Compensation for Automatic White Balance Correction with Histogram Equalization

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Abstract

Histogram equalization rather than hard scaling can be used as an effective technique to counter automatic white balance correction in video processing to facilitate motion detection in video sequences. Benefits of this method are less user interaction needed by not needing to preview the image to select a scaling area and reduction of the non-focused changes in the video caused by using a scaling area. Reduced interaction lends itself to data mining of video.

Keywords: motion detection, scaling, histogram equalization, video, video data mining.

1. Introduction

Detection of motion in video is dependant upon the change in color intensity. The motion of an object that is not transparent will make a corresponding change in the pixels in the area of interest (AOI). If change is observed, it is evident that something has moved into or out of the AOI. This detection is relatively simple to perform under controlled circumstances, such as in surveillance systems in indoor environments. When dealing with video sequences which are captured under less controlled circumstances such as outdoors in natural lighting, this process becomes more difficult.

One factor that makes this difficult is the automatic white balance (AWB) circuitry that is present in consumer video equipment as part of the color calibration process. AWB is present in video capture equipment to try to match the color in video to match the color correction inherent in human vision. When we view an object, an automatic calibration takes place in our vision system to estimate the color of an object based on the lighting conditions that are present and a pre-conceived notion of what color it should be under daylight based on cues we receive from our memory and relative colors such as ambient lighting. When we view an object under artificial lighting, such as tungsten filament light bulb, our perception calibrates the image to try to match what we would perceive under other lighting conditions.

Producers of video equipment include circuitry to try to match what we would perceive with the image captured by the camera. Several algorithms exist, such as [1] [2] [3], to perform AWB in video capture equipment. They fall into two main categories. One will take the lightest area in the video where the image is not totally saturated where the three color channels for red, green, and blue (RGB) are close but not quite the maximum value and perform a transform on the image to create this as the standard which will be assumed white. The other method is to make the assumption that the average of all the colors in the image is a uniform gray and perform a similar transformation on the image. Regardless of the method used, which is not easily discerned from the resulting video, this AWB is not a uniform transformation that can just be simply rescaled to cancel its effects.

Higher quality video capture equipment has the ability to turn off this enhancement, but general consumer quality equipment available in the market does not have the ability to turn off this enhancement. Being able to utilize consumer grade equipment at much lower cost would be much more amenable to collecting video footage which would lend itself to data mining.

The image pair in Fig. 1 shows an example of the amount of color change in the video caused by the AWB from two separate times in the video sequence. The wall on the left hand side of the frame changes from white to a gray as it goes from being selected as the white point in the beginning of the video clip and changing to gray as a white car comes into the scene which then is selected as the white point in the frame.

Fig. 1: First frame (Left); Most effected frame (Right). Note the difference in intensity (up to 7 bits change in the 8 bits scale) of the wall on the left of the image.

To consider this data in a more abstract manner, the root mean square (RMS) of an area of interest in a grayscale video sequence is an integer value between 0 and 254. When nothing is in the area, it is a stable value. As an object moves into this area having a different color value, the RMS of that area will change. This in itself is useful but even more useful is to take the original frame with nothing in the AOI and calculate the absolute value of the difference of the original frame and each subsequent frame. When nothing is in the AOI under ideal circumstances, the difference would be zero and when something is in the AOI that is of a different grayscale value, the resulting value will be non-zero. The resulting plot of the RMS of the AOI will create a stable graph that reflects a deflection when an object moves into the AOI. Under controlled lighting conditions, this is relatively straightforward. Under dynamic lighting conditions, this is more difficult. Fig. 2 illustrates the problematic effect of the AWB on the resulting video. As the vehicle moves into frame, the AWB creates it's own change in the AOI independent of an object actually occupying the AOI. This makes it very difficult to discern the gap between the first two vehicles in the video, which occurs between frame 210 and frame 220 of the sequence.

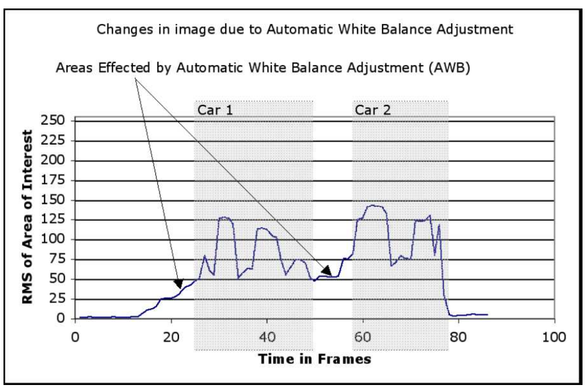

Fig. 2: Plot of RMS of the Absolute Difference of the Base Image and the Current Image for the AOI of raw video for a segment of the video showing two cars and the effect of the AWB.

What this research proposes is a means restore the base level during the disruption caused by the AWB. At first glance, a more obvious way to counter this AWB correction would be to find an area which should remain constant in the video and apply a scale factor for each frame thereby keeping that area constant as a base level. This is problematic for several reasons:

- The transformation performed on the image by the AWB may not be uniform over the entire image.
- There may not be an area that should remain constant throughout the sequence.
- The selection process requires previewing the entire sequence.

The technique proposed in this paper is using a classical image enhancement method, Histogram Equalization [4], for the compensation of AWB correction. This alternative method addresses all the negative features of the scaling method and performs comparably to hard scaling in the worst case and outperforms hard scaling in the best case.

2. System Architecture

The video used for this research was obtained from consumer grade video equipment. The sequences were taken of vehicular traffic moving through different scenes. The resulting video was separated into a sequence of individual frames using Transcode [5]. Python [6] was selected for the implementation language for the prototype application. The Python Imaging Library [7] was used to manipulate the images. The interface for the program was created with the Tkinter [8] library which is standard with the Python language. Graphing was done with Gnuplot [9]. The image compositing was done with ImageMagick [10] for comparison of images from different times in the video sequence. The tools in use are freely available and platform independent.

In testing, the program was used on several machines with differing operating systems and processors. In all cases, the program yielded faster than real time processing of the video and would lend itself to real time data collection of live video and faster than real time data mining existing video sequences.

3. Methodology

The first images in all of the sequences were without any object in the AOI. Both hard scaling and Histogram Equalization were performed with the same AOI to make a comparison of the efficacy of this technique. The general technique used in this experiment was:

1. Use the first image in the sequence as a reference ($Image_0$).
2. Select AOI and the scaling region.
3. With all of the subsequent $Image_n$ in the sequence:
   - 3.1 Create a grayscale version of $Image_n$ and perform the desired image enhancement.
   - 3.2 Create an abstract image that is the absolute value of the differences in $Image_0$ and $Image_n$. $|Image_0-Image_n|$
   - 3.3 Calculate the Root Mean Square (RMS) of the intensity values of the AOI in the new

image. Other metrics, such as sum of absolute difference, may be used for this step.

The resulting RMS values for the AOI were plotted in two sets of graphs for each image sequence, one with the value obtained with Histogram Equalization plotted against the raw image and the other with the value of a hard scaling against the same raw image data.

4. Experimental Results

The following data presented is representative of the results of the experiments. Only the first video labeled as “original” is presented here. The remaining video clips and the data collected is included on the author’s web page [11] along with source code and instructions for pre-processing the video to generate the still images as was done for this experiment.

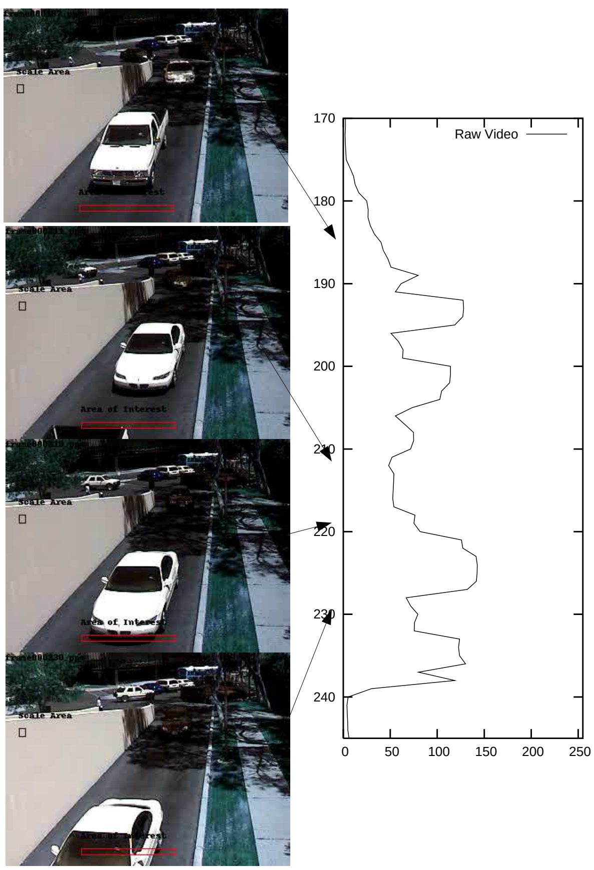

Fig. 3: Raw Video Sequence. RMS of intensity for AOI plotted with the frame number representing time. Note the period between frames 210 and 220 where first vehicle has passed and second has not yet entered.

The first image sequence was used for primary testing. It was a short sequence with three cars passing through the entrance to a parking garage. Fig. 3 shows the graph of the RMS of the area of interest (shown as the red rectangular box in the image). The four video frames show the problem presented by the AWB’s effect on the video. The RMS of the AOI is seen as a plot against the frame number. As the AWB changes the overall balance of the images in the sequence, it becomes impossible to tell whether the change in the AOI is due to the AWB or due to an object moving through the AOI.

The images in the sequence were then processed as seen in Fig. 4, by applying a hard coded scale factor which readjusted the color of the scaled region to a constant level. While the color of the wall remained constant through the video sequence, it still is difficult to discriminate individual objects moving through the AOI as the AWB is not necessarily applied uniformly over the images. This is most apparent in the frames between frames 210 and 220. The scaling improves the delineation between the two white vehicles but still demonstrates the main problem with hard coding a scale area into the image. The area chosen for the scale area has to be distinct from the area of interest and the adjustment by the AWB is not uniform.

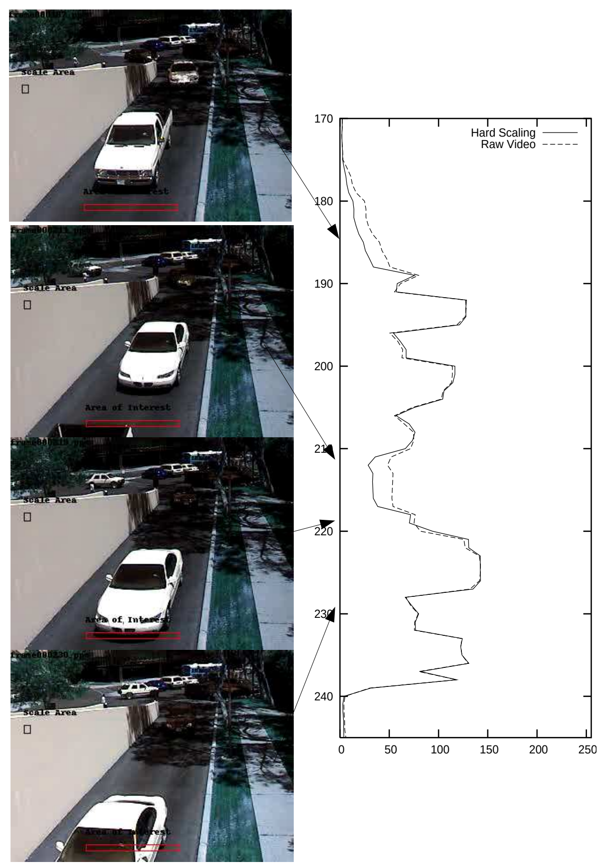

Fig. 4: Video Sequence with Hard Scaling. Same as Fig. 3 but with the addition of the graph of the AOI after a scale factor was applied to the images seen on the wall on the left. Note the improvement between frames 210 and 220.

The same source of data is presented in Fig. 5 but the Histogram Equalization was applied to all frames of the video instead of scaling. Of particular interest is the series of frames between frame 210 and 220. The passing of the first vehicle is clearly seen as separate from the second. In addition, the change caused by the windshield of the second vehicle passing through the AOI in the raw video was near the same level as the AOI between the first two vehicles in the scaled version. In the Histogram Equalized video sequence, the windshield is clearly discernable as being of a different value than the gap between the first and second vehicle.

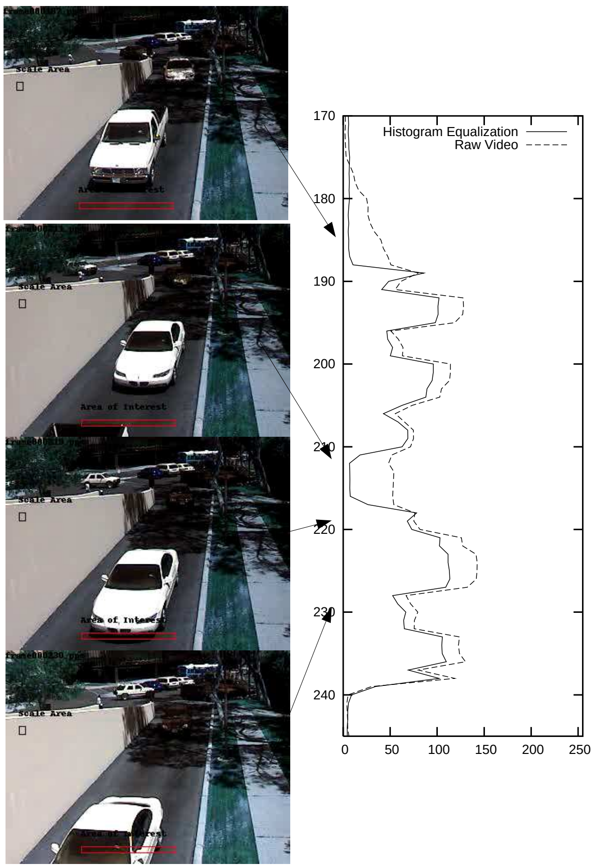

Fig. 5: Video Sequence with Histogram Equalization. Note the clear delineation between frames 210 and 220 and the difference in intensity level of frame 230 where the windshield of the vehicle is passing through the AOI.

The remaining video sequences used for testing included other problems with the video such as camera motion (jittering), automatic focus adjustment changes, less direct lighting, and inability to select an un-occluded area for scaling. The results of all video sequences tested showed efficacy of using Histogram Equalization rather than hard scaling.

5. Conclusions

All the video sequences showed more accurate detection of objects moving through the AOI using the Histogram Equalization method over the hard scaling method. The Histogram Equalization method avoided the problems inherent in the hard scaling method. The Histogram Equalization method did not require the previewing of the sequence. It allowed arbitrary selection of an AOI in the frame.

The main benefits of this technique are especially applicable to data mining of video. The arbitrary selection of AOI allows for detection of more dynamic events such as objects passing between two or more AOI. For example, with two AOIs in a bank ATM drive through location, we can use the video recoded by the security camera to answer the question likes “What are the average waiting/service time per customer?” With overhead traffic video it is possible to monitor waiting times at intersections, traffic patterns collected per lane for selection of commercial properties, and monitoring parking lot utilization. Using similar techniques coupled with programming triggered by events, it would be possible to monitor things such as average wait time in single feed queues such as at a bank teller line to signal the need to open or close teller booths based on average wait time in line.

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6. References

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