Demo: RhythmEdge: Enabling Contactless Heart Rate Estimation on the Edge

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Introduction

Heart rate (HR) is a crucial and versatile biomarker as it indicates a variety of physiological conditions and **should be monitored regularly.** Among different HR monitoring approaches, remote Photoplethysmography (**rPPG**) in contact-less manner by capturing the variations in the light reflection off the human skin **using regular video sensors.** However, the primary challenge is to **develop a ubiquitous system** that can extract rPPG accurately and compatible **with commercially available edge computing devices.**

Addressed CHALLENGES:

1. **Technical Aspects:**
   a. Appropriate settings to capture PPG from the subjects
   b. Facilitate off-line and real-time operations, and stable rPPG system
   c. Compatible with available low-cost resource constraint edge platforms and cameras
2. **Scientific Aspects:**
   a. Development of robust model to extract PPG
   b. Effectively scaling down the model for resource-efficient operation inside edge devices

Methodology

- Collection of rPPG dataset
  - Camera variations
  - Subject variations
  - Environment variations
- Train Deep-Learning based model to infer rPPG from raw video data
- Compress the model (Pruning, quantization)
- Prepare Edge Compatible format.
- Device integration with edges
- Pipeline the rPPG system inside Edge device

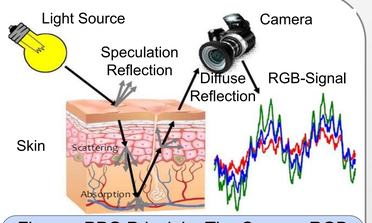


Figure: rPPG Principle. The Camera RGB channel capture the heart-synchronous skin reflection signal. The rPPG system extracts these signal from the video.

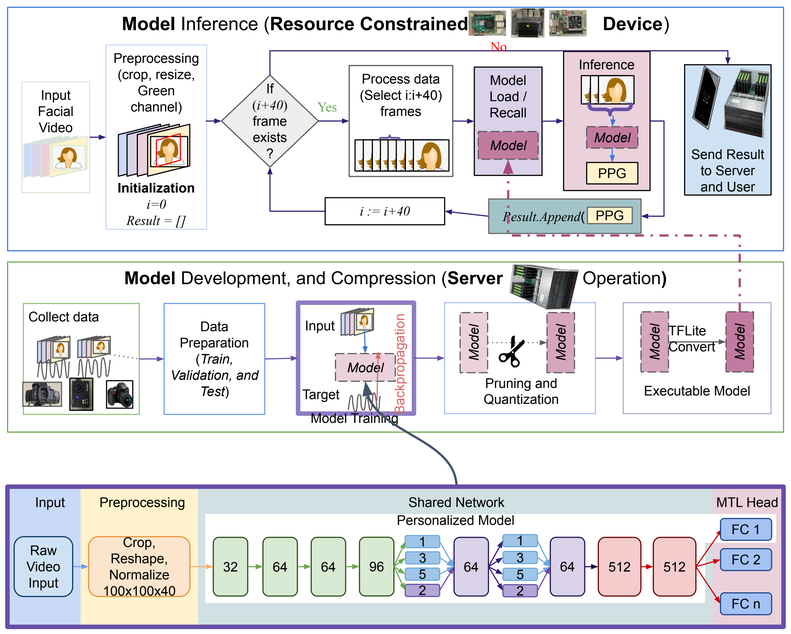
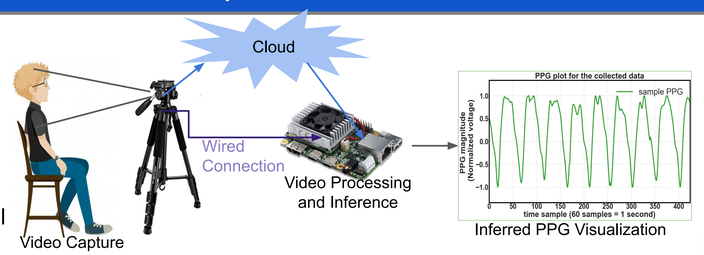


Figure: Methodology Overview of System Development

System Overview

- Takes video using camera
- Sends to Edge devices
  - *Real-time*
  - *Offline*
- Edge devices infer rPPG (HR)
  - Preprocessing of videos
  - Infer rPPG (HR)) using the rPPG model
- Sends the HR information to the user.
- Store the longitudinal HR information



Overview of our developed rPPG system. It can monitor heart rate in real-time (using wired connection) or offline mode (using cloud service). We require only regular camera and low-cost edge devices.

Prototype of our rPPG system using available web-camera and raspberry-pi

Experiment and Results

- ***Experimented Dataset***
  - UBFC-rPPG
  - MERL-rPPG
  - MPSC-rPPG
- ***Device Compatibility***
  - Jetson Nano
  - Raspberry-pi
  - Google Coral Dev-Board
- ***Metrics***
  - rPPG accuracy
  - System parameters
    - Time Complexity
    - Memory Occupancy
    - Power Consumption

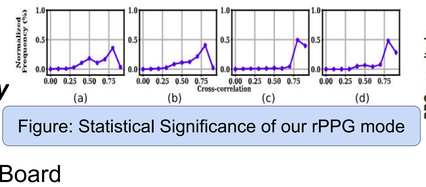


Figure: Statistical Significance of our rPPG mode

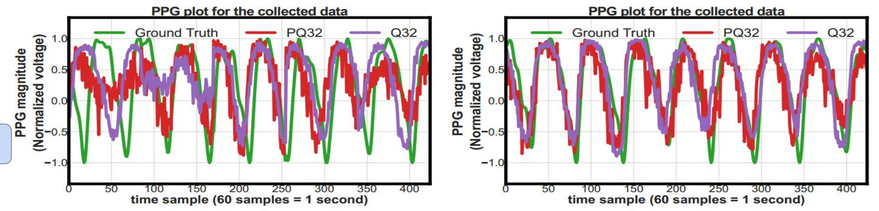


Figure: Sample test result of our rPPG system.

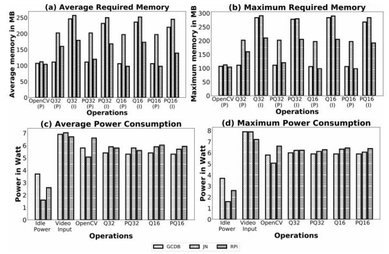


Figure: Memory and Power of different rPPG components

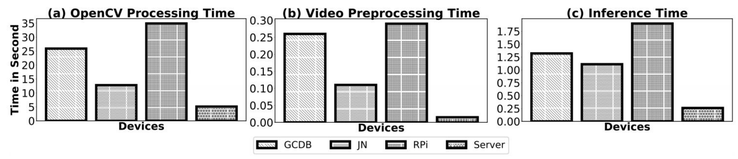


Figure: Execution time of different rPPG components

Summary and Conclusion

- We develop edge compatible rPPG devices for ubiquitous HR monitoring
- We develop robust rPPG detection model utilizing Deep learning based data-driven model.
- We propose rPPG domain specific pruning to scale down computational heavy deep learning model.
- We test our approach on two publicly available dataset and our own-collected MPSC dataset.
- We test the system performance under varying conditions like camera movements, lighting variations, fps variations.
- We thoroughly test our system stability for time, power, memory performance and benchmark our system.
- We open-source our dataset and codes to facilitate further research.

References and Publications

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