ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2015

A Review: Eulerian Video Motion Magnification

Kranti Kamble[1], Nitin Jagtap[1], R.A Patil[2], Ankit Bhurane[3]

M.Tech Student, Dept. of Electrical Engg., VJTI, Mumbai University, Maharashtra, India[1]

Associate Professor, Dept. of Electrical Engg., VJTI, Mumbai University, Maharashtra, India[2]

Phd Student, Dept. of Electrical Engg., IITB, India[3]

ABSTRACT: Thispaper reviews computational techniques to efficiently represent, analyse and visualise both short-term and long-term temporal variation in video and image sequences. This paper reveals temporal variation in videos that are imperceptible to the naked eye. The method takes a standard video sequence as an input, and applies spatial decomposition, followed by temporal filtering to the frames which is called "Eulerian Video Magnification". The resulting signal is then amplified to reveal the hidden information. Paper contains four techniques which are: 1.Linear approximation method, 2.Phase based video processing, 3. Riesz pyramid for fast phase based video processing and 4.Enhanced Eulerian video magnification. Using above methods, one is able to amplify and visualize small motions and temporal colour changes.

KEYWORDS: Spatio-temporal analysis, Eulerian motion, phase based video magnification, image wrapping and motion mapping.

I. Introduction

The motions which are too small in amplitude, below human visual spatio-temporal sensitivity are explanatory. The variations which are invisible for human eye can be useful to extract important information. e.g. respiratory motion, the human skin colour varies with blood circulation can be employed to extract pulse rate[1][2]; high speed videos such as small eye movement, engines vibration, long term physical processes such as melting of glacier, growth of plants can reveal biological and physical changes[3]. The motions with low spatial amplitude are hard to see for human, can be amplified to divulge the mechanical behaviour [4]. The video motion magnification is useful in the field of medical and scientific application, for contactless vital-sign monitoring applications in health care, pulse rate measurement, in photography to retouch the time lapse video, in mechanical systems to monitor vibration of system or to analyse structural integrity of building, bridges, and railroads and in search and rescue operations.

The method Eulerian video magnification (EVM) is used to disclose the temporal variation or invisible signals in videos which are difficult to see with naked eye and display them.

The EVM is a combination of spatial and temporal filtering to reveal the subtle temporal changes in videos. The input, standard video sequence, is spatial decomposed and followed by temporal filtering and the resulting signal is then amplified with some amplification factor and reveals small motions. The EVM is inspired by Eulerian approach which deals with fluid motion properties such as pressure and velocity over time and space.

In the EVM, approach is to study variations of pixel over time at any spatial location and magnifying variation in interested temporal frequency band. Temporal filtering is applied to lower spatial frequencies such as human heart rate, respiration of baby, etc. It permits the imperceptible signals to arise above quantization noise level. The temporal filtering touch amplifies colour variations as well as explores the low amplitude motion or subtle motion. The temporal filtering is uniform for each spatial level of frequency band and for all pixels at each level. The combination of temporal filtering and spatial processing is best suited for small displacement as well as low spatial frequencies. Fuchs et al. [5] discuss the high-pass filtering of motion mostly for non-photorealistic effects and large motions.

II. Literature review

In last decade, assorted methods have been developed to disclose the imperceptible changes in videos. Some methods are found to be very effective, useful and establish the foundation of this area of work. The motions which are invisible or impossible to see with naked eye are analysed and amplified to reveal the temporal variations in videos

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2015

under motion magnification technique [4]. Here the input is image sequence from a stationary camera. System segments a reference frame (pixels) based on properties like similarities in colour, proximity and correlated motions. The user can magnify the motion of any selected layer by specified motion magnification factor. Now re-render the video sequence with magnified motion of selected layers. The output sequence allows the user to see the form and characteristics of the magnified motions.

The motion information is a normal flow associate with edge moments [6]. The visual processing can be represented as a non-linear system which is a function of time and space. This function is basically a composition of temporal band pass filter and spatial band pass filter. The bandwidth and central frequency interpret the range and sensitivity of motion detection ability. This filtering allows finding the highest correlation in both temporal and spatial domain. Spatio-temporal data structure, with time as a third dimension was introduced by Bolles and Baker [7] and provides a way to trace a line segment through frames. The spatial and temporal analysis module links edges into contours in the first time frame of volume and estimate normal velocity of a line feature by taking slices in temporal direction [6].

Wang et al. presented the Cartoon Animation Filter (CAF), a filter which takes impure motion signal as an input and blend in such a way that output motion is more animated or alive [8]. Filter adds a salved, inverted, and time shifted version of the second derivative of the signal back into original signal. From experimental results, the filtered motion predict, follow-through, exaggeration and squash and-stretch effects which are absent in the original input motion data.

Applications of the CAF will be in either real time applications such as games, or in 2D presentation systems like PowerPoint, or in a child focused animation tool and probably is not satisfactory for hand crafted off-line animation systems .

The above methods [4,8] follow a Lagrangian proposal, in reference to fluid dynamics where the trajectory of particles is tracked over time. As it believe in accurate motion evaluation, which is working out expensive and strenuous to make artifact-free, especially at regions of obstruction boundaries and tricky motions. The additional technologies, including image in-painting and motion fragmentations are required to generate good quality composites. But this increases the involution of the algorithm further [4].

Eulerian proposal deals with fluid motion properties such as pressure and velocity over time and space. In Eulerian perspective to motion magnification, the motions are exaggerated by amplifying temporal colour changes at fixed positions rather than estimating motion in Lagrangian proposal. EVM rely on the same differential approximations that form the basis of optical flow algorithms [9].

Previously, temporal processing has been used to smooth motions [5] and to reveal invisible signals [2]. A novel methodology for remote measurement of cardiac pulse rate from video recordings of the human face based on automatic face tracking and executed using a simple webcam with extensive daylight providing illumination is presented [2].The cardio-vascular pulse variation using mass light and a simple consumer level digital camera in movie mode had extracted in [1]. From results it is clear that the ambient light photo-plethysmography can be useful for medical purposes such as remote sensing of vital signs such as heart and respiration rates for triage, for sports purposes and characterization of vascular skin ulcer. Research has become one of the backbones for motion analysis in video sequence for the measurement of various medical parameters related to human body.

Fuchs et al. provided the controlled temporal sampling behaviour of system [5]. It transforms a high frames per second input stream into a standard speed output video in real- time. Using these filters, a real-time temporal pre-filtering is performed to lessen temporal aliasing. Authors have made the provision to arbitrarily choose the shape and extent of the temporal filter to perform different filtering operations such as desirable pre-filtering for a given output kernel or artistically highlighting or modulating motion blur. Furthermore, they have signified specialized filter banks to examine the signal in the Fourier domain, in order to intensify and understand video content based on its temporal behaviour such as emphasizing or de-emphasizing motion.

A method called “Eulerian video magnification” which discovers the temporal variations in the videos which are imperceptible to naked eye is proposed by Hao-Yu Wu et al. [3]. The Eulerian based linear approximation method is described in the section III. To overcome the limitations of this method Neal Wadhwa et al. [10] extended his work called phase based video processing using complex steerable pyramid which is discussed in section IV. In section V

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2015

same author introduced the new image pyramid representation called Riesz Pyramid for fast phase based video magnification in [11].Finally in section VI Lie Lu.[15] proposed the post processing technique to improve the EVM given in section III.

III. LINEAR APPROXIMATION METHOD

The Eulerian based linear approximation method combines the spatial and temporal processing to explore the imperceptible motion, temporal variations in video. This process is illustrated in figure1.

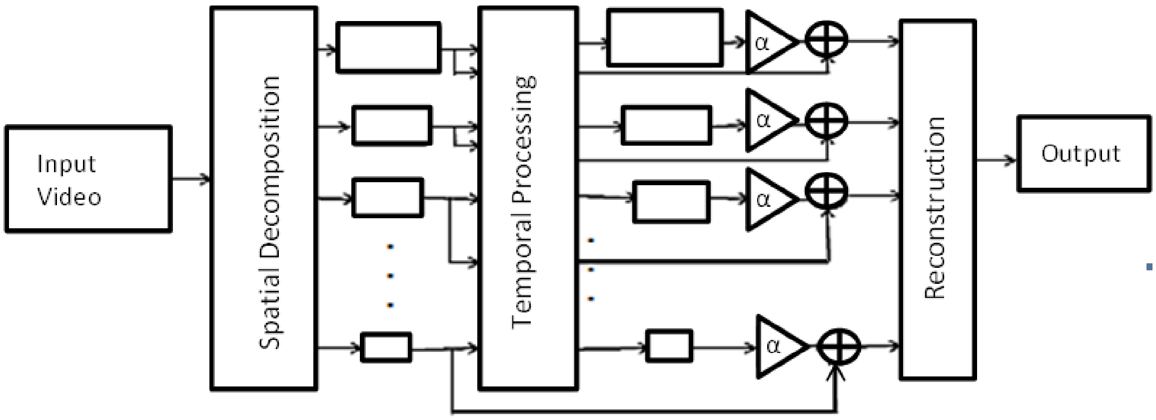

Fig.1: Video magnification framework [3]

- This takes the standered video sequence as an input. Then we decompose the video sequence into different frequency bands using gaussian pyramid of 3-4 levels to figure out the band of interest. The video frame is passed through Low pass filter (LPF) and then down samples it to construct the laplacian pyramid [12]. Due to different signal to noise ratios of diffeerent frequency band these bands may be amplified differently.
- Then we go for temporal filtering on each spatial frequency band by performing band pass filtering to extract the frequency band of interest. Here, we consider the time series values at any spatial pixel in frequency band. For example, to magnify baby pulse rate we might select frequency band of 0.4-4Hz which corresponds to pulse rate of 24-240 beats per minute and applies the narrow band arround that frequecy band.
- The extracted signals are now amplified with some amplification factor (α). From [3] the limits of α is given below as,

$$(1 + \alpha)\delta(t) < \lambda/8$$

Where, δ(t)= spatial displacement function

Spatial wavelength $(\lambda) = \frac{2\pi}{\omega}$ ω = spatial frequency.

The motion magnification in temporal relies on the first-order Taylor series expansions.

- Reconstruction of final output video is done by adding the magnified signal to original signal and disintegrating the spatial pyramid.

The heart rate can be determined by frequency analysis of colour variation in extracted band pass signal. Generally for good results, the size of temporal window is found as 10-15 for 30 frames per seconds for video [3].
The choice of temporal filter is application dependent. E.g. To get noise free results, for colour amplification, narrow pass band filter is preferred while for motion magnification, broad pass band is preferred. Two first order low pass IIR filters are used to construct an IIR band pass filter having cut off frequencies ωl and ωh. Low order IIR filters are useful for colour as well as motion magnification.
The above Eulerian based Linear approximation method to magnify motion is simple and fast.
It works for magnitude of input signal and not on phase.
A. Limitations:

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2015

- In linear approximation method the noise gets amplify linearly with amplification factor.
- It supports small amplification factors.

IV. PHASE BASED VIDEO PROCESSING USING COMPLEX STEERABLE PYRAMID

Phase based video motion processing is another Eulerian approach which overcomes linear approximation limitations [10].

- It supports larger amplification factor at all spatial frequencies.
- Gives better noise performance than linear method as it deals with phase only.

The phase based motion processing is based on complex valued steerable pyramids [13] is inspired by phase based optical flow. Phase variation corresponds to the local motions in spatial sub bands of image. Aim of this approach is to de-noise phase signal spatially in each sub bands of image and to magnify small motion with less noise. Here the expansion of complex valued steerable pyramids to sub octave bandwidth pyramids is done to amplify the small motions. In order to increase spatial support of filter and motion magnification, it extends to sub octave bandwidth filters. An image is decomposed according to spatial scale, orientation and position. The framework of phase based motion processing is shown in figure 2.

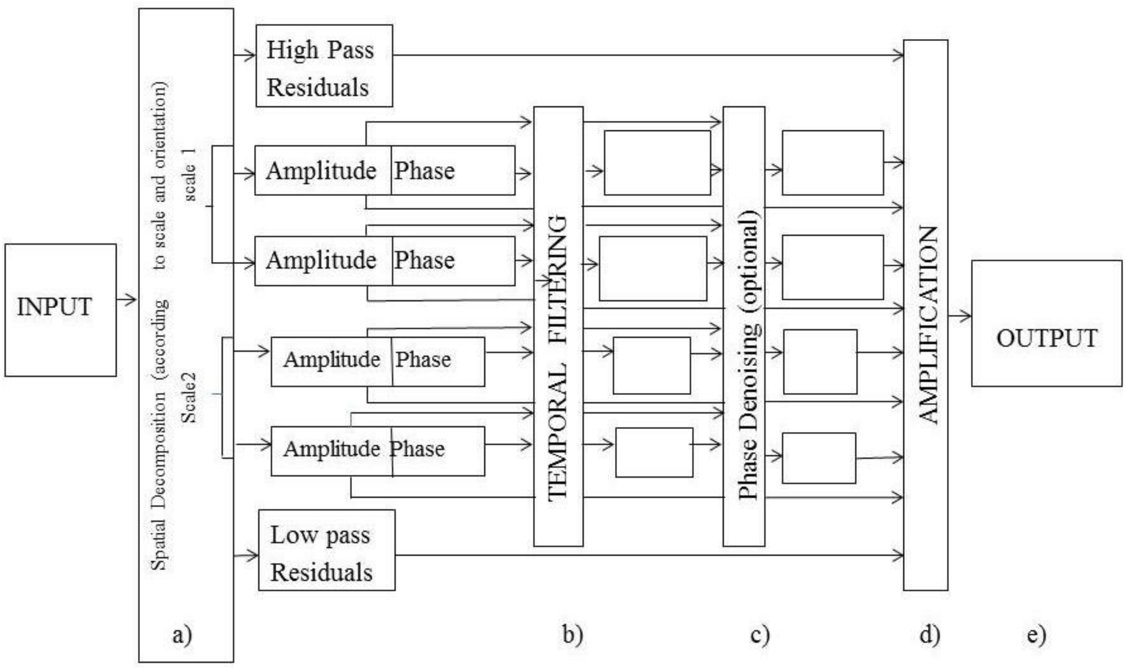

Fig2.Process for phased based video motion magnification [10]
a) Decomposition of video and separation of amplitude from phase. b) Temporal filtering at each location, orientation and scale. c) Phase denoising to increase phase SNR. d) Amplify or attenuate temporally bandpass phase. e) Reconstruction of video.

Here we compute local phase over time at every spatial scale and orientation of steerable pyramid. Then, phases are passed through temporal bandpass filters to filter out the specific temporal frequencies and any temporal DC component. As these bandpassed phases correspond to motion, we multiply the bandpassed phases by some amplification factor α. Then we use the amplified phase differences to magnify the motion for each frame.
The limits of α for octave-bandwidth (for 4 orientation) steerable pyramid is [13],

$$\alpha\, \delta(t) < \frac{\lambda}{4}$$

and from N.Wadhwa et al. [10] limits of α for half-octave (for 8 orientation) pyramid is

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2015

$$\alpha\, \delta(t) < \frac{\lambda}{2}$$

V. FAST PHASE BASED VIDEO PROCESSING USING RIESZ PYRAMID

The new image representation, Riesz pyramid is suitable for Eulerian phase based video magnification processing. It produces motion magnified videos of comparable quality and executes videos in quarter of time than complex steerable pyramid used by Wadhwa et al. [10]. The entire process is done in spatial domain to avoid spatial wrap-around artifacts present in frequency domain [11]. It uses the Riesz transform to do phase analysis on all scales of an input image.

Riesz pyramid is constructed by decomposing image into non-oriented sub-bands [11]. It uses an efficient, self-invertible image pyramid (similar to Laplacian pyramid) and then Riesz transforms is applied to each sub band [12, 14]. The invertible image pyramid with wider impulse response can be constructed using low pass and high pass filter pair [11]. Riesz transform (RT) is a two-dimensional generalised form of one-dimensional Hilbert transforms and constructed by using two three-tap finite difference filters [11, 14]. RT allows computing a quadrature pair (90 degrees) phase-shifted with respect to the dominant orientation at every pixel. The block diagram for motion magnification using Riesz pyramid is given in fig 3.

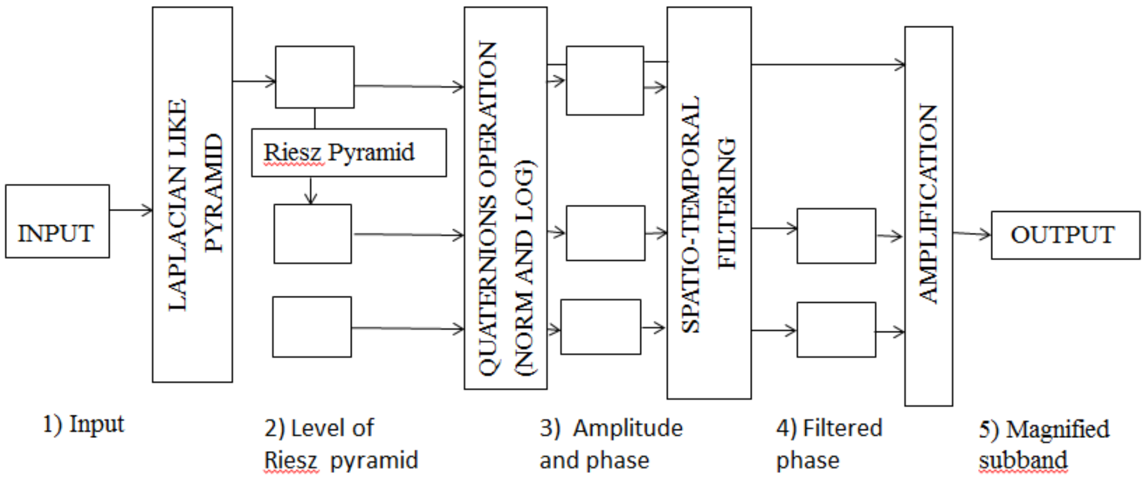

Fig 3. Stages for motion magnification using Riesz pyramid [15].
(a) Input video (b) Decomposition using a Laplacian-like pyramid (only one level is shown). The Riesz transform is taken to produce the Riesz pyramid. (c)The quaternion norm is used to compute the amplitude (top row) and the quaternion logarithm is used to produce the quaternionic phase (bottom rows). (d) The quaternionic phase is spatio-temporally filtered to isolate motions of interest and then this quantity is used to phase-shift the input Riesz pyramid level to produce a motion magnified subband (e). These subbands can then be collapsed to produce a motion magnified video (not shown).

Using the spatial domain, Riesz pyramid yields the fastest phase based method. The results shows that this method is four to five times faster than 8 orientations complex steerable pyramid [11, 14]. Also it is less expensive to implement than complex steerable pyramid.

A. Limitations

The approximate Riesz transform does not maintain the power of an input signal like the ideal Riesz transform does which can cause minor artefact.

Main difference between above three methods is listed in below table 1.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2015

	Linear approximation	Phase based motion magnification	Fast phase based video magnification
Decomposition	Laplacian pyramid	Complex steerable pyramid	Riesz pyramid
Limits of amplification factor (α)	$(1+\alpha)\delta(t) < \lambda/8$	$\alpha\delta(t) < \lambda n/4$	Similar as complex steerable pyramid
Noise	Magnified	Minimized	Minimized
Over-complete	4/3 [3]	$\frac{2k}{(1-2^{-\frac{2}{n}})}$	4 times overcomplete than complex steerable [11]
Exact for	Linear ramp [3]	Sinusoid [10]	Sinusoid [11]

Table1. n - Number of filters per octave for each orientation.
K - Number of orientation bands.

VI. Enhanced Eulerian Video Magnification (E2VM)

Le Liu et al. [15] proposed a new post processing technique to surpass the Eulerian video magnification given by EVM. In this method, EVM is used as video spatial-temporal motion analyser to gain pixel-level motion mapping. As E2VM process does not involve pixel modification, it supports large amplification and is less influenced by noise. The block diagram of E2VM is given in fig.4.

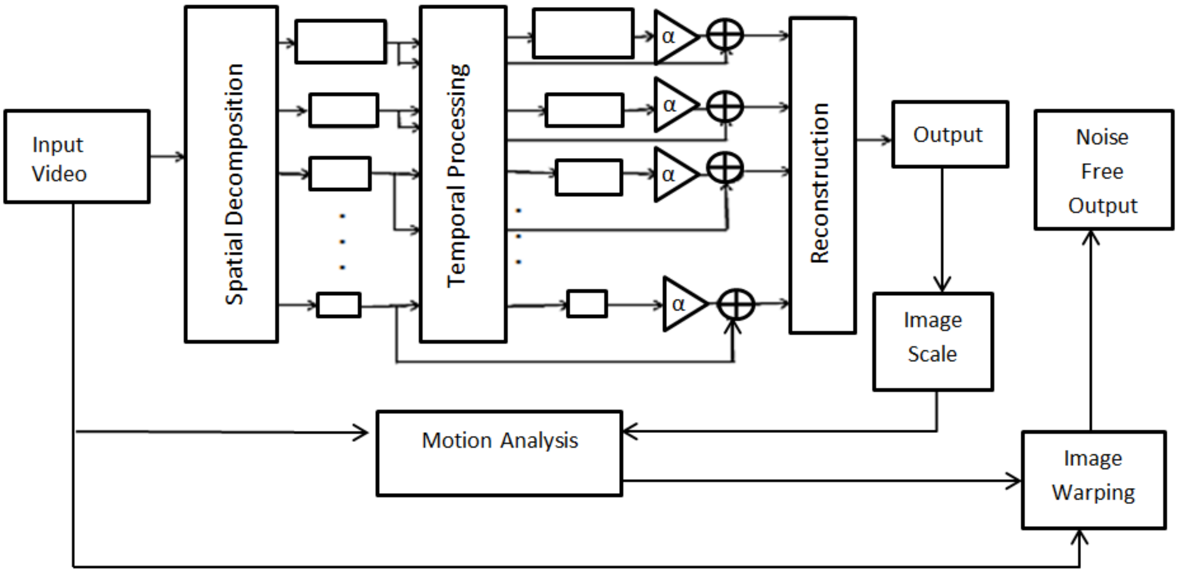

Fig4. Overview of the E2VM framework [16]

Pixel level motion mapping is calculated by taking the difference between input video and EVM processing result. Using image warping, we can amplify video motion by warping some frame pixels across motion mapping direction. In order to boost the video processing speed, motion mapping is sub-sampled to get a spares grid. E2VM allocates a better way to handle noise of EVM. E2VM method involves sparse grid image warping and only small resolution image difference calculation. Though it does not increase additional computation time but still has some advantages like support for larger amplification factors with fewer artefacts and less noise compared to EVM.
Using negative motion mapping, E2VM method can also be used to remove small motions of video for applications, such as motion de-noising [3], de-animating and video stabilization.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2015

VII. CONCLUSION

Eulerian based linear approximation method magnify the subtle colour and invisible motions by using spatio-temporal process to reveal both imperceptible spatial signals and temporal colour changes of video. This method is simple and fast but have some limitations. Phase based video processing using complex steerable pyramid analyses the local phase over time at different scales and orientaion for processing small motions and amplifies the temporal phase differece in corresponding band. Phase based technique produces noise free results and high quality photo realistic videos with amplified motion. Fast phase based video processing uses Riesz pyramid which is mainly focus on speed in phase based video magnification without reduction in quality. Riesz pyramid allows real-time implementation of phase based motion magnification.Enhanced Eulerian video magnification magnifies the temporal video motion by image warping based-on the previous motion mapping. E2VM presents an efficient and noise free motion magnification method by spatio-temporal filtering and image warping.

REFERENCES

1. Verkruysse, W., S vaasand, L. O., Nelson, J. S. :'Remote plethysmographic imaging using ambient light.' Opt. Express 16, 26, 21434–21445, 2008
2. Poh. M. Z., M. Ccduff, D. J., Picard, R. W.: 'Non-contact, automated cardiac pulse measurements using video imaging and blind source separation.' Opt. Express 18, 10, 10762–10774, 2010.
3. Wu H, Rubinstein M, Shih E, et al.: 'Eulerian Video Magnification for Revealing Subtle Changes in the World.' ACM Transactions on Graphics. 2012, 31(4): 65.
4. Liu, C., Torralba, A., Freeman, W. T., Durand, F., Adelson, E. H.: 'Motion magnification.' ACM Trans.Graph. 24, 519 –526, 2005
5. Fuchs, M., Chen, T., Wang, O., Raskar, R., Seidel, H. -P.,Lensch, H. P.: 'Real-time temporal shaping of high speed video streams.' Computers & Graphics 34, 5, 575–584, 2010.
6. Shou-Ling Peng and Gkrard Medioni.: 'Spatio-temporal Analysis for Velocity Estimation of Contours in an Image Sequence with Occlusion.' Pattern Recognition, 1988., 9th International Conference on , Nov 1988 ,pp.236 - 241 vol.1
7. R. C. Bolles and H. H. Baker.: 'Epipolar-Plane.:'Image Analysis: A Technique for Analyzing Motion Sequences.' Proceedings of the Third Workshop on Computer Vision: Rep resentation and Control, October 1985, pp. 168-178.
8. Wang, J., Drucker, S. M., Agrawala, M., Cohen, M. F.: ' The cartoon animation filter.' ACM Trans. Graph.25, 1169–1173.
9. Horn, B., Schunck, B.: 'Determining optical flow' Artificial Intelligence Laboratory, Massachusetts Institute of Technology, Cambridge, MA 02139, U.S.A. 17, 1-3, 185–203.
10. Wadhwa, N., Rubinstein, M., Durand, F., Freeman, W.: 'Phase-based Video Motion Processing.'ACM Trans. Graph. 32, 4, Article 80 (July 2013).
11. N. Wadhwa, M. Rubinstein, F. Durand, and W. T. Freeman.: 'Riesz pyramid for fast phase-based video magnification.'In Computational Photography (ICCP), 2014 IEEE International Conference on. IEEE, 2014.
12. Burt, P., Adelson, E. 1983. : 'The Laplacian pyramid as a compact image code.' IEEE Trans. Comm. 31, 4, 532–540.
13. Simoncelli, E. P., Freeman, W. T.:'The steerable pyramid: a flexible architecture for multi-scale derivative computation.' In Proceedings of the 1995 International Conference on Image Processing (Vol. 3)-Volume 3 - Volume 3, IEEE Computer Society, Washington, DC, USA, ICIP '95, 3444, 1195.
14. M. Felsberg and G. Sommer.: 'The monogenic signal'. IEEETrans. Signal Process. 49(12):3136–3144, 2001.
15. Wadhwa, N. ; CSAIL, MIT, Cambridge, MA, USA ; Rubinstein, M. ; Durand, F. ; Freeman, W.T..: 'Quaternionic Representation of Riesz pyramid for fast phase-based video magnification.' IEEE International Conference on In Computational Photography (ICCP), 2014.
16. Le Liu , Lu L, Jingjing Luo ,Jun Zhang, Xiuhong Chen.: 'Enhanced Eulerian video magnification.' 7th International Congress on Image and Signal Processing (CISP), oct.2014.

BIOGRAPHY

Kranti Sadashiv Kambleis a M.tech student in the Electrical Department, VJTI, Mumbai University.Her research interests are Signal Processing and Image Processing.

Nitin Kundalik Jagtapis a M.tech student in the Electrical Department, VJTI, Mumbai University. His research interests are Image Processing, Embedded and Computer Communication.

R.A Patilis associate professor in the Electrical Department, VJTI, Mumbai University. His research interests are Signal Processing.

Ankit Bhurane is a Phd student in the Electrical Department, IIT, BOMBAY. His research interests are Image Processing andSignal Processing.