REAL TIME MOTION MAGNIFICATION

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ABSTRACT

REAL TIME MOTION MAGNIFICATION

There are certain vital changes in this world that cannot be perceived with the naked human eye such as pulsation in wrist , color changes on face due to blood perfusion, motion of head due to breathing etc. Real-Time Motion Magnification aims at magnification of these changes using digital image processing techniques in real time. The technique used is Eulerian video magnification which has at least two times the efficiency and accuracy as compared to previous video magnification techniques. It is an inexpensive , easy to use and portable technique which can magnify minute details and small variations. Hardware will be implemented on Raspberry Pi kit using Python. Camera and LCD are integrated for recording and display.

DEDICATION

This thesis is dedicated to our supervisor Lt. Col. Dr. Abdul Ghafoor for his endless support and efforts and to our families for their affection and blessings.

CERTIFICATE OF CORRECTNESS AND APPROVAL

It is certified that the work contained in the thesis titled "Real time Motion Magnification", carried out by NC Reem Javed, NC Kinza Behram, PC Rabia Naseem and NC Sehel Asif under the supervision of Lt Col Dr Abdul Ghafoor in partial fulfilment of Degree of Bachelor of Electrical (Telecom) Engineering, is correct and approved.

Approved By:

Lt. Col. Dr. Abdul Ghafoor

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ACKNOWLEDGMENT

We are grateful to ALLAH, who has given us guidance, strength and enabled us to accomplish this task. The journey on this road of success had not been possible without His will, and henceforth, all this success and accomplishment, we owe it to Him, in totality.

We are also grateful to our parents and family and well-wishers for their untiring support. We would like to thank our supervisor Lt Col Dr Abdul Ghafoor and co-supervisor Dr Mohsin Riaz for their help and motivation throughout the course of our project. Without their help we would have not been able to accomplish anything. Under their guidance, we were able to achieve our goals.

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KEY TO ABBREVIATIONS

LCD	Liquid Crystal Display
OpenCV	Opensource Computer Vision
IIR	Infinite Impulse Response
MATLAB	Matrix Laboratory
RAM	Random Access Memory
USB	Universal Serial Bus
SD	Secure Digital
GB	Giga Byte
PIL	Python Imaging Library
DC	Direct Current
CSI	Camera Serial Interface
RGB	Red Green Blue
ScipPy	Scientific Library for Python
bpm	Beats Per Minute

CHAPTER 1

INTRODUCTION

1.1. BACKGROUND/MOTIVATION

There are certain vital changes in this world that cannot be perceived with the naked human eye such as pulsation in wrist, color changes on face due to blood perfusion, motion of head due to breathing etc. Our focus is using image processing techniques to magnify these significant changes for analysis and use in various fields such as military, medical, chemical etc.

1.2. PROJECT DESCRIPTION AND SALIENT FEATURES

Our project actually focuses on magnification of such changes in this world that cannot be perceived by naked human eye. Our aim is to magnify these significant invisible colour changes and motions around us for analysis and use in the fields of Medicine, Military and Chemistry. Our entire project will be implemented on a raspberry pi kit as a standalone system, operating in real-time. A camera will capture the video at 25 frames / second. After extremely efficient quality improving processing, the motion magnified output is displayed simultaneously on the LCD screen with the original video.

1.3. PROJECT SCOPE, SPECIFICATIONS AND DELIVERABLES

The scope of this project is very vast. It will be useful in variety of applications including medical (non-contact pulse counting, vessel extraction), military (intrusion detection by enhancing small movements of hidden enemies), agriculture (time lapse videos), chemical, microscopy and microbiological applications.

1.3.1 OBJECTIVES

The academic objective of the project is to expertise in the fields of digital image/video enhancement and signal processing.

1.3.2 SPECIFICATIONS

The hardware specifications include:

- Raspberry Pi Kit
- Camera
- LCD
- Mouse
- Keyboard

The software specifications include:

- Raspbian Wheezy as an operating system.
- Python.
- OpenCV

1.3.3 DELIVERABLES

The final deliverables of our project \will be the development of above mentioned hardware and software system for real-time motion magnification. The input and output videos will be shown on an LCD.

CHAPTER SUMMARY:

There are certain small changes in this world that cannot be perceived with the naked human eye and need to be magnified to be utilized in different fields. This project aims at the magnification of these changes using Image Processing techniques and implementation is done on Raspberry Pi kit.

CHAPTER 2:

LITERATURE REVIEW

Video processing applications manipulate frames from video sequences. Motion detection and estimation of object in videos play an important role in object tracking, detecting regions of motion in video. However, there are some motions which fall below the humanly acceptable video spectrum. These invisible variations (like breathing pattern, colour changes in chemical reactions, movement of micro-organisms) may reveal important information. Therefore, it is desirable to enhance these changes, so that they can be observed easily without any technical aide.

2.1 LANGRANGIAN APPROACH TO MOTION MAGNIFICATION:

Liu et al. [3] proposed a motion magnification technique that groups together similar pixels on the basis of their colour and motion. Pixels in segmented areas are then magnified by the user specified factor. Magnified video highlights small motions which were previously invisible. Due to magnification in some areas, unwanted holes are created, which are filled by texture synthesis. This technique enhances small motions only in the specified area. Inspired by their approach, [10] magnified mechanical movements in cartoon animation filter. The filter adds the self-inverted version of second derivative of input signal. Filtered motions are exaggerated and more animated as compared to original motions. However, both of these techniques use Langrangian approach [11] for motions estimation. In Langrangian motion estimation, entire motion trajectory of an object is observed, approach commonly used in fluid dynamics. This approach is not only computationally expensive as motion is estimated explicitly, but may produce incorrect results due to errors in motion estimation.

2.2 EULERIAN APPROACH TO MOTION MAGNIFICATION:

To overcome the problem of costly motion estimation, use of Eulerian approach was proposed [12] for magnification in videos. In Eulerian approach, motion of object is observed at a specific location with the passage of time. In [12], motion is not explicitly estimated, but magnified in specific temporal frequency band of interest.

In literature, there has been work done on temporal processing [13,14], where [21] used temporal filters to dampen effects of temporal aliasing per pixel in high speed video streaming (given output in real time) and [19] introduced the concept of pulse rate extraction by exploiting temporal aliasing (from skin colour variations in face).

Wu et al. [12] combined temporal and spatial processing and decompose video sequence spatially decomposed into Laplacian pyramids. To extract the frequency band of interest, each spatial band is passed through a temporal filter and then multiplied by a magnification factor to reveal imperceptible motions. Although linear magnification technique [12] provides robustness. However, the quality of magnification is dependent upon magnification factor. For high spatial frequencies, as magnification factor is increased, unwanted/noise artefacts are introduced. To eliminate noise from videos, introduced due to large magnification factor, [19] proposed the use of steerable pyramids [16] in spatial decomposition. They also provide qualitative comparisons with linear magnification [12]. However, Laplacian pyramids used in [12] are computationally faster than steerable pyramids and for some videos produce better magnification than [19]. *Wadhwa et al.* [22] proposed phase-based magnification for videos using complex steerable pyramids. Local-phase variations are measured and then temporally filtered to magnify frequencies in interest band to amplify minute variations without introducing noise. Magnification in variation of local phase of coefficients of complex steerable pyramid support large magnification are 21 times costly to implement and require extra filter taps for construction. The increased computational cost and over completeness of steerable pyramids make [22] inefficient [14].

To remove over completeness of complex steerable pyramids and to improve efficiency. [14] used Riesz pyramid (invertible octave bandwidth pyramid) for spatial decomposition. Their proposed technique is twice faster than [22] and produce much better quality magnified outputs than [14]. As approximate Riesz pyramid cannot maintain the power of original signal, artifacts are introduced, which require extra smoothing effect. Also, they produce noisy effects for large magnification factor and incorrect results in high spatial frequencies. Eulerian video magnification [12] magnifies small motions to reveal hidden information around us. For example, in medical field, heart rate can be extracted from magnification of face colour variations as blood fills the face [20] or head motions due to blood circulation can also be enhanced to measure heart rate [21]. Heart rate calculated from these techniques is comparable to ground truth collected from hospital [12]. These contactless techniques to measure vital signs are also useful for patients in remote areas. In the work of [19], a robot is built for old age people living alone, which can easily manoeuvre through home and analyzes video feed to measure vital signs by using Eulerian magnification. This technology can also be used to enhance movements in chest which were hardly visible before, to monitor breathing patterns of infant babies [12].

Besides medical field, this technique can be applied to other fields as well. For example it can be used for security purposes. In [22] enhanced facial features in face spoofing algorithm for biometric systems. Eulerian magnification when used as a pre-processor , effectively and efficiently enhances micro and macro changes in facial expressions, so any variation can be easily detected using spoofing detecting algorithms. Eulerian magnification can also be used to magnify small gaps and imbalances in mechanical structures . Any particular pixel in a frame of video captured from sensors is magnified using Eulerian magnification and then analyzed to amplify frequency of vibration. However, they can only determine frequency of vibration and not its amplitude. Small vibrations are produced in an object due to sound. Similarly, sound can be recovered from these minute vibrations by enhancing them using phase-based Eulerian video magnification [22]. Quality of recovered sounds were then compared with original sounds producing them. They demonstrated an effective technique to recover sound from standard videos.

2.3 EXISTING EULERIAN MOTION MAGNIFICATION:

Videos have usually small amplitude motions and signals which are not visible to naked eye. These hidden signals may contain useful information such as heart beat or changes in colour of skin due to blood circulation. These minute changes can be enhanced to extract desired information.

We et al [12] proposed Eulerian video magnification to extract these hidden signals. Eulerian magnification is inspired by Eulerian approach in fluid dynamics [11], in which motion of particle is observed at a specific location. Based on this approach, change is magnified at a specific location instead of motion tracking. This not only saves computational time but also reveals imperceptible changes.

Eulerian video magnification is a combination of spatial and temporal processing. Each frame of respective video sequence is decomposed into spatial bands using Laplacian pyramids or Gaussian pyramids. Gaussian pyramid can be simply formed by the successive down sampling of the image by the factor of 2 and by calculating Gaussian average of each pixel. Laplacian pyramid is formed by taking difference of adjacent low pass images in Gaussian pyramid. Full Laplacian pyramid is computed. Spatial decomposition is performed to reduce the computational complexity, as each spatial band is of different spatial resolution and to increase signal-to-noise ratio.

Every spatial band is then passed through a temporal band pass filter to extract signals of our interest. Choice of filter depends on type of application and desired information which has to be magnified. For colour amplification, ideal filters are used, Due to their narrow pass band and sharp cut-off frequency, they produce noise free colour amplification. Infinite Impulse Response filters (IIR) have broad pass band and they amplify both colour and motion variations. For example, to determine pulse rate or movements in chest due to heart beat, IIR filter with pass band 0.05 - 0.4Hz corresponding to 40 - 220 bpm can be used. To amplify face colour as blood flows, ideal filter with narrow pass band 0.83 - 1 for 50 - 60 bpm is used.

After temporal filtering, every pixel in each filtered sub band is amplified by a magnification factor B, Magnification factor can be specified by user or it can be calculated from Taylor series expansion [12]. However for high spatial frequencies and large magnification factor, existing Eulerian magnification has some bounds which produce noisy magnified videos for value B above specified bound [12]. Desired magnification for specific video can be obtained by trying different values.

To obtain the final magnified video, spatial pyramid is reconstructed and magnified signal is back into original signal. Magnified final output video reveals small colour and motion variations. Since each and every pixel is filtered and magnified, processed video implicitly maintains the spatial and temporal smoothness of natural videos.

2.4 LIMITATIONS OF EXISTING EULERIAN MAGNIFICATION:

Existing Eulerian magnification [12] has few limitations; it amplifies noise along with motion and produces incorrect motion estimation for high spatial frequencies [17]. Also *Wu et al.* [12] used Laplacian pyramids for spatial decomposition in motion magnification, which utilizes information contained in low pass spatial frequencies only. Hence, reconstructed pyramids are oversampled (by the factor of 4/3 and 2 in one and two dimensions respectively), introducing aliasing effect in transform.

Moreover, this technique has been implemented in MATLAB on recorded videos. It processes the whole frame so it is too slow for real-time implementation. There is no hardware implementation of this technique uptil now.

2.5 PROBLEM FORMULATION:

The existing techniques are slower to be implemented in real-time. Firstly, there is a need to implement Eulerian Magnification in a suitable programming language that will add to its efficiency and robustness. This will also determine the ease of hardware implementation. Secondly, we need to implement efficient and highly effective noise removal techniques to improve its quality. Then we will be using different methods such as grey-scale conversion, spatial size reduction and Alternate Frame processing to increase speed and efficiency of existing technique to make it suitable for implementation in real-time. We will also be implementing the code on hardware (Raspberry Pi kit) to develop an application based standalone system.

CHAPTER SUMMARY:

The previous technique employed for motion magnification was Langrangian. However, Eulerian motion magnification technique is the latest technique which is more efficient than the former. It is employed using suitable programming language to increase its efficiency, robustness and for implementation in real time.

CHAPTER 3:

DESIGN AND DEVELOPMENT

3.1. DESIGN REQUIREMENTS

1. Efficient image processing technique (Eulerian) for video motion magnification.
2. Image processing software tools and libraries (OpenCV).
3. Adequate programming language for efficient, shorter code (Python).
4. Embedded system kit for implementing code.
5. High speed camera, display screen (LCD), keyboard and mouse.
6. Kit to display and kit to camera interface.
7. Operating system to be installed on hardware (Raspbian Wheezy).

3.2. DESIGN SPECIFICATIONS:

3.2.1. EMBEDDED SYSTEM KIT

The embedded system kit used is Raspberry Pi 2 model B, also termed as credit card size computer. It has Broadcom BCM2836 Quad Core Processor running at 900MHz and 1GB RAM. Its CSI camera port makes image acquisition fast. It consumes very low power with its micro USB power source. Following is the figure of a Raspberry Pi Kit.

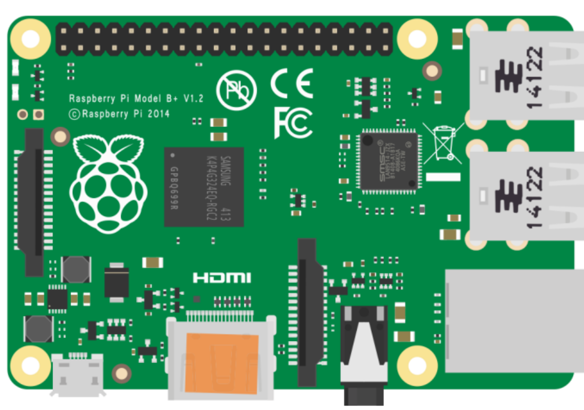

Figure 1: Raspberry Pi 2 model B

3.2.2. OS FOR RASPBERRY PI KIT

Raspbian Wheezy 2015 is one of the latest operating systems for Raspberry Pi kit. It is a Linux-based operating system and is installed on the SD Card of 8 GB memory.

3.2.3. CAMERA

The camera used for video acquisition is Raspberry Pi dedicated Camera. It is a tiny, light weight camera. Following is the figure of a camera.

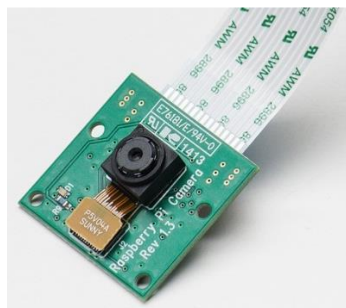

Figure 2: Raspberry Pi Dedicated Camera

3.2.4. PERIPHERALS

Output will be displayed on a 17” LCD. A standard keyboard and a mouse will be attached for the functions like pausing and resuming the recorded as well as amplified videos.

3.2.5. MAGNIFICATION TECHNIQUE

The magnification technique proposed is Eulerian Video Magnification. It includes the implementation of image pyramids and temporal filtering to extract the region of interest. After the extraction, the amplification of the part is done.

3.2.6. IMAGE PROCESSING SOFTWARE AND PROGRAMMING LANGUAGE

The programming language on which we have developed our codes is Python 2.7 and the image processing libraries include OpenCV-2.4.11 and PIL (Python Imaging Library).

3.3. DETAILED DESIGN WITH JUSTIFICATION

In the detailed design the complete hardware of the project including all the required components, flow chart of the algorithm used and its detailed description is mentioned.

3.3.1. HARDWARE DESIGN

As mentioned earlier, the hardware will be including a motherboard as Raspberry Pi Kit with which a mouse, keyboard, dedicated camera and an LCD will be attached. The Raspberry Pi Kit is will be powered by 5V DC charger.

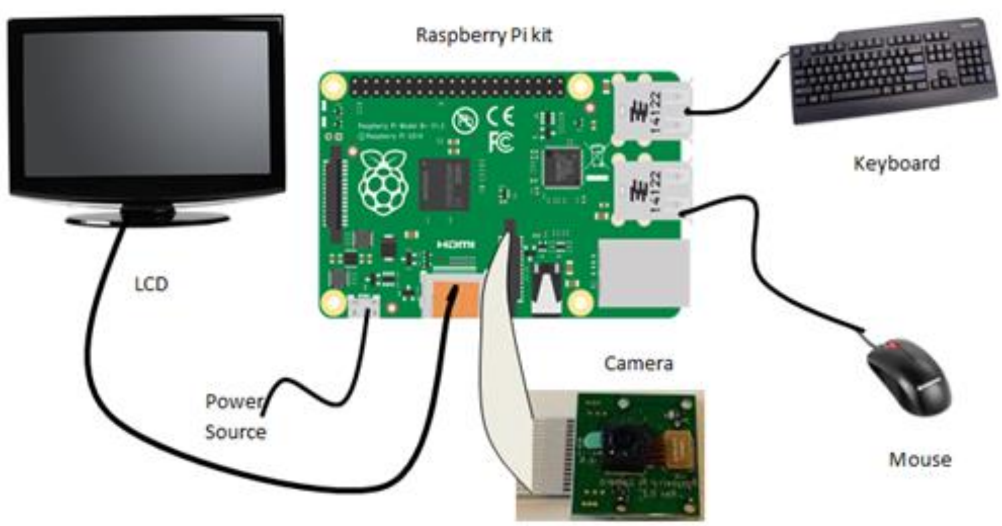

Figure 3: Detailed Hardware Design

3.3.2. FLOW CHART OF ALGORITHM

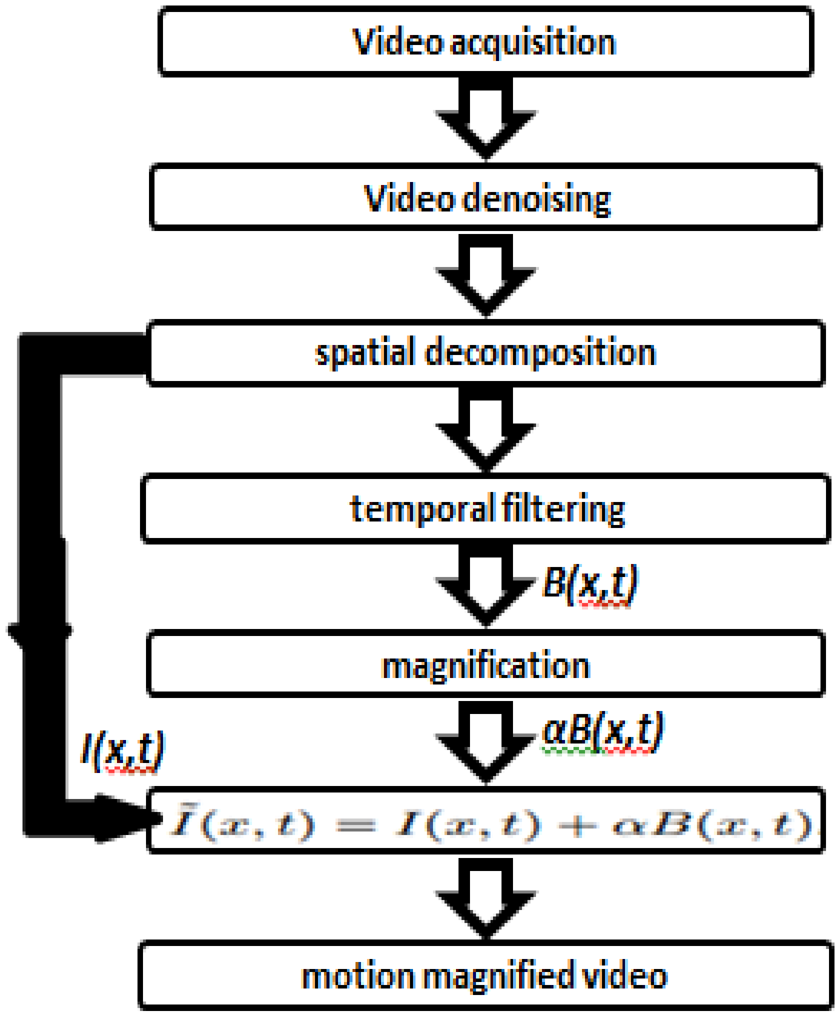

Figure 4: Flowchart of Motion Magnification

3.4. DETAILED DESCRIPTION OF ALGORITHM

3.4.1. VIDEO ACQUISITION

Video is captured in real time using Raspberry Pi camera module at 30 frames per second. The camera is connected to the BCM2835 processor on the Pi via the CSI bus, which carries pixel data from the camera back to the processor at a higher bandwidth. An extremely low power draw, small form factor, no noise, solid state storage, and other features make it an attractive solution for a small and lightweight server.

3.4.2 VIDEO DE-NOISING

The images captured by the camera are usually blur, noisy, have low resolution and irregularities in contrast. Spatial filtering is proposed to remove the noise effectively. Other image smoothing techniques like Gaussian Blurring and Median Blurring are good to some extent in removing small quantities of noise. In these techniques, noise removal at a pixel was local to its neighbourhood. In spatial filtering we use image pyramids that removes noise considerably.

3.4.3 EULERIAN MOTION MAGNIFICATION

Initially a Langrangian motion magnification was proposed which was not only computationally expensive, but also produced incorrect results. Eulerian motion magnification is far more accurate, more efficient and robust as compared to the former techniques.

To magnify small motion in each extracted region of interest, input region with RGB (Red Blue Green) intensities is decomposed into multiple sub-bands at different spatial frequencies using Laplacian pyramids. The required sub-bands are then filtered using Ideal or Butterworth filters. After then the modified magnification factor is multiplied with filtered sub-bands and the magnified signal is added back into the original signal to obtain the final magnified output.

3.4.4 SPATIAL DECOMPOSITION

Spatial decomposition is to decompose *the* image into multiple sub-bands at different spatial frequencies. Laplacian and Gaussian pyramids will be used for spatial decomposition in this technique.

The equivalent existing technique is filtering using a fast Fourier transform. The image pyramid is efficient to compute and faster than the equivalent filtering done with a fast Fourier transform. Tasks can be done rapidly and simultaneously at all scales. The information is also available in a format that is convenient to use, since the nodes in each level represent information that is localized in both space and spatial frequency.

3.4.5 TEMPORAL FILTERING

The required frequencies which are to be magnified are then filtered from the image pyramids through two different types of filters. These filters include Ideal and Butterworth Bandpass filters. The choice of filter is dependent on application.

a) IDEAL BANDPASS FILTER

The ideal filter has flat frequency response in the passband. There is a step function transition from passband to stopband. It also results zero group delay everywhere. Following is the figure that illustrates the concept of ideal bandpass filter.

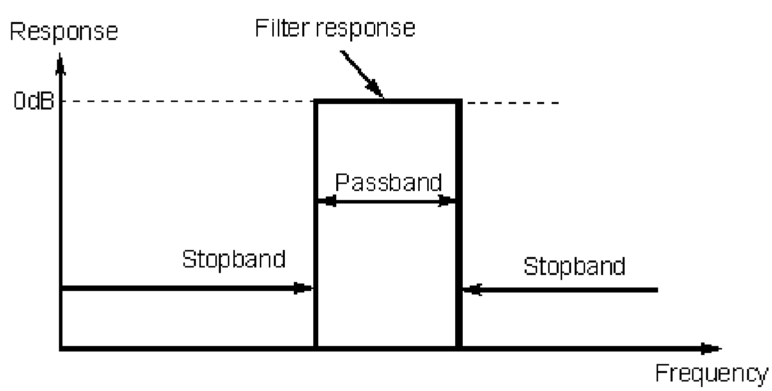

Figure 5: Frequency Response of Ideal Bandpass Filter

Its implementation includes Discrete Fourier Transformation

$$X_k = \sum_{n=0}^{N-1} x_n e^{-i2\pi k \frac{n}{N}} \qquad k = 0, \dots, N-1.$$

After filtering the required frequency components, the inverse is applied.

FFT and IFFT are applied to images using functions from SciPy libraries. Ideal filter is used where sharp response is required, for example, in colour magnification applications.

b) IRR TEMPORAL BANDPASS FILTER

IIR filters have an impulse response which does not become exactly zero past a certain point, but continues indefinitely. In practice, the impulse response approaches zero and can be neglected past a certain point. IIR filters have a memory as they employ feedback.

One simple way to implement an IIR bandpass filter is through subtraction of two lowpass filters.

y1[n] = r1*x[n] + (1-r1) *y1[n-1]

y2[n] = r2*x[n] + (1-r2) *y2[n-1], where (r1 > r2)

y[n] = y1[n] - y2[n]

Here y is the output and x is the input.

The main advantage of digital IIR filters is their efficiency in implementation. If implemented in digital image processing, this implies a correspondingly fewer number of calculations per time step and the computational saving is often of a rather large factor.

c) BUTTERWORTH BANDPASS FILTER

The Butterworth filter has a flat frequency response in the passband and rolls off towards zero in the stopband. It has low group delay variation near centre of band. It is also referred to as a maximally flat magnitude filter.

The governing equation for lowpass Butterworth filter is:

y[n] = (-b2*y[n-1] + a1*x[n] + a2*x[n-1]) / b1

where y is the output, x is the input and a1, a2, b1, b2 are the filter coefficients.

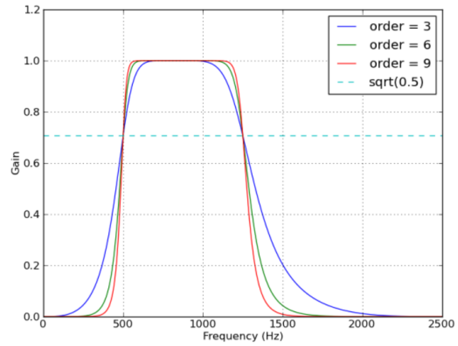

Figure 6: Frequency Response of Butterworth Filter

The advantage of Butterworth filters is their smooth, monotonically decreasing frequency response. It will be implemented in OpenCV-python using Scipy libraries. Butterworth filters are suitable for motion magnification applications, especially in real-time implementation.

It will be implemented in OpenCV-Python using Scipy libraries. Butterworth filters are suitable for motion magnification applications, especially in real-time implementation.

GOVERNING EQUATION FOR MAGNIFICATION

$$\tilde{I}(x,t) = I(x,t) + \alpha B(x,t).$$

where "α" is the amplification factor

ADDITION IN ORIGINAL IMAGE

When the required frequencies from the image are filtered and magnified, they are added to all the levels of pyramid of the original frame. These levels are always of different dimensions. Each level is added to its correspondent magnified level of pyramid. In this way the summation of sub-bands is made. Following is the image indicating the different levels of a pyramid.

RECONSTRUCTION

The final step of the project is the reconstruction of all the levels of pyramid into a single image. This will combine all the sub-bands, filtered and original ones, to each other to form a single frame. In reconstruction, there always remain a chance of addition of unwanted noise in the frames. This issue can be resolved using a de-noising filter at the end. This de-noising is optional. This will only be applied to the final frame if the delay of the processing of frames is unnoticeable. On the other hand, if the delay is highly noticeable, the filter will be skipped from the reconstruction process.

CHAPTER SUMMARY:

This chapter covers the entire design with the detailed description of hardware and software specifications. The video is captured using a Raspberry Pi camera and is denoised using different image processing techniques. To apply Eulerian motion magnification, the frames are first decomposed spatially into Laplacian and Gaussian pyramids. The required frequencies which are to be magnified are then filtered from the image pyramids through different types of filters: Ideal bandpass filter and Butterworth bandpass filter. When the required frequencies from the image are filtered and magnified, they are added to all the levels of pyramid of the original frame.

CHAPTER 4:

DESIGN IMPLEMENTATION AND PROGRESS

The hardware of this project is complete. Different parts of software design are implemented on images first. When successfully implemented on the images, these are implemented in real-time. Finally, these parts will be combined to implement complete algorithm first on recorded videos and then in real-time.

The design implementation achieved up till now is as follows:

4.1 HARDWARE SETUP AND CONFIGURATION

Raspberry Pi is setup, configured and interfaced with peripherals according to the mentioned design.

4.2 REAL-TIME VIDEO ACQUISITION

Real-time video acquisition is performed by interfacing Dedicated Raspberry Pi Camera with the Raspberry Pi kit and accessing it in python through its libraries.

4.3 SPATIAL DECOMPOSITION AND RECONSTRUCTION

Spatial decomposition is implemented using Gaussian and Laplacian pyramids. The code is first tested on images and then applied in real-time. Efficiency and output quality of reconstruction of pyramids decide their use in motion and color magnification.

4.4 TEMPORAL BANDPASS FILTERING

The two types of bandpass filters implemented are ideal bandpass and butterworth bandpass filters. The desired frequency components are extracted by giving cut-off frequencies to the filters. A comparison of their performance is done to determine which filter is suitable for motion and colour magnification.

4.5 AMPLIFICATION OF FILTERED VIDEO

Amplification is implemented by multiplying filtered video with amplification factor before decomposition. Then after decomposition it is added back to original video.

4.6 SAVING OR DISPLAYING VIDEOS

After processing the videos, they need to be saved or displayed in an effective way. The recorded videos after processing are concatenated with original video before saving. The real-time processed videos are displayed simultaneously in separate windows.

4.7 APPLICATION DEVELOPMENT AND OPTIMIZATION

After completing the implementation of technique, we develop its different application such as motion magnification of breathing, color magnification of color changes on face due to blood perfusion.

We also implemented different techniques to improve efficiency and quality of our code.

CHAPTER SUMMARY

This chapter covers the design implementation using Raspberry pi kit. The hardware was configured and the video was captured using the Raspberry pi dedicated camera. To apply Eulerian motion magnification, the frames were first decomposed spatially into Laplacian and Gaussian pyramids. The required frequencies which were to be magnified were then filtered from the image pyramids through different filters. When the required frequencies from the image were filtered and magnified, they were added to all the levels of pyramid of the original frame. The code was first tested on pictures and recorded videos. Then it was implemented for the real time. Different techniques were implemented to improve the efficiency and quality of the processed frames.

CHAPTER 5:

PROJECT ANALYSIS AND EVALUATION

In this demonstration the design implementation will be shown. Different parts of algorithm are first implemented and tested on images, then on recorded videos and in real-time.

5.1 SPATIAL DECOMPOSITION AND RECONSTRUCTION:

Implementation of two different types of Spatial Decomposition is demonstrated.

A comparison of effects of decomposition through Gaussian Pyramids and Laplacian pyramids are also shown.

Figure 7: Original (on the right) and Gaussian pyramid Reconstructed (on left) frames

Figure 8: Original (on the right) and Laplacian pyramid Reconstructed (on left) frames

5.2 MOTION MAGNIFICATION:

5.2.1 TEMPORAL BANDPASS FILTERING:

Temporal bandpass filtering is done using Ideal, Infinite Impulse Response (IRR) and Butter-worth bandpass filters. The extraction of desired frequency components through both the filters is shown

5.2.2 INFINITE IMPULSE RESPONSE (IIR) TEMPORAL BANDPASS FILTER

The frequencies of our interest are extracted using Infinite Impulse Response (IIR) bandpass filter as shown below:

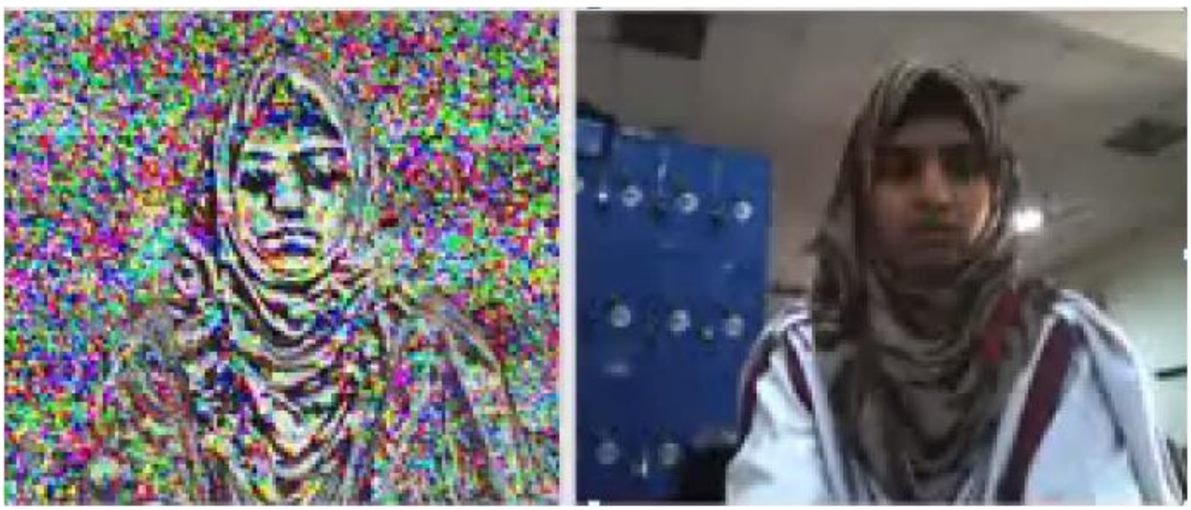

Figure 9: Original (on the right) and filter result (on left) frames

5.2.3 COMBINING LAPLACIAN PYRAMIDS WITH INFINITE IMPULSE RESPONSE (IIR) TEMPORAL BANDPASS FILTER:

The Laplacian pyramids are applied in real time and their output is filtered using Infinite Impulse Response (IIR) bandpass filter. This can be seen in the figure below:

Figure 10: Original (on the right) and Laplacian pyramid combined with IIR filter (on left) frames

5.2.4 MOTION MAGNIFICATION USING INFINITE IMPULSE RESPONSE TEMPORAL BANDPASS FILTER:

Complete implementation of IIR filter for motion magnification gave the desired output.

Figure 11: Original (on the right) and motion magnified using IIR filter (on left) frames

5.2.5 CODE OPTIMIZATION:

The code is optimized to remove noise and a better quality output. This is shown in the figure below:

Figure 12: Original (on right) and motion magnified using IIR filter after optimization (on left) frames

5.2.6 BUTTERWORTH TEMPORAL BANDPASS FILTER:

Motion magnification is also done using Butterworth temporal bandpass filter as it gives better results for many applications.

Figure 13: Original (on right) and Butterworth filter result (on left) frames

5.2.7 COMBINING LAPLACIAN PYRAMIDS WITH BUTTERWORTH TEMPORAL BANDPASS FILTER:

The Laplacian pyramids are applied in real time and their output is filtered using Butterworth temporal bandpass filter. This can be shown the figure below:

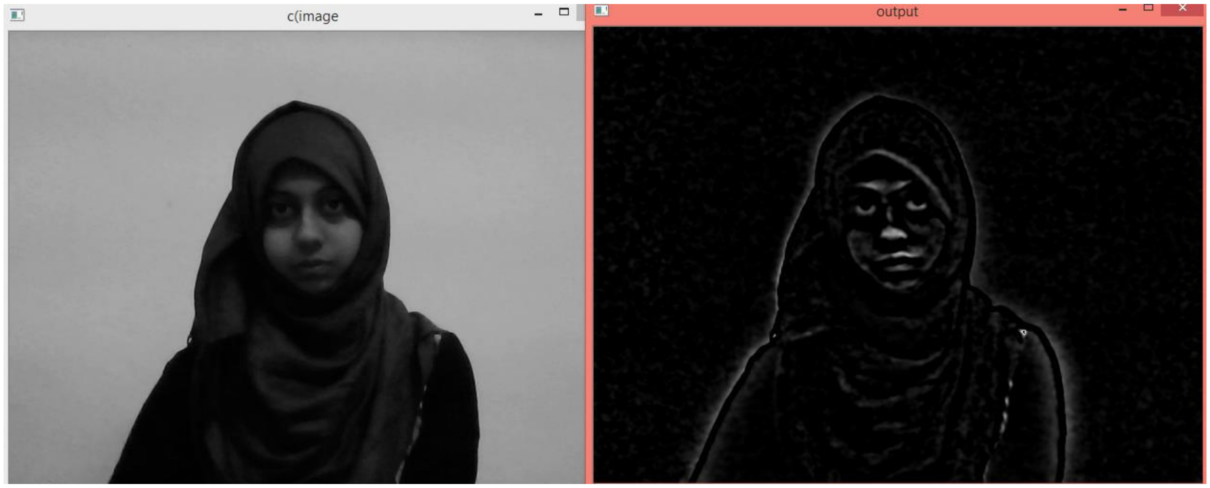

Figure 14: Original (on the left) and Laplacian pyramids combined with Butterworth filter (on right) frames

5.2.8 MAGNIFICATION USING BUTTERWORTH TEMPORAL BANDPASS FILTER:

Complete implementation of Butterworth filter for motion magnification is shown in the figure below:

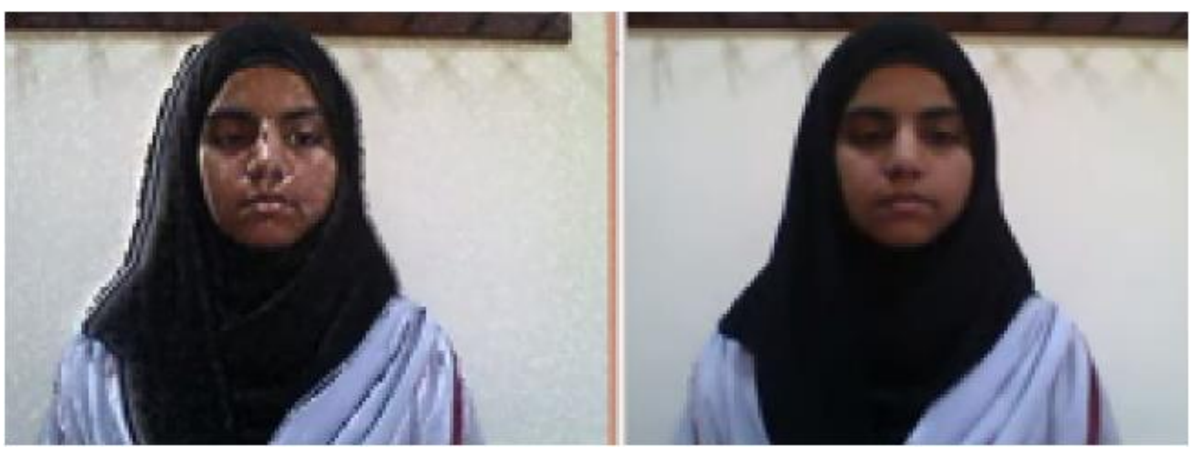

Figure 15: Original (on the left) and motion magnified using Butterworth filter (on right) frames

5.2.9 CODE OPTIMIZATION:

The code is further optimized to get a better quality output with lesser noise.

Figure 16: Original (on the left) and motion magnified using Butterworth filter with optimized code (on right) frame

5.3 COLOR MAGNIFICATION:

Eulerian motion magnification magnifies colorimetric changes without the use of time consuming analysis by other techniques. We provide a robust technique, which can easily detect colorimetric changes at low cost. To extract the maximum information reflected by each color component, frame of video sequence is decomposed into different spatial bands using Gaussian pyramids. As spatial decomposition utilizes information gathered from both course and fine scales of magnification, the final magnified video is reconstructed with high precision.

Figure 17: Color magnification on face due to blood perfusion

5.4 CALCULATING HEART RATE (BEATS PER MINUTE) USING IMAGE PROCESSING:

This is an extension of our project. The camera detects the face of the person in front of it and uses image processing technique on the person's forehead to calculate the heart rate in beats per minute. Heart rate of normal resting heart ranges from 60-100 bpm and 100-150 bpm of active heart. However, if it goes beyond normal range, it might be the symptom of cardiac failure. It processes in real time and has been implemented in Python.

The following pictures show the working of this module.

Figure 18: bpm indicated on forehead

CHAPTER SUMMARY

This chapter covers the entire progress of the project through different stages. The project has three phases: Motion magnification, Color magnification and calculation of heart rate (beats per minute) using image processing. The implementation at each stage is shown in figures.

CHAPTER 6

RECOMMENDATIONS AND CONCLUSIONS

6.1 RECOMMENDATIONS FOR FUTURE WORK

For future directions, it is recommended:

- To explore use of eulerian magnification in different domains to highlight minute changes which cannot be seen with naked eye.
- To find different spatial decomposition methods for color magnification in videos and enhance color changes with more precision.
- To make this implementation more efficient in speed and processing by using the advanced kits in the near future which support the Linux-based operating systems and have better processing speed than Raspberry Pi 2.

6.2 CONCLUSION:

The completed project of ours is now capable of magnifying the small changes that could not be perceived with the naked human eye. Now the pulse and breathing can be detected in real-time very easily. The heart rate is calculated in beats per minute. Moreover, such codes are also developed with which the colour changes in the body due to the flow of blood can be seen.

6.2.1 LIMITATIONS:

The project also has some speed limitations like the Raspberry Pi Kit is unable to run the code smoothly and properly if the code is complex and comprises of too many libraries and functions. This is due to the limit of the processor speed and RAM of the Kit.

6.2.2 APPLICATIONS:

The applications of this project include Vital Signs Extraction, Pulse rate Extraction, Detection of frozen body parts, Micro-organisms Observation, Colorimetric Change Detection. Thus this project will be useful in variety of applications including medical military (intrusion detection by enhancing small movements of hidden enemies), agriculture (time lapse videos), chemical, microscopy and microbiological applications.

CHAPTER SUMMARY:

This chapter covers the recommendations for the future work on this project. The limitations of the project are described. Moreover, different applications are enlisted which can be implemented using this technique for further utilization in different fields.

CHAPTER 7:

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APPENDICES:

APPENDIX A: SYNOPSIS – REAL TIME MOTION MAGNIFICATION

Extended Title: Real time magnification of subtle movements invisible to the naked human eye
Brief Description of The Project / Thesis with Salient Specifications: This project aims at magnification of insignificant motion invisible to the naked human eye in real time.
Scope of Work: The project will be useful in variety of application including medical (non-contact pulse counting, vessel extraction), military (intrusion detection by enhancing small movements of hidden enemies), agriculture (time lapse videos), chemical, microscopy and microbiological applications.
Academic Objectives: The academic objective of the project is to expertise in the fields of digital image/video enhancement and signal processing.
Application / End Goal Objectives: Development of hardware and software system for real-time motion magnification.
Previous Work Done on The Subject: Motion magnification in videos is a state of the art research area. However, no such prototype is already available at national or international markets.
Material Resources Required: Raspberry Pi kit, LCD, camera, keyboard/mouse
No of Students Required : 4 **Group Members:** NC Reem Javed , NC Kinza Behram, NC Sehel Asif, PC Rabia Naseem
Special Skills Required: Programming skills

Approval Status:

Supervisor Name and Signature : Lt. Col Dr Abdul Ghafoor ___________________________

Co-Supervisor Name :Dr Muhammad Mohsin Riaz (COMSATS)

Assigned to : NC Reem Javed, NC Kinza Behram, NC Sehel Asif, PC Rabia Naseem