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Mobile application for fast and accurate pH prediction

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Abstract
Abstract— Purity of common liquids, such as drinks are important for public safety and reliability. Measurement of the pH of a liquid helps in identifying its purity. Precise measurement of pH requires use of instruments, such as electrode based pH meters, or colorimetry based devices. Without such devices, people need to fall back to visual estimation of pH with the help of pH strips, which are generally available, but suffer from subjectivity and visual ability of the individual. Hence, to facilitate easy pH measurement we have developed a colorimetry based app that can execute on Android smartphones. Based on photo captures from several mobile phones, a mathematical model is prepared, relating captured colour and pH of test sample. To reduce the effect of ambient light, the colorimetric observation is made in reference to an unaffected region of the ph strip. The overall model is ported into an Android app, thus allowing instant pH measurement. This app would find use in laboratories for educational and research purposes as well as for consumers to estimate water quality and adulteration in beverages.

Keywords: android app, colorimetry, measurement

Introduction

The advent of information technology has indeed revolutionized our daily lives. We affect and in turn get affected by the barrage of modern devices loaded with sensors which till some days back people used to think as a luxury. These have helped everybody in two ways first, information democratization and second a relatively easier life. When we talk of modern devices, the name of mobile comes to the fore. Mobiles have become ubiquitous. The global sales of mobile-cellular subscriptions have grown 70% over the last five years, reaching 6.8 billion as of 2013 [1]. The ever burgeoning population and its concomitant hunger for consumption have driven its demand, which has been made possible by the advancement in electronic manufacturing effectively making them cheap. As mobiles are portable, there has also been an associated boom in innovative software which has been very useful. At first, the software applications revolved around entertainment purposes only but lately we have seen a plethora of applications which are both scientific and daily work related. For example, the heart rate monitor, the BMI calculator, calorie intake assistants, colony counters, pairwise Protein aligner, DNA&Prot Gel Analyzer etc the list is fast growing [2, 3].

The mobile devices with camera besides being for entertainment purposes can be an effective tool in analyzing and recording data. It has earlier been used for developing useful applications like colony counters [4, 5]. The high computing power of the present day mobiles can also be useful for developing compute intensive applications.

Purity of common liquids such as drinks is important for public safety and reliability. Measurement of pH of a liquid helps in identifying its purity. Electrode based pH meters or colorimetric devices are needed to get precise measurement of pH scale. Visual estimation of pH with the help of generally available pH strips can suffer from subjectivity and visual ability of the individuals. Thus, to facilitate easy pH measurement, a colorimetry based application is developed in mobile version [6, 8]. Based on the captured image from several mobile phones, a mathematical model is prepared, relating captured color and pH of test sample [9]. To reduce the effect of ambient light, the colorimetric observation is made in reference to an unaffected region of the pH strip. This application can help in getting instant pH measurement.

Methodology

Data Capture

The application has a camera viewfinder that shows output from the rear camera to the user. Overlaid on this viewfinder are markers that help the user to place the ph strip in the required fashion. Figure 1 shows the application interface. There are two markers on the finder. One of them captures visual of the unaffected pH strip, the other one captures the part that has been

treated. During data capture, which is triggered by a touch action, the current viewfinder image is captured. Next, image regions underlying both of these markers are sampled separately, and averaged. The average RGB intensity of the untreated region forms the reference and of the treated region forms the observation. The reference is subtracted from the observation to form the final observation.
To form the prediction model, 90 sample pH solutions was prepared in the range of pH from 1 to 14, at gap of 0.3 pH. 3 samples were prepared for each pH. Each of this pH solution was treated in a standard (brand) strip. Data was captured from these pH strips in 5 to 10 seconds of treatment time. Multiple models of the Motorola brand (Moto E, Moto E 2nd Gen and Moto X) were used for data capture.

Prediction Model
The observed RGB intensities are used for identification of pH of the sample. Figure 2 shows the red and blue and figure **Error! Reference source not found.** shows the green channel intensities with respect to the pH. It is observed that the blue channel does not provide further useful information for prediction. Hence, the blue channel is neglected further.
Figure 1shows the clusters of acidic and basic pH intensities in RG channels. Perceptron [10] was used to classify the two groups. It is a simple supervised algorithm that divides two groups of data by a straight line. Equation (1) is the equation of the decision boundary:

$$1.8105*g - 1.3879*r = 1 \quad (1)$$

Here, g and r represents the green and red channel intensities respectively.

For each cluster, linear regression model is constructed to relate the green channel intensity with pH. These models are created with the training data, which is 70% of the entire dataset. The obtained models for acidic and basic samples are as shown in (2) and (3) respectively:

$$pH = 9.0714*g - 116.5208 \quad (2)$$
$$pH = -10.5086*g + 42.7343 \quad (3)$$

Results
A test dataset is constructed from 30% of the full dataset, which was not used for line fitting. The acidic and basic samples equally comprised this test dataset. Average errors of 0.958 and 0.977 in pH for acidic and basic samples were obtained respectively.
The prediction method proved fast enough to perform pH predictions within 10ms, including the time required for image capture. Hence, to reduce errors due to non-uniform exposure of the strip to the test solution, the app is programmed to continuously perform pH prediction. This continuous mode is kept on as long as the user touches the app screen. An updated average pH value is shown to the user at the top left, and an instantaneous prediction is shown on the sidebar as shown in figure 1.

Conclusion
Fast processors and availability of camera have enabled smartphones for colorimetric applications. Further, applications such as pH measurement are beneficial to the general public during daily usage to detect food adulteration, mil adultration,etc. Apart from the food industry the same application stands good for the soil sample also, hence few modification and proper calibration may enable it to use for the measurement of soil pH.Hence, applications such as that presented in this paper should be developed and made available to the public.

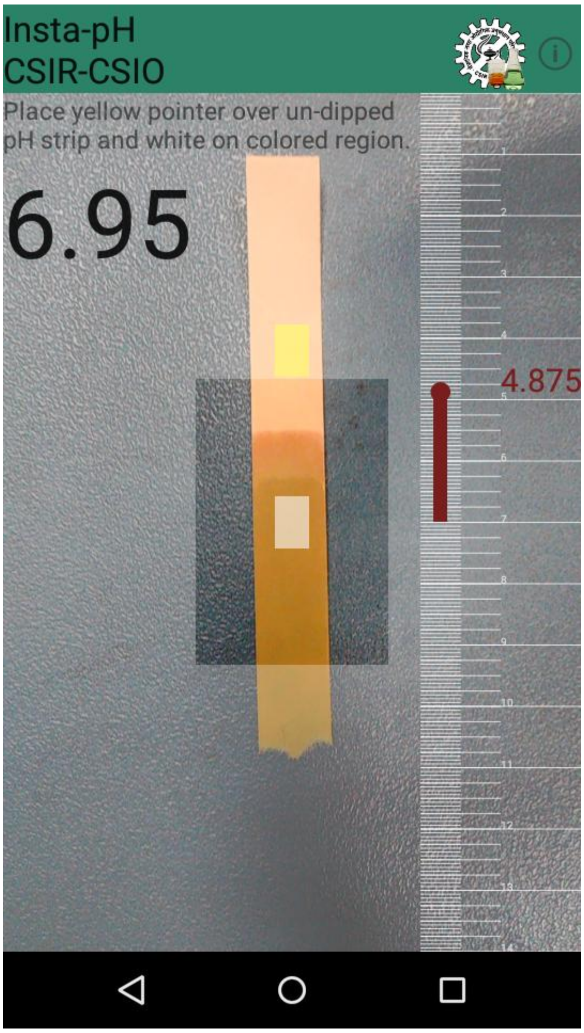

Fig 1: Interface for taking observation and forming prediction with the smartphone.

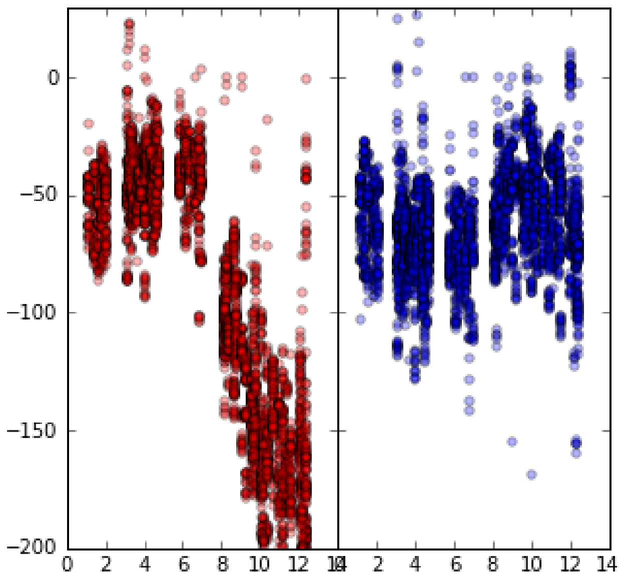

Fig 2: Red (left) and blue channel intensity variation with pH.

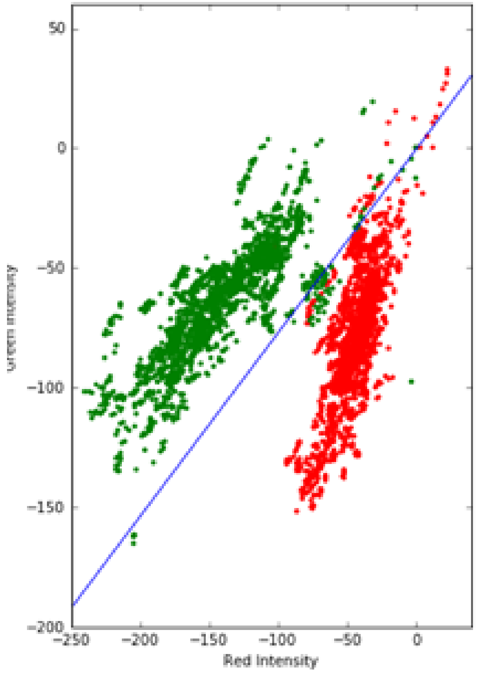

Fig 3: Scatter plot of red and green channel intensities. The acidic and basic regions form two seperate clusters, with some overlap.

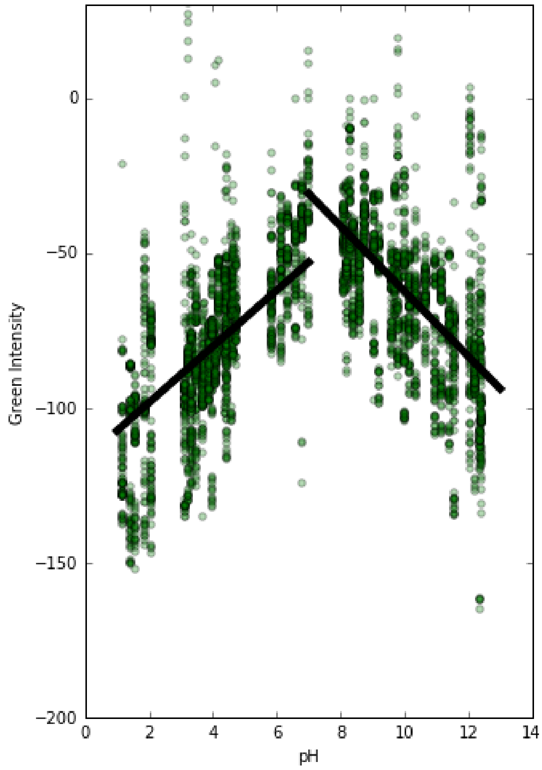

Fig 4: Variation in green channel intensity with pH. Linear models relating the two are shown.

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