A Novel Method to Improve Measurement Results of Flame Photometry Using Image Change Detection

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Abstract

The estimation of alkali metals in clinical chemistry has many parameters which can influence the result. A novel method to improve the measurement parameters of the Flame Photometer is presented. The improvement of accuracy and reliability is achieved through image processing Change Detection technique using Wiener Filter. The proposed method can be used in low cost Medical Equipment with improved measurement parameters performance.

Keywords: Flame Photometer, Image Processing, Change Detection, Wiener Filter, Medical Equipment.

1. INTRODUCTION

The measurement of the alkali metals (like Na, K) in blood samples is one of the important factors for the critically ill patient related to kidney function in Intensive Care Unit. The two major techniques used for these measurements are Flame Photometry and Atomic Absorption. Though the Flame Photometry method is comparatively economic, it suffers from lot of measurement errors. On the other hand, the Atomic Absorption method produces reliable results at significant higher cost. This work aims to provide a novel method which can improve the measurement values of the Flame Photometer with cost advantage. Though this paper focuses on medical application, it can be used in various other fields of science and technology such as environmental protection and electric energy production.

2. MEASUREMENT

Generally there are two methods exist in estimating the alkali metals using Flame Photometry:

i)   Optical sensor method and
ii)   Digital Camera method

2.1   Optical Sensor Method

Principles of flame photometer operations are based on the measurement of the radiating power of light emitted by atoms of known chemical elements, which are excited in a flame. The measurement of radiating power in the photometer goes through two optical sensors with interference filters, which have a maximum transmission for wavelengths of 589 nm for sodium and 768 nm for potassium. Burner is supplied with a mixture of air sample and propane-butane gas. This mixture is prepared in two-chamber nebulizer. Constant pressure, hot air sucks and atomizes the aqueous sample into the first chamber on a principle jet pump (ejector effect). So obtained aerosol is mixed with gas. [1]
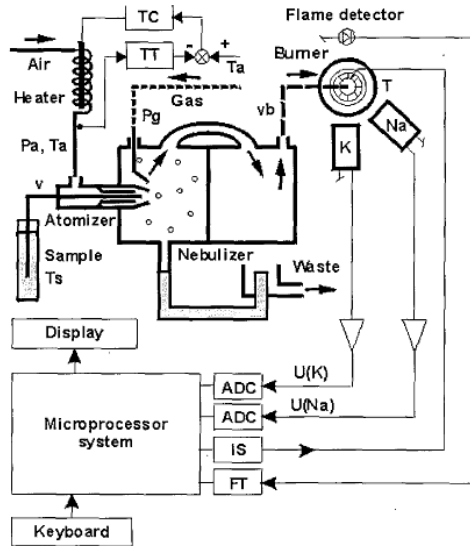
Figure1: Flame Photometer Block Diagram [3]

Next it flows intrinsically into the second chamber for additional mixing, continuing burning in the burner. Block diagram of apparatus is presented in **Figure1:** Flame Photometer Block Diagram [3]

2.2 Digital Camera method
Digital cameras have gained significant popularity in recent years. When sample is burnt in flame, colour of flame changes with respect to the concentration. So if images of the source are captured and post processing is carried out, it is possible to predict the amount of electrolytes in a flame by correlating it with colour values [3]. Anagha Panditrao et al have proposed a low cost non-contact temperature measurement technique using consumer grade digital still camera. The images of various visible heat sources are captured. Using colour image segmentation, source zones are identified. The colour temperature correlation is established by applying various analytical techniques [2].
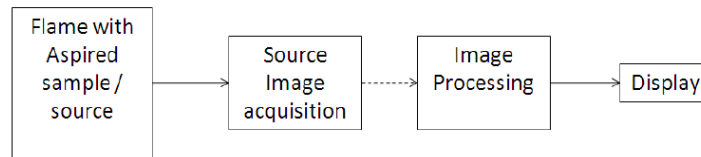
Figure2: Direct Reading Flame Photometer [3]

The basic block schematic of the proposed technique is shown in **Figure2:** Direct Reading Flame Photometer [3]

3. EARLIER WORKS
There are two important papers on Flame Photometry [1] and [3].

W. Holiczer et al introduced an error model of the system and chosen two erroneous situations: sucking of air bubbles and partial or full clogging liquid sucking pipe. However, it presented the event of perturbation "air bubble" (U_{pow}) which is more general than "clogging" and proposes an adaptive filter AMGM [1]. The estimator structure consists of the basic Kalman filter matched to the undisturbed model and bank of M filters with models adequate to the expected specific changes in successive time moments. The practical results of AMGM are compared against

various different methods like Direct Measurement (DM), Transversal Filter (TF100) and Kalman Filter (KF) [1]. It summarizes the AMGM improves metrological features of measurement signal in stationary states of measurement system and it is immune to anomal disturbances.

Anagha Panditrao et al proposed new technique to use digital camera and image processing and establish correlation between colour and concentration [3]. This technique improves the accuracy by the construction/process wherein there is no moving parts and minimal human interface with the total digital process. This technique has cost advantage too and has flexibility of continuous monitoring. Though this paper has image processing algorithm like Segmentation but it is used primarily for co-relation of the colour and concentration and doesn't address the improvement of the measurements results using image processing techniques.

In this paper, we propose a new method to improve the measurement results of [3]. In this novel method, the event of perturbation "air bubble" case is considered as disturbance and image processing technique to identify the same being evaluated.

4. PROPOSED METHOD

Detecting regions of change in images of the same scene taken at different times is of widespread interest due to a large number of applications in diverse disciplines [4]. Important applications of change detection include video surveillance, remote sensing medical diagnosis and treatment, civil infrastructure, underwater sensing and driver assistance systems.

The proposed method is to detect the change in frame caused due to bubble disturbance in sample flow path is shown in **Figure3:** Proposed Method to Improve Measurement Parameters. We have a set of images of the same scene taken at several different times. The method is to identify the set of pixels that are "significantly different" between the last image of the sequence and the previous images; these pixels comprise the change mask. For this paper case, it is changes in brightness or color.
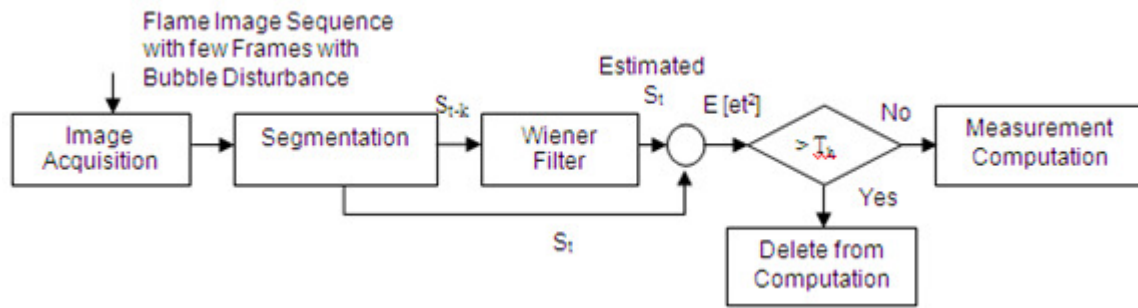
Figure3: Proposed Method to Improve Measurement Parameters

To make the change detection problem more precise, let $\{I_1, I_2, \ldots, I_M\}$ be an image sequence. The acquired image is segmented based on the expected range of intensity values. The intensity of the pixels are computed on the segmented image frames.

The intensity of each pixels are calculated as per ITU-R BT.601 Standard

$Y' = 0.299r + 0.587 g + 0.114 b$

Where r, g, b are each pixel S_{rgb} co-ordinates values [5]. The average intensity of the each frame is then computed. The change detection is done using one step wiener prediction filter on the averaged intensity values of each frame.

This frame-level algorithm makes probabilistic predictions about what average frame intensity values are expected in the next live image using a one-step Wiener prediction filter. The Wiener filter is a linear predictor based on a recent history of values. Any frame intensity that deviates significantly from its predicted value is declared bubble frame. For a given frame, the linear prediction of its next value in time is

$$St = -\sum_{k=1}^{p} ak \quad St - k$$

where St is the predicted average intensity value of the image frame at frame t, the S_{t-k} is a past frame value, and the a_k are the prediction coefficients. The filter uses p past frame values to make its prediction. The expected squared prediction error,

$$E[et^2] = E[St^2] + \sum_{k=1}^{p} ak \quad E[St\ St - k]$$

The a_k are computed from the sample covariance values of the Sn. In this implementation, we used the past 60 values of Sn to compute p=30 prediction coefficients. The average intensity of the frame is calculated. If the actual value of the frame average intensity value differs by more than 4.0*$\sqrt{E[et^2]}$ (Threshold T_h) from its predicted value [6], the frame is considered to be bubble error frame. The measurement is computed using only the frames which are not tagged as bubble error frames. The threshold will be chosen based on the allowable performance limits of the system.

5. PROCESSING OF REAL MEASUREMENT DATA
The experiment was conducted on 100/3 m Eq./l Sodium/Potassium solution and the video was captured using webcam at 15 frames/per second at resolution of 160 x 120pixels. The visibly different flames during no samples, with sample and Bubble disturbances are given in **Figure4:** Captured Flame Details. The captured video file (.avi format, approximately 400 frames) is passed through wiener filter algorithm after segmentation.

No Sample Flame   Sample Flame   Bubble Disturbance Flame

Figure4: Captured Flame Details

The algorithm separates the bubble frame and normal frame using change detection technique. If the difference between the actual values and wiener predicted values are more than threshold, either we can skip the frames from computation or use the last best values of the frames.
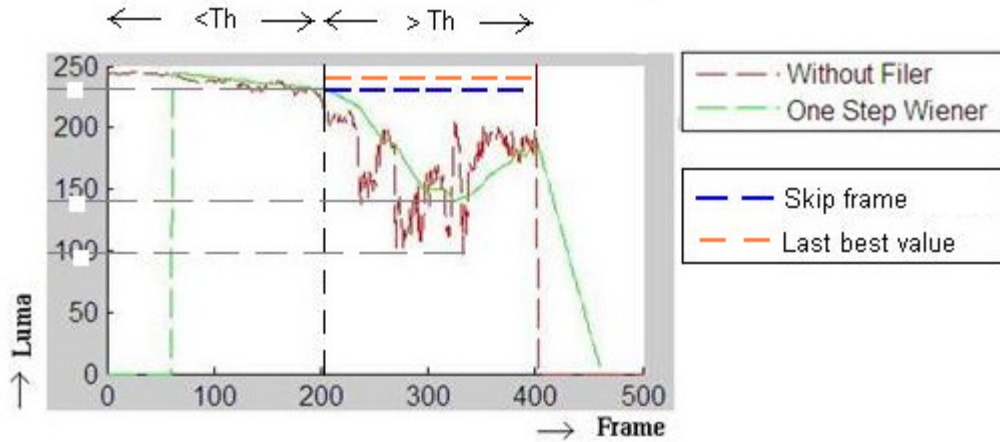
Figure5: System Response in Direct Digital Method

The four different results are compared to arrive at the best result to improve measurement parameter, variation in intensity of the photo flame meter. Refer **Figure5:** System Response in Direct Digital Method.

Filter/Method Type	*Error % (Variation)
Direct Measurement	> 58%
Wiener Filter	> 39%
Wiener Filter and Skip frames	< 5%
Wiener Filter and Last Best Value	< 3%

*255 values Luma steps, each 1% variation corresponds to 2.55 Luma

TABLE 1: Measurement Results

Basic statistic parameters of sodium and potassium concentration values in terms of Luma before and after disturbance of the bubble frames were presented in **TABLE 1:** Measurement Results

The following results are derived from the analysis of the results
- Wiener filter predicted values with skipping frames or using last best values provides better results.
- Variation in intensity level due to bubble frame can be filtered out by using image change detection technique

6. CONCLUSION
The Change Detection using one-step Wiener Prediction Algorithm to improve the measurement errors originated from instantaneous changes of image intensity due to bubble in sample flow path had been designed. The experimental observations of the MATLAB results are provided comparing the performance of with and without wiener filter. Based on threshold, the actual and predicted values are compared and decision to skip the frame or use the last best values is derived. The proposed new Digital Image Processing algorithm has significant potential to improve measurement results variations of low cost medical equipment. The implementation of the designed Wiener Filter makes it possible to eliminate or replace the bad frames in the measurements computation what is especially important in medical equipments. In future, image processing results are converted to concentration values and it will be compared against the Transversal Filer (TF), Kalman filter (KM), Adaptive filters of [1].

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