REVEALING THE HIDDEN DETAILS OF VIDEO USING MOTION AND COLOUR MAGNIFICATION

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Abstract: The real-world videos contain subtle yet informative signals which are difficult to perceive through naked eyes such as tiny motions or small color changes. We have proposed a non-contact, visualization tool that allows the determination of these temporal variations in position and colour. The proposed motion detection technique that amplifies the colour with low amplitude revealing small or invisible signals in a video using Eulerian motion magnification algorithm. The algorithm takes a video as input and magnifies the temporal colour changes and imperceptible motions using spatial-temporal processing. The proposed method was also used to estimate the heart rate of a person by combining the extracted localized time series of colour values with the onset time differences.
Keywords: Motion Magnification; Spatial-Temporal Filtering; Colour Magnification; Frequency Analysis; Video Processing

I. INTRODUCTION

Over the past few years the several image processing techniques have been increasingly used in the field of medical sciences on images acquired using different imaging techniques like X-ray, MRI, Electrocardiography, Computed tomography and Ultrasound machines. It has aided the scientists to develop equipment that can extract minute details of substances and assists them to identify the problem precisely. The availability of all these devices in public places is limited and expensive. Hence there is a need for non-contact, easy-to-use, cost effective tool to estimate and detect common health parameters like breathing, heart rate, body temperature etc. In this work we propose a motion detection technique with video magnification that magnifies the temporal colour changes and imperceptible motions using spatial-temporal processing.

Attempts have been made to unveil imperceptible motions in videos by analyzing and amplifying subtle motions and visualize deformations that would otherwise be invisible [1]. Wang et al. [2] have proposed the use of Cartoon Animation Filter to create perceptually appealing motion exaggeration. These approaches follow a Lagrangian perspective, in reference to fluid dynamics where the trajectory of particles is tracked over time. As such, they rely on accurate motion estimation, which is computationally expensive and difficult to make artifact-free, especially at regions of occlusion boundaries and complicated motions. Moreover, Liu et al. [3] have shown that additional techniques, including motion segmentation and image in-painting, are required to produce good quality synthesis. This increases the complexity of the algorithm further.

Temporal processing has been used previously to extract invisible signals and to smooth motions [4]. Poh et al. [5] extracted heart rate from the video of a face based on the temporal variation of the skin color, which is normally invisible to the human eye.

The Eulerian perspective is different from the above mentioned methods in the sense the variation of pixel values over time are amplified in a spatially-multiscale manner. The Eulerian approach of motion magnification do not explicitly estimates motion, but rather exaggerates motion by amplifying temporal color changes at fixed positions. It relies on the same differential approximations that form the basis of optical flow algorithms [6].

II. MATERIALS AND METHODS

In the proposed model for video amplification the following contributions are achieved:

- The system demonstrates that nearly invisible changes in a dynamic environment can be revealed through Eulerian spatio-temporal processing of standard monocular video sequences.
- The system provides an analysis of the link between temporal filtering and spatial motion and show that our method is best suited to small displacements and lower spatial frequencies.
- The system also presents a single framework that can be used to amplify both spatial motion and purely temporal changes.

Motion Magnification

The overview of Eulerian video magnification framework is shown in Fig. 1. The system first decomposes the input video sequence into different spatial frequency bands, and applies the same temporal filter to all bands. The filtered spatial bands are then amplified by a given factor, added back to the original signal, and collapsed to generate the output video. The choice of temporal filter and amplification factors can be tuned to support different applications. We then add the magnified signal to the original and collapse the spatial pyramid to obtain the final output. Since natural videos are spatially and temporally smooth, and since our filtering is performed uniformly over the pixels, our method implicitly maintains spatio-temporal coherency of the results.

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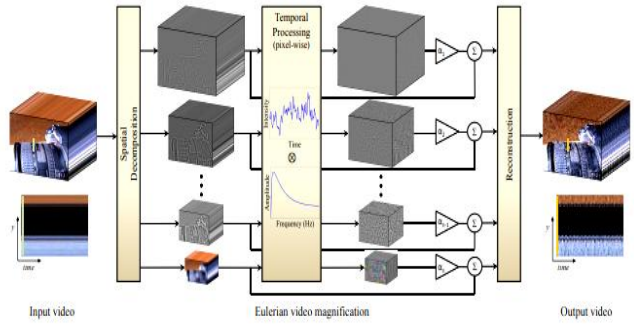

Fig. 1. Overview of the Eulerian video magnification framework

Colour Magnification

The colour magnification using vital sign extraction framework is shown in Fig. 2. The system first uses Eulerian preprocessing to generate a bank of denoised temporal color series from input video. Weight/onset map is computed from these denoised color series. These color series then is combined according to the weight/onset map and the combined series will be used for generating better heart rate estimation. A partial history of all color series are kept for updating the weight/onset map. offline. An initial weight map is selected by the user and an initial offset map is set to zero for all pixels. The system can combine the color series according to the weight/onset map from a previous iteration and uses the resulting color series as a reference to estimate the new weight/onset map. The system continues to iterate until a user designated number of iterations.

The weight/onset map can also be updated in real-time. We keep a partial history of all the color series as training data to compute the new weight/onset map. The previous weight/onset map is used to obtain the reference color series and this reference series is treated as the ground truth for computing the new weight/onset map.

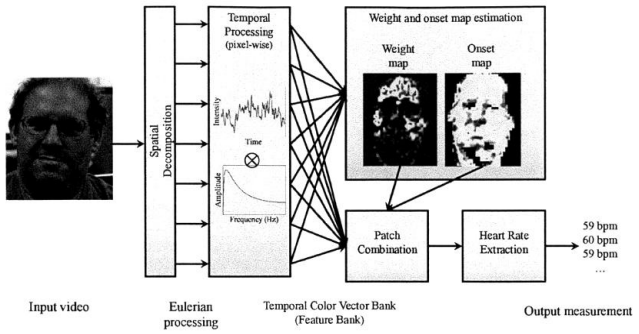

Fig. 2. Overview of the vital sign extraction method

III. RESULTS AND DISCUSSIONS

Motion Magnification

Separable binomial filter of size five was used to construct the video pyramids. A prototype application was also built that reveals subtle changes in real-time from live video feeds, essentially serving as a microscope for temporal variations. To process an input video by Eulerian video magnification, the following steps were followed:

- Selecting a temporal band pass filter.
- Selecting an amplification factor, α.
- Selecting a spatial frequency cutoff (specified by spatial wavelength, λc) beyond which an attenuated version of α is used; and
- Selecting the form of the attenuation for α—either force α to zero for all λ < λc, or linearly scale α down to zero.

The input to the proposed motion magnification system was a video recorded from a baby monitoring camera a screenshot of which is shown in Fig. 3.

Fig. 3. Screenshot of original/non-amplified video

Standard Laplacian pyramid for spatial filtering with $\alpha = 10$ and $\lambda_c = 16$ was chosen. Since our intention is to check the breathing behaviour of the baby which is considered to be subtle motion, we used temporal filters with a broader passband. The video was magnified 30 times using the proposed algorithm such that the breathing becomes much more visible as shown in Fig. 4 and Fig. 5.

Fig. 4. Screenshot of the magnified video where the baby's chest has expanded caused due to inhaling

Fig. 5. Screenshot of the amplified/ magnified video, where we can see the exhaled chest while breathing

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Colour Magnification

The input to this system is the video of a random person the colour of which is magnified using vital sign extraction framework. The colour at each pixel was measured and colour variations were identified which were amplified. Then, the process of figuring the red pixel value in both the original and amplified video is initiated. The screenshots of original video and colour amplified one is shown Fig. 6. The figure also displays the evaluation of red pixel values which are the end values achieved. The final pulse rate of the person in video is calculated by:

Final pulse rate = (x / y) * 60 bpm

where, *x* is the number of variations of pixel values from high to low and *y* is the duration of video.

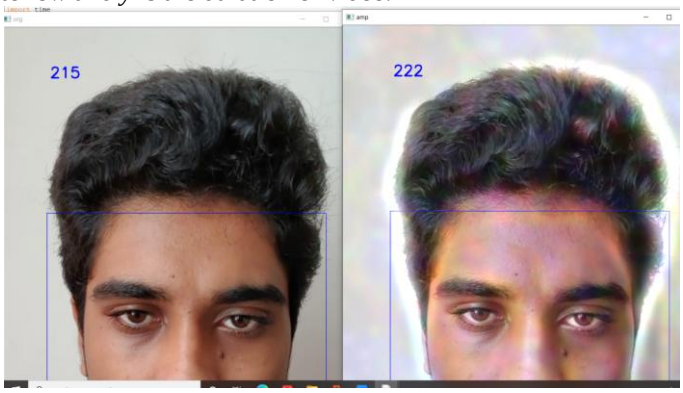

Fig. 6 Screenshot of the original input video (left) and the video that is being amplified (right)

The obtained pulse rate is approximately 92.66, where the round figure of that is equal to 93, which was the value obtained by the oximeter when the video was taken.

After the image segmentation, feature extraction was performed to obtain the quantitative attributes of each sample from the regions of interest. Color components were extracted from each color image in red, green and blue (RGB) channels and in addition, gray scale image was obtained from each image. Therefore, four intensity images were obtained from each color image. The extracted features included standard intensity features, local binary patterns (LBP), Discrete Fourier Transforms (DFT) and Discrete Cosine Transform (DCT), Hu with intensity and Gabor filters. The features that depend on contrast, orientation and location were avoided as the fruit quality is independent of these characteristics. Extracting the features upon which the fruit quality does not depend on leads to false correlation.

IV. CONCLUSIONS

In this work, we proposed a simple method that takes a video as input and reveals the information of subtle signals that are invisible to the naked eye in the video. The Eulerian video magnification takes a video as input and amplifies subtle colour changes and imperceptible motions to make them visible. To amplify motion, our method does not perform feature tracking or optical flow computation, but merely magnifies temporal colour changes using spatial-temporal processing. We built a pulse rate extraction system that takes localized time series of colour values that was generated by the Eulerian-based spatial-temporal processing, and combined them based on the onset time differences to estimate heart rate.

The proposed work could be tested on magnifying small mechanical movements, like vibrations in engines, that can help engineers detect and diagnose machinery problems, or see how buildings and structures sway in the wind and reacts to forces. In an extension to the work described here, quantitative analysis of structural motions can be performed to test their safety non-destructively.

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