CARDIOVISION

REAL-TIME NON-INVASIVE CONTACT-LESS HEART RATE DETECTION UNDER ADVERSARIAL CONDITIONS

Team PANDAVAS Members

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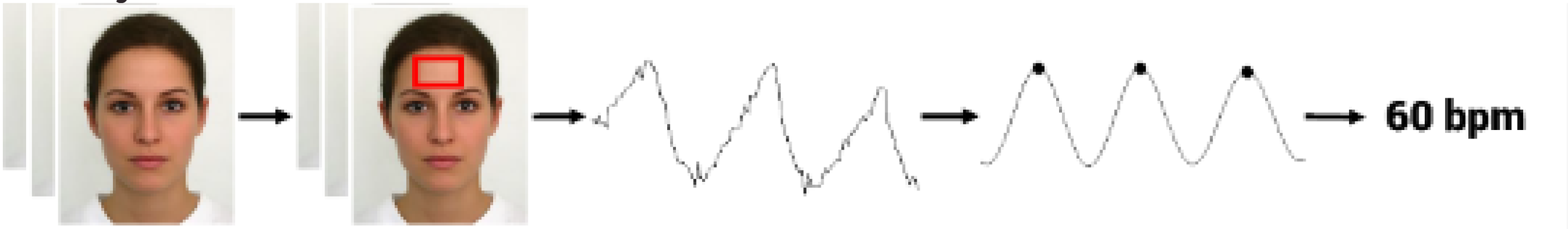
Problem Statement

- The problem statement is to develop a deep learning-based system for contact-less heart rate detection from real-time video in adverse conditions.
- Most of the traditional methods for measuring heart rate require physical contact with the user, which can be uncomfortable and inconvenient.
- Therefore, the proposed system aims to provide a non-invasive and user-friendly solution for heart rate detection.
- The system should be able to accurately detect heart rates from real-time video data, which can be captured using various devices such as smartphones, webcams, and security cameras.



Problem Statement

- However, detecting heart rates from video data presents several challenges.
- Firstly, the video data may have low-light conditions that can affect the accuracy of the heart rate detection.
- Additionally, the video data may contain motion artifacts that can make it difficult to detect the heart rate accurately.
- Therefore, the system needs to be able to handle such adverse conditions and provide accurate heart rate measurements.

Literature Review

- **Heart Rate Measurement Using Face Detection in Video** – This paper had presented a solution that works on live video streams. However, it uses both face detection and object tracking which has a reduced computational time. But it did not work on low quality video and the accuracy was influenced by the distance between the camera and object.
- **Real Time Video based Heart and Respiration Rate Monitoring** - this paper had provided a real-time HR and RR monitoring method based on the change in the Hue channel in the HSV color space. However, it did not investigate the impact of different colors of the skin on the ability of the proposed technique. Also, it did not take into consideration the lighting conditions and motion artifacts.
- **Real-Time Webcam Heart-Rate and Variability Estimation with Clean Ground Truth for Evaluation** - an unsupervised method for rPPG analysis that achieves high accuracies on several public datasets, but faces challenges in extreme cases such as overtly bright or flickering lighting and large head and body movements (e.g., during exercising), proved challenging for the unsupervised rPPG analysis method. Additionally, HR analysis during high facial arousal was marginally challenging.

Literature Review

- **Effects of Lighting and Window Length on Heart Rate Assessment through Video Magnification** - The accuracy of contactless heart rate measurement using Video Magnification was found to vary with lighting condition and time window duration. The study found that participant movement across videos affected the accuracy of heart rate detection via Video Magnification. This suggests that the method may not be as reliable in real-world scenarios where subjects may not remain still.
- **EnlightenGAN: Deep Light Enhancement without Paired Supervision**- proposed a GAN-based approach for low-light image enhancement without paired supervision. Compared to traditional methods such as Retinex and gamma correction, the proposed EnlightenGAN can generate more visually pleasing and realistic images with better texture and color information.
- **LEIS: A Low-Light Image Enhancement System using Generative Adversarial Networks** -proposed a GAN-based approach to low-light image enhancement, which can effectively preserve the details and edges of the images while reducing noise and enhancing brightness. The proposed method was shown to outperform traditional image enhancement methods, such as gamma correction and histogram equalization, in terms of both visual quality and objective metrics.
- **Multi-level Attention Network for Low-light Image/Video Enhancement" by W. Ren et al -** This paper proposes a multi-level attention network (MLAN) that integrates global and local features for low-light image and video enhancement. The MLAN employs a GAN-based adversarial loss to produce visually pleasing results while preserving image details.

Literature Review

- **Assessment of ROI Selection for Facial Video-Based rPPG** - The selection of the region of interest (ROI) is crucial for accurate heart rate measurement in remote photoplethysmography (rPPG) as the thickness of the skin affects the result. In this study, they concluded that forehead and cheeks provide more accurate results.
- **Deep Video Stabilization with Multi-Grid Warping Transformation Learning** - The proposed method is a deep learning-based video stabilization method that learns to perform multi-grid warping transformation for frame alignment. The method may not work well on videos with extreme motion or large camera shakes, as it is primarily designed to align frames using warping transformation.
- **Heart Rate Measurement Using Facial Videos** - In this paper, a methodology for measuring heart rate using person's facial image was implemented. BBHE technique was applied to minimize low light effect which may also introduce artifacts and noise.
- **Contact-Less Heart Rate Detection in Low Light Videos** - This paper discusses the benefits of remotely measuring heart rate and proposes a new approach using a convolutional neural network to analyze time-series color variation data for autonomous heart rate monitoring. The proposed method works well even in low-light conditions and has been compared to a heuristic signal processing approach.

Literature Review

- **Learning Video Stabilization Using Optical Flow" by Yanchao Yang, Deqing Sun, Huaizu Jiang, and Ming-Hsuan Yang (ICCV 2017**): This paper proposes a video stabilization method that learns to estimate the camera motion using optical flow. The method includes a CNN-based motion estimation module and a stabilization module that uses the estimated motion to stabilize the frames.
- **Low-Light Video Enhancement Using Generative Adversarial Networks With Channel Attention" by Yang Li, Shangwen Liang, and Shiqi Wang (IEEE Access 2019)**: This paper proposes a GAN-based video enhancement method that includes a channel attention mechanism to improve the contrast and color balance of low-light videos. The method includes a generator network that produces enhanced frames and a discriminator network that distinguishes between the enhanced frames and the ground truth frames
- **Heart Rate Measurement Combining Motion and Color Information (2022):**The paper "Combining Motion and Color Information for Heart Rate Estimation Using RGB Camera" proposes a method to estimate heart rate using an RGB camera. The method combines motion and color information, achieving an average absolute error of 2.68 BPM and a correlation coefficient of 0.86 between the estimated and ground truth heart rates.
- **Heart rate prediction from facial video with masks using eye location and corrected by convolutional neural networks** -The paper proposes a HR detection method that combines traditional methods with deep learning to solve the problem of lack of facial information and unstable output. They also designed a method to create a mask dataset to test the effectiveness of their algorithm and concluded that their proposed algorithm is effective on test datasets.

Research Gap

1. The existing methodologies do not investigate much into low-light videos in **real-time** and do not provide considerable performance for low-light videos for heart rate detection.
2. The current methods either disregard the impact of motion in **real-time** videos on heart rate detection, or the proposed solutions yield unsatisfactory results and fail to significantly enhance the accuracy of heart rate detection.
3. While Face Detection combined with object tracking, OpenCV, or segmentation are common techniques for Region of Interest detection in research papers, a deep-learning based model dedicated to forehead detection may offer superior performance. This is because such a model can learn to recognize intricate patterns and features in images, resulting in more precise and reliable detections. Moreover, deep learning models can be trained on large datasets, allowing them to generalize well to new data and perform well even in complex and variable environments, making them well-suited for critical applications such as healthcare.

Proposed Solution

Real-time video

real time low Light Video enhancement

enhanced video

Real Time Video Stabilization

enhanced stabilized video

ROI Detection (Forehead)

ROI (FP's)

Conversion of FPs to HSV

Norm Computation of FPs that have Hue within(0,0.1)

Fourier Tranformation

Selection of the Highest peak in the range of (0.8-2)

Compute H * 60

Heart Rate

Proposed solution for Research Gap 1

Real-Time Low Light Video enahancement

- To develop an improved method for enhancing low-light videos that enables accurate real-time heart rate detection. Current solutions, such as GANs, have shown promise but are computationally expensive and can cause issues with inference time at real-time heart rate detection.
- To address these limitations, we will design a novel approach that reduces the computational complexity while maintaining the accuracy.
- The new approach should effectively resolve the challenges of low-light videos and enable real-time monitoring of heart rate in low-light settings.
- To accomplish this goal, we will conduct a thorough review of the existing literature on low-light video enhancement and heart rate detection techniques. We will then develop and test our new model using real-world low-light video datasets and compare its performance against existing methods. Our ultimate aim is to provide a more efficient and accurate solution that can significantly improve heart rate measurement from low-light videos at real - time.

Proposed solution for Research Gap 2

Real-Time Video Stabilization

- To address the issues of motion artifacts and instability in video, we propose to develop a novel solution that leverages deep learning techniques for real-time heart rate measurement.
- Current solutions such as CNNs and recurrent neural networks (RNNs) to predict and correct camera motion, resulting in more stable and smoother video recordings are computationally expensive, making it difficult to handle motion artifacts and instability in real-time heart measurement.
- Our model will address these challenges with efficient computation and noise reduction techniques, enabling more accurate and reliable heart rate measurement in challenging scenarios.
- We anticipate that our proposed solution will outperform existing solutions for heart rate detection in real-time videos.

Proposed solution for Research Gap 3

Automated Region of Interest Detection

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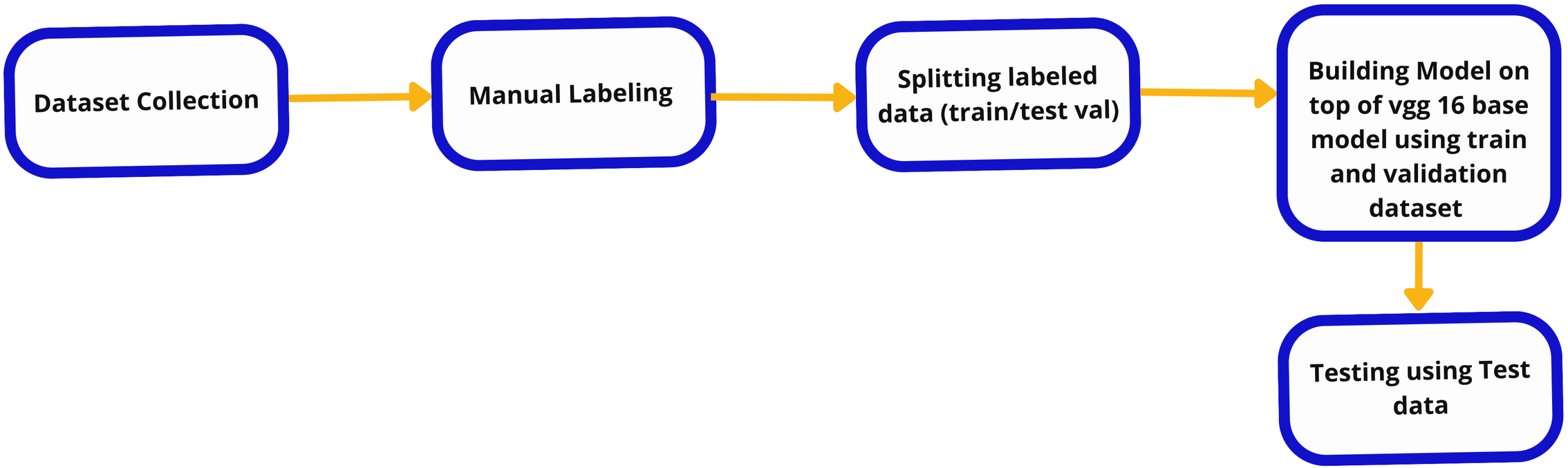
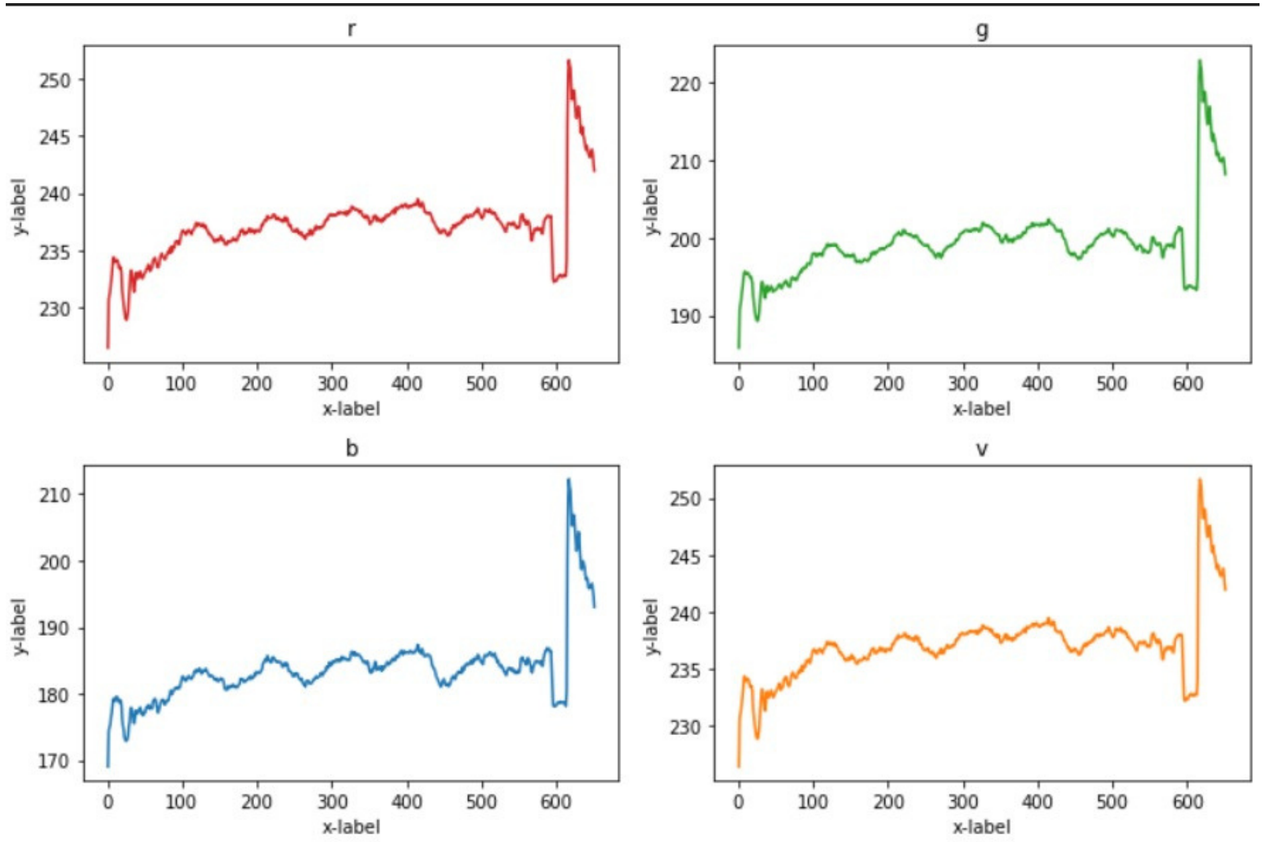
Automated ROI Detection



Change Measurement

- In the context of analyzing color changes in an image, the Standard Deviation(SD) of pixel values in the area of interest can provide useful information about the degree of color variation in that area.
- If the SD is high, it means that the colors in the area of interest are varied and not concentrated around a single color.
- If the SD is low, it means that the colors in the area of interest are similar and concentrated around a single color.
- To use SD for this purpose, one can calculate the SD of pixel values in the area of interest for each image in a sequence, and then compare the SD values between images.
- A higher change in SD values between images indicates a greater change in color in the area of interest.

Change Measurement



Progress Till Now

- We have made significant progress in our efforts to identify different approaches to improve the performance of heart rate detection from low-light videos while also addressing the problem of motion artifacts.
- Through a thorough literature review, we have gained a solid understanding of the state-of-the-art techniques and methodologies for video stabilization, heart rate detection from videos, automated region of interest detection, and related areas.
- Our analysis of the literature has revealed several promising deep learning-based approaches that can be used to address these challenges.
- Specifically, we have identified techniques that can automatically detect the region of interest in a video and apply video stabilization and other relevant pre-processing steps to improve the accuracy of heart rate detection.
- The task of dataset collection for automated ROI detection has been completed.

Final Deliverables

A Github repository comprising of the following-
1. model capable for low light video enhancement in real-time video
2. model capable for video stabilization in real-time video
3. Dataset for ROI detection
4. model for ROI Detection
5. explainable model for heart rate detection.
6. final prediction of heart rate under adverse conditions
7. Report, readme, requirement file, etc

Time-Line of the Project

1	**WEEK 1:**	• Develop the code for extracting the change in colour values in RGB and HSV color channels. • Plotting the curve for color change. • Completion of initial Pre-processing on that curve.
2	**WEEK 2:**	• Develop the code for techniques that are explainable and which could be applied on the heart rate curve so as to accurately detect the heart rate. • Creation of Labelled Dataset • Development of the model for ROI detection(Forehead Detection)
3	**WEEK 3:**	• Development of the model for low-light video enhancement in real-time video • Begin the evelopmemt of the model for video stabilization in real-time video
4	**WEEK 3:**	• Completion of model development for video stabilization in real-time video • Completion of the pipeline for real-time heart rate detection. • Final Assembly and Testing • Deployment of the Project.

Contribution of each team member

1.	Allan Robey	20%
2.	Avnish Tripathi	20%
3.	Divyesh Tripathi	20%
4.	Kush Shah	20%
5.	Pulkit Sharma	20%

References

1) Heart Rate Measurement Using Face Detection in Video (Carmen Nadrag, Vlad Poenaru, and George Suciu,R&D Department, Beia Consult International, Bucharest, Romania{carmen.nadrag, vlad.poenaru, george}@beia.ro)
2) Real Time Video based Heart and Respiration Rate Monitoring (Jafar Pourbemany, Almabrok Essa, and Ye ZhuDepartment of Electrical Engineering and Computer ScienceCleveland State University, Cleveland, OH, USA)
3) Real-Time Webcam Heart-Rate and Variability Estimation with Clean Ground Truth for Evaluation (Amogh Gudi , Marian Bittner and Jan van Gemert)
4) Effects of Lighting and Window Length on Heart Rate Assessment through Video Magnification(Leen Yassin Kassab,Andrew Law,Bruce Wallace,Julien Larivière-Chartier,Rafik Goubran,Frank Knoefel)
5) EnlightenGAN: Deep Light Enhancement without Paired Supervision (Yifan Jiang , Xinyu Gong, Ding Liu, Yu Cheng, Chen Fang, Xiaohui Shen, Jianchao Yang,Pan Zhou , and Zhangyang Wang , Member, IEEE)
6) Generative adversarial network for low-light image enhancement (Fei Li1,Jiangbin Zheng , Yuan-fang Zhang)
7) Assessment of ROI Selection for Facial Video-Based rPPG (Dae-Yeol Kim, Kwangkee Lee, Chae-Bong Sohn)
8) Deep Online Video Stabilization With Multi-Grid Warping Transformation Learning (Miao Wang, Guo-Ye Yang, Jin-Kun Lin, Song-Hai Zhang, Ariel Shamir, Shao-Ping Lu, Shi-Min Hu)
9) Heart Rate Measurement Using Facial Videos (Carmen Nadrag, Vlad Poenaru, George Suciu)
10) Contact-Less Heart Rate Detection in Low Light Videos (Tamal Chowdhury, Sukalpa Chanda, Saumik Bhattacharya, Soma Biswas & Umapada Pal)
11) Learning Video Stabilization Using Optical Flow" by Yanchao Yang, Deqing Sun, Huaizu Jiang, and Ming-Hsuan Yang (ICCV 2017)
12) Low-Light Video Enhancement Using Generative Adversarial Networks With Channel Attention" by Yang Li, Shangwen Liang, and Shiqi Wang (IEEE Access 2019)
13) Heart Rate Measurement Combining Motion and Color Information (2022) (Jean-Pierre Lomaliza, Hanhoon Park, Kwang-Seok Moon)
14) Heart rate prediction from facial video with masks using eye location and corrected by convolutional neural networks
15)Multi-level Attention Network for Low-light Image/Video Enhancement" by W. Ren et al