Video Magnification for Revealing Subtle Temporal Variations

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***Abstract*—** With the advent of high definition video cameras, it is possible to record even the subtle temporal variations of recorded subject, that are not visible to the naked eyes.For revealing such subtle details the video captured using such cameras requires some processing on it. Magnification of subtle temporal changes like motion or coloris known as video magnification. This paper explores two methods for video magnification,namely the Eulerian and Lagrangian video magnification. The paper also focuses on the preprocessing and denoising methods that are essential for these two methods. The operations that are performed under the video magnification are preprocessing, magnification, and post processing (error correction). Preprocessing involves the converting the video into frames array. After this conversion of the video into frames, an individual frame goes through the noise removal process. Video-frames may contain many types of noise that directly affect the result of the video magnification. Motion denoising is one of the techniques that deal with motion noise in the video frames. Further processing continues with the motion and color magnification that is a main part of a video magnification algorithm. In this work,Eulerian and Lagrangian motion magnification methods are implemented.This helps in ameliorating the final results of the video magnification process. Video magnification algorithm revel subtle changes in the video those are visible to the necked eye and useful in analyzing vital signs of person, like observing the facial blood circulation. It is also useful in monitoring object subtle movement under various constraints.

Keywords- *Video magnification, Subtle temporal variations,Eulerian and Lagrangian magnification*

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I. INTRODUCTION

Current camerawork delivers us with useful gears to capture, physical facts happening over different scales of time. The ultra-high speed camera can support the much higher frame rate one can see the phenomenon as shock waves and other natural activity. Long term processes can also be analyzed using the time-lapse such as expansion of the city, melting of polar ice. All this data is easily available due to day by day reducing communication barrier across the globe. This makes content arability on the click of the button. Data is growing rapidly, but analysis tools are not.Thismakes all these data containing relevant information have to be analyzed manually for extraction of the relevant information. Video magnification process focuses on examining and operating on subtle changes in the video.Video magnification process enhances these changes at the level that changes which was not substantial becomes easily notable for better analysis and make the analysis of the video much easier. Over the time interval changes in the varying intensities are recorded that mainly caused due to the motion or color variations.In this video magnification processnoise is reduced using noise reduction methodin preprocessing phase. This makes video more suitable for the optimal results as noise in the video will not be affecting the video magnification process. This methodology is useful in the long term analysis like time-lapse sequences and even in the short term analysis. When very long duration events are enclosed with the minutes or even in seconds, significant time aliasing pixels can be getting inconsistent temporally. This is especially useful for time-lapse sequences that are often used for long-period medical and scientific analysis, where dynamic scenes are captured over long periods of time. When day- or even year-long events are condensed into minutes or seconds, the pixels can be temporally inconsistent due to the significant time aliasing. This aliasing may cause the effect of making the object suddenly disappearing and reappearing or changing illumination rapidly in between frames in this frame sequence makes the long-term process in this process difficult to analyze. By treating the short-term changes as the noise and long-term changes as the relevant changes helps to revel long-term events in the video magnification process. In the final output there is a decomposition of original video into two short-term and long-term components of the motion. Naive filtering approaches are incompetent of achieving the results and current computational approach to make the motion in the input video less noisy without any explicit analysis on the video makes it versatile and can be applied to different videos that contain high motion dynamics. Magnifying indiscernible changes that is magnification of the motion and color changes in the video whichwas not noticeable to the observer and then amplifying those changes to the extent that common observer can easily notice that changes by naked eye. This subtle motion may include the changes in the skin tone of the human due to the blood flow. These variations are too subtle that cannot be seen by simple observation. With this video magnification algorithm one can determine the pulse rate using the blood circulation pattern which is not possible using human vision.Similar process can also uncover the motion of lower amplitude that is also hard to detect in the videos.If such video data containing similar type information remainunanalyzed

and unprocessed, then subtle changesin those videos remain unseen.Thus video magnification process is important tool in subtle motion analysis.

II. PREPROCESSING

Preprocessing is very important as the captured video may contain many types of noise. In preprocessing this noise is reduced from video using noise reduction method in order to get the desired result [1]. Observations show that noise reduction play important part and affect final obtained results. Noise may include out of focus subject, blur subject, motion blur due to camera motion while recording subject [3]. Low light pictures may cause grain in the image due to the low exposure of light. Low light images are likewise subject to the poor color representation.A noise like film grain can be reduced at certain extent by applying the blur mask on the video frames. Taking into consideration that excess blurring can also result in blurring the subject also. Another type of noiseis motion blur it is common phenomenon happened during the video capture.In motion blur subject gets blurred because of the sudden motion of the cameraor due to improper stabilization of video capturing device. This problem is taken careusing the estimation models for the motion blur. In this process captured video and optical flow of the camera is analyzed. By applying counter virtual motion pattern on the captured video motion blur noise is reduced at most of the extent.Another technique used for noise removal is to identify the short term changes in the captured video by applying the certain threshold these short term changes can be filtered out from the captured video [2]. Most of the time recorded video may have noise and inconsistency that affect resulting output. By removing this noise and inconsistency from video frames result quality gets improved, but practically it is not possible to remove all noise from video frames. So noise is reduced up to some tolerable threshold such that it will not affect output in a substantial way.

In preprocessing noise reduction is performed, and inconsistency as well as noise in the video frames is reduced. Figure 1 is cropped sample of recorded human face showing the impurities in skin tone and recoding noise in the frame.Noise reduction techniques are used to reduce these kinds of impurities in the video frames. Figure 2 is cropped frame of the recorded human face, showing the frame after the preprocessing. This frame has gone through the noise reduction process, there are many possible methods for noise reduction like Gaussian blur given by the equation

, Median filter, Bilateral filter represented by the bilateral filter equation as $\frac{1}{W_p}\sum_{x_i \in \Omega} I(x_i) f_r(\|I(x_i) - I(x)\|) g_s(\|x_i$ another filter that can be used is a Wiener filter which is given by the equation

$H(f) = \frac{S_{ss}(f)}{S_{yy}(f)} = \frac{S_{ss}(f)}{S_{ss}(f) + S_{nn}(f)}$. Depending on the estimated noise, noise levels and type of noise the reduction method can be selected for the noise reduction. After the processing of the video frames that is after enchantment there processing noise is generated due to saturation and distortion of the frame pixels. This processing noise can be taken under the consideration and noise reduction can be performed after

Figure 1. Cropped sample of recorded human face showing the noise in frame before preprocessing (noise removal process)

Figure 2. Cropped sample of recorded human face showing the removed noise in frame after preprocessing (noise removal process)

amplification of the video frame. Thispost processing noise reduction can be achieved by two specific methods one method is Gaussian blur and another method that is used is the Box blur [1]. Both work as the radial blur, depending on the motion and color magnification processing these methodscan be applied independently. These post processing filtering methods produce different results when applied to the video. Gaussian blur when applied to the processed video it is found that it makes the subtle motion more visible than subtle color variations. In contrast Box blur when applied to processed video it is found that it makes subtle color changes more visible than the subtle motion. This gives two distinct uses of Gaussian and box blur methods. Two methods can be differentiated on the basis of their output. For enhancing motion in the video Gaussian blur method can be used, and for enhancing the subtle color changes in video box blur can be used. Similarity between applied Gaussian and Box blur is

both method works as the redial blur methods and need external radius parameter as blur radius.

III. MOTION AND VIDEO MAGNIFICATION

Preprocessing of videomainly consistsnoise reduction process this preprocessing enhances the results of video magnification algorithm. There are further more preprocessing steps involve. In these steps video is decomposedinto many special videos components by using special decomposing techniques. This decomposed video many components, and then amplified using the temporal processing. This temporal processing is done pixel wise on the each video component frame,and then this processed video component is added back tothe original video. Original video with these amplified video components gives the magnified video. In this processof video color and motion magnification final composition of the original video and other video component is done depending upon the parameters given during the processing of the input video. There are mainly two blur techniques used in post processing the input video under the video magnification process. These post processing methods blur the video frame after the amplification in the color intensity of the frame pixels. This post process helpsto even out the abrupt change in the sharpness of and in color intensity. The post processing technique includes Gaussian blur and the Box blur techniques [4]. These two methods are used for two different purposes one is for motion magnification which is Gaussian technique. The second technique is used for color magnificationwhich is Box blurtechnique. Amplification in the intensity can be derived using Taylor expansion, and can be denoted as $B(x,t) = I(x,$. In figure 3shows the intensity variationover the time period derived from the changing pixel intensity values. Recorded video from the video capturing device is of subject appearing to be still.This video has to be amplified for the subtle motion magnification most of the video frame pixels intensity values remain unchanged through the video magnification process.Inactive pixelsprovide a base for marking an overall change in the intensity of the other pixels with respect to the time [5]. This change in the intensity of the pixels can be modeled using mathematical representation by Taylor expansion shown in figure 4.A relative pixel can be made to adopt this change in relative intensity according to the derived formulation and thus provides an amplification model for video. An intensity variation in between these two relative pixels with respect to the time is amplified to give the amplified results. It introducesrelative amplification in the corresponding motion. This leads to the magnification of the subtle motion in video. This amplification can be visualized as from the figure 5. It shows the amplification in the pixel intensity is estimated that using the Taylor expansion.Video magnification process targets two different aspects of the video magnification motion magnification and the color magnification.After the amplification process produced output frames are those frames that contain the both aspects that have been amplified. In such case the post processing is done to separate the subtle motion amplification form the subtle color amplification. Separation of these two components is done by using special filtering mechanisms such as the Gaussian blur and Box blur.The Gaussian blur out the subtle motion changes in the video sequence, Box blur helps to bring out the color variation in the frame sequence. After amplification of video details Gaussianblur is used inpost processing for the motion magnification process,whereas the box blur is used in post

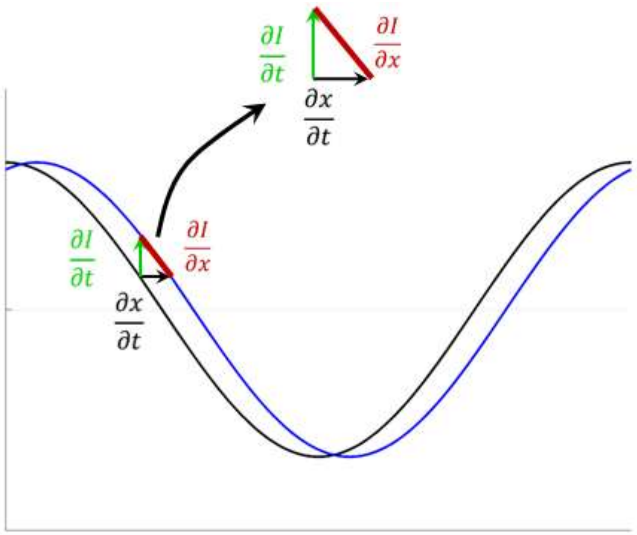

Figure 3. Intensity variation is shown in the figure derived with respect to the time

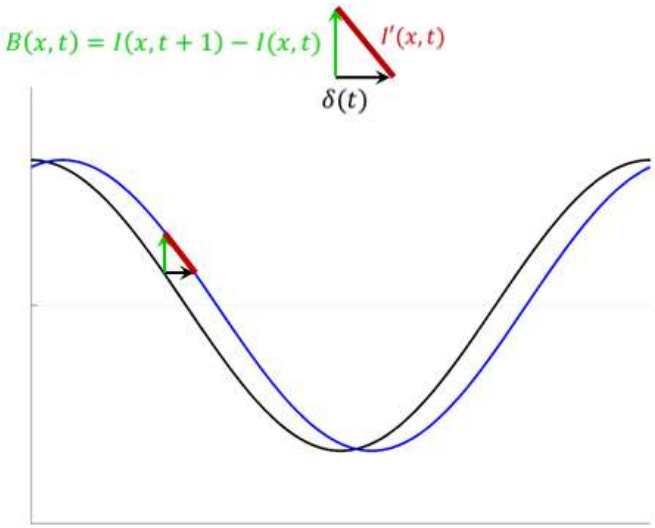

Figure 4. Taylor expansion for derived amplification with respect to time

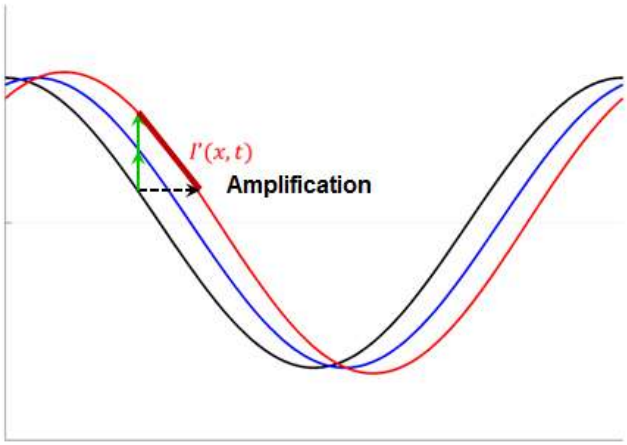

Figure 5. Amplification performed on original intensity computed by the intensity variation in the sequential frame in frame sequence

processing for the color magnification process.

IV. OUTPUT

After all the processing final video obtained using the video magnification process contains the information that was hidden previously in unprocessed video. Video magnification process not only explores the hidden motion, but also explores the subtle color changes in the recorded subject. These colorvariations when visibility can be used for analyzing various patterns and other aspects. One of the examples of analyzing the color variation is blood circulation in the subject skin. The blood circulation can be analyzed using color amplification process,this amplifies small variation in skin colors. There are mainly systolic blood circulations and diastolic blood circulation. In systolic blood circulation, heartpumps blood in body parts, thus skin appears to be more read. In the diastolic blood circulation blood returns to the heart and thus skin appears green. This process also used to extract pulse signals and vital signs form observation of skin color subtle variations. In this process subject face is recorded and then using video magnification process subtle changes in the color are amplified. Figure 6 shows the cropped sample of recorded human face showing the noise in the frame before preprocessing. Before the noise removal process as this fame contains the noise that may affect the overall output it is important to reduce the noise in the frame. Figure 7 shows the cropped sample of recorded human face showing reduced noise in the frame after noise reduction preprocessing. The noise reduction process is the part of the preprocessing these preprocessing may include may other process also to improve the quality of the output. After preprocessing the video magnification process is initiated and then depending upon the required result either Gaussian blurs or the box blurring is performed, for the color magnification box blursare used whereas for the motion enhancement Gaussian blur is used. This blurring reduces the noise occurred due to the over saturation and intensity amplification in the video magnification process. In the case of the systolic blood circulation phase the color of skin looks more read because of the more blood is present in the skin due to the pumping action of heart.Figure8 shows cropped sample of recorded human face showing the systolic blood circulation redness in skin (this result is obtained after processing the input video form which previous samples are taken). Following similar means of processing after certain frames the greenish color skin is observed, indicating the diastolic blood cycle.Indiastolic blood cycle, blood is circulated back to the heart and thus the skin color becomes greenish. This is represented by the figure 9 which is cropped sample of recorded human face showing the diastolic blood circulation. By calculating the time difference between these two frames the pulse signals can be extracted from the video, this helps in finding the improper pulse signals and unusual heart beats in the subject body. The output produced by the process can be observed simultaneously with the original video.For more detailed observation as the processing methodology is able to produce the output with very less delays, these delays are subject to, the changes under the various frame size and the various frame rate of the video. Larger frame size tends to produce more processing delays than compare to the smaller frame size video. Optimization can be carried out to reduce these types of delays using prepressing video in the smaller components and processing them individually to minimize delay and enhance the processing to produce output instantly.

Figure 6. Cropped sample of recorded human face showing the noise in frame before preprocessing (noise removal process)

Figure 7. Cropped sample of recorded human face showing the removed noise in frame after preprocessing (noise removal process)

Figure 8. Cropped sample of recorded human face showing the systolic blood circulation (redness in skin)

Figure 9. Cropped sample of recorded human face showing the diastolic blood circulation (Greenish in skin)

V. CONCLUSION

The paper illustrates an upcoming application of image processing. The algorithm presented here demonstrates that a video captured by medium to high definition cameras can be magnified to highlight the subtle temporal variations in color and motion. Such details are quite useful in applications like observing blood circulation from skin video, observing, and counting pulse signals, civil structure analysis, etc. Using this algorithm video magnification can be performed on any pre-recorded video, irrespective of which hardware is used for capturingthe video. This algorithm is modified to suite the desktop environment my eliminating some of the computationally heavy processes for signal decomposition.

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