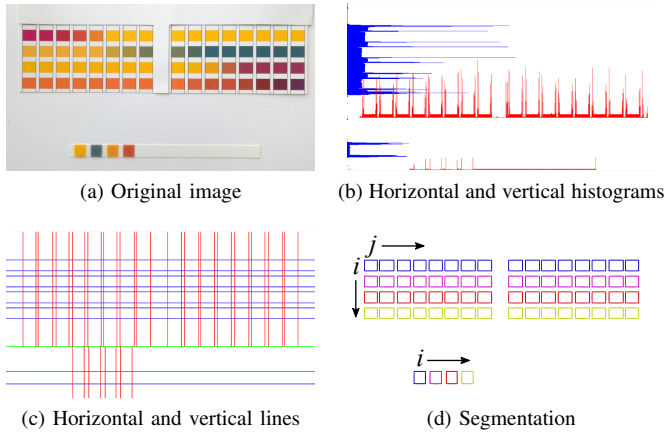


Fig. 2: Segmentation steps of image.

B. pH identification

The first step for color identification was the conversion to the CIE $L^*a^*b^*$ (CIELAB) color space. For each square a preliminary mean vector $\bar{\mathbf{m}} = [\bar{L} \ \bar{a} \ \bar{b}]$ was calculated from its pixels $\mathbf{p} = [L \ a \ b]$. Then, a definitive mean was made only with pixels whose Euclidean distance (1) relative to the preliminary mean did not exceed an established threshold.

$$d(\mathbf{p}, \bar{\mathbf{m}}) = \sqrt{(L - \bar{L})^2 + (a - \bar{a})^2 + (b - \bar{b})^2} \quad (1)$$

In order to determine the pH value of the sample, the sum of the distances between the mean vector of each area is adopted. Equation 2 shows that for each column j of the reference card (Figure 2d), the sum of the module of the difference between the means of the squares i of the strip \bar{S} and their counterparts on the reference \bar{R} is made.

$$D(j) = \sum_{i=1}^4 |\bar{S}_i - \bar{R}_{i,j}| \quad (2)$$

Thus, the pH level corresponds to the column j whose distance D is the lowest.

III. RESULTS

The samples were immersed in different concentrations of pH solutions provided by sulfuric acid and sodium hydroxide combination. Samples with pH levels 4 and 7 were obtained using buffer solutions. Measurements using the pH meter MS Tecnopon® mPA-210P were done simultaneously. Problems with lack of pH values occurred due to the difficulty of stabilizing the pH levels of the solutions.

Sample	Visual	pH meter	App
01	7	7.75	7
02	9 – 10	10.26	9
03	9 – 10	10.40	10
04	7 – 8	8.05	7
05	8 – 9	9.05	8
06	9 – 10	9.05	9
07	3 – 4	2.88	5
08	4	4.00	4
09	7	7.00	7
10	1 – 2	1.57	2

TABLE I: Comparative of pH values using different measurements methods.

PH levels obtained using visual matching of pH strip and its reference chart, pH meter measurements and Android app results are shown in Table I.

It was not possible to determine the exact value of samples 02–07 and 10 using the visual method, due to the fact that the reference chart shows little difference between some neighbor pH levels. Besides that, most measurements made with the pH meter resulted in non-integer values because it was not possible to stabilize the pH in whole numbers.

In general, the software have a good reliability rate, according to the results in Table I. Nine out of ten samples matched the visual interpretation of the strips. The sample 07 was the only measure that assumed an incompatible value of pH when compared with methods A and B maybe due to lighting issues.

IV. CONCLUSIONS

The software developed during the research showed in this paper presented satisfactory efficiency and accuracy in 90% of cases. Under those circumstances, this technology seemed to be promising, being especially useful for people with some vision impairment, suffering from eye fatigue and elderly people. In the future, it is expected to implement this technology for the analysis of other pH test strip models.

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