SMART INDIA HACKATHON 2019

Real-Time Estimation of Heart Rate using Smartphone Camera

Ministry category: Industry personnel

Organization name: Samsung R&D

Technology Bucket: Software, Healthcare & BioMedical Devices

Problem Code : SS1

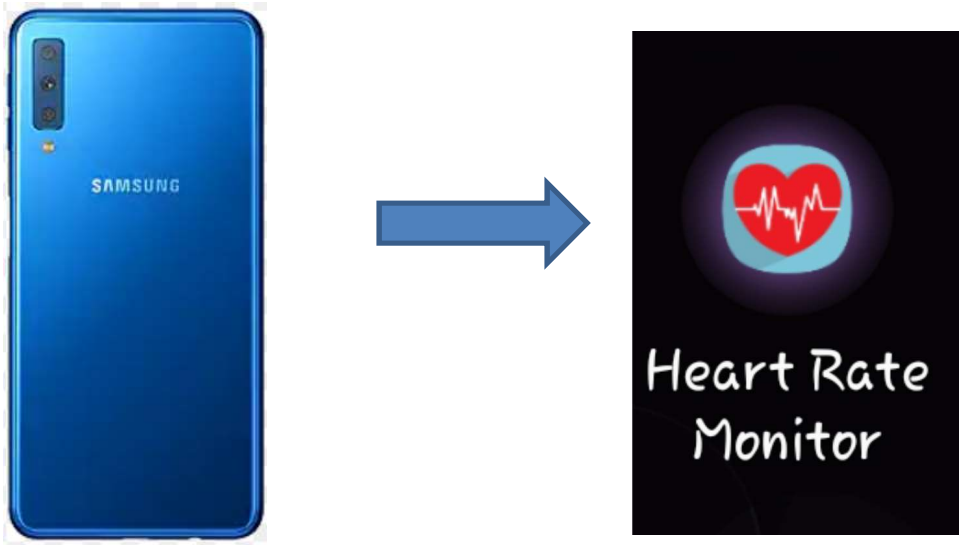
Team name: Virtual Police

Team leader name: Sneha S.

College AICTE code: 1-3511485177

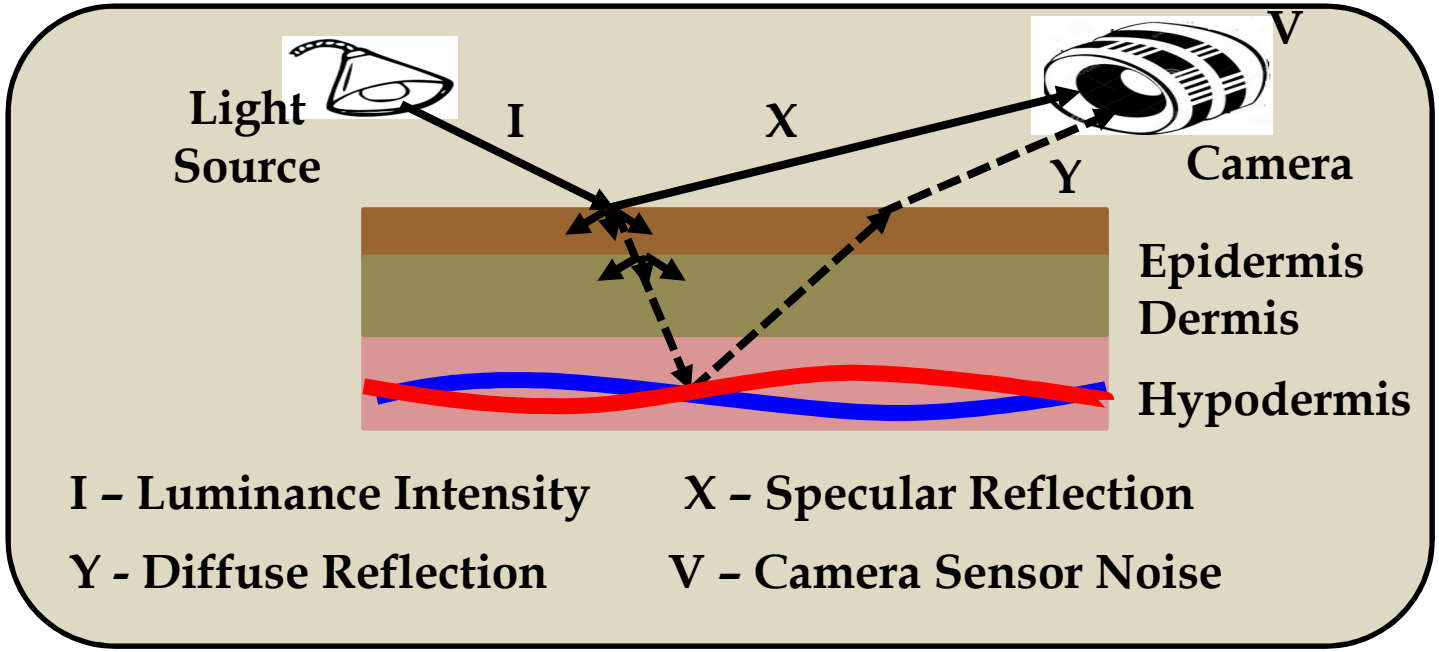
Problem Statement

- **Real-time estimation of Heart Rate** from facial images under different lighting conditions using **Smartphone Camera**.
- Analysis of the spatio-temporal variations in the time-series facial images and amplify the variations in light reflected from the face when blood flows.



Solution

- The objective is to estimate the heart rate using luminance intensity variations, thereby suppressing the effects due to specular reflection, diffuse reflection and camera sensor noise.
- Coding is done using Kotlin, Android Studio for app development and Python for image/signal processing.
- The heart rate using Samsung Health will serve as the ground truth.



Block Diagram

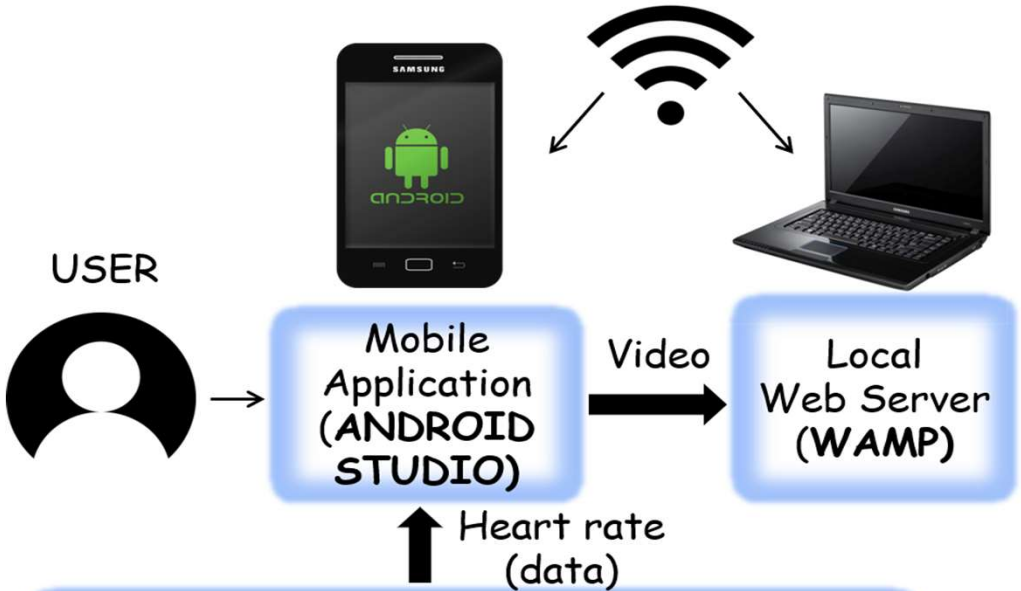
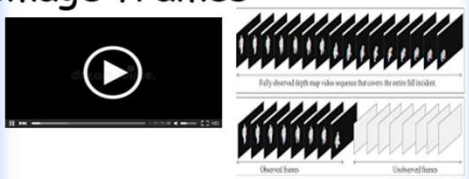
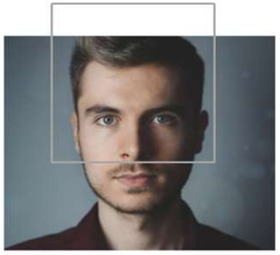


IMAGE PROCESSING

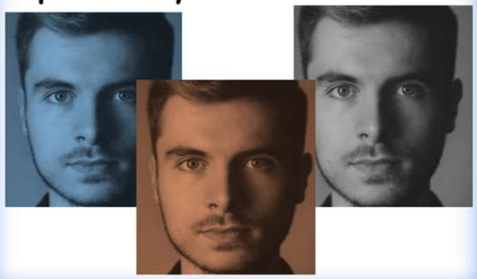
1.Splitting of video into image frames



2.Face detection



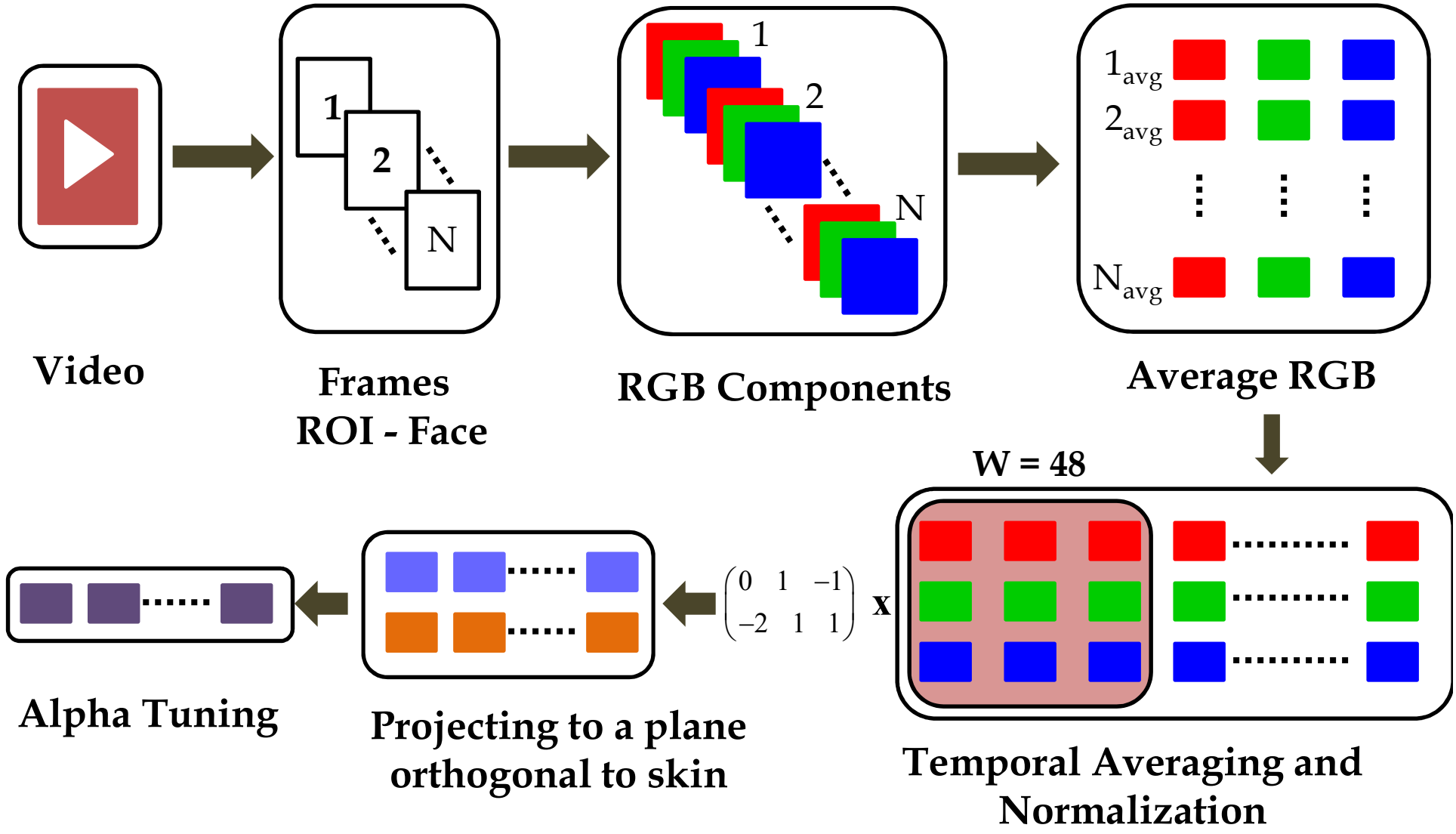
3.Cropping and filtering of the RGB components separately.



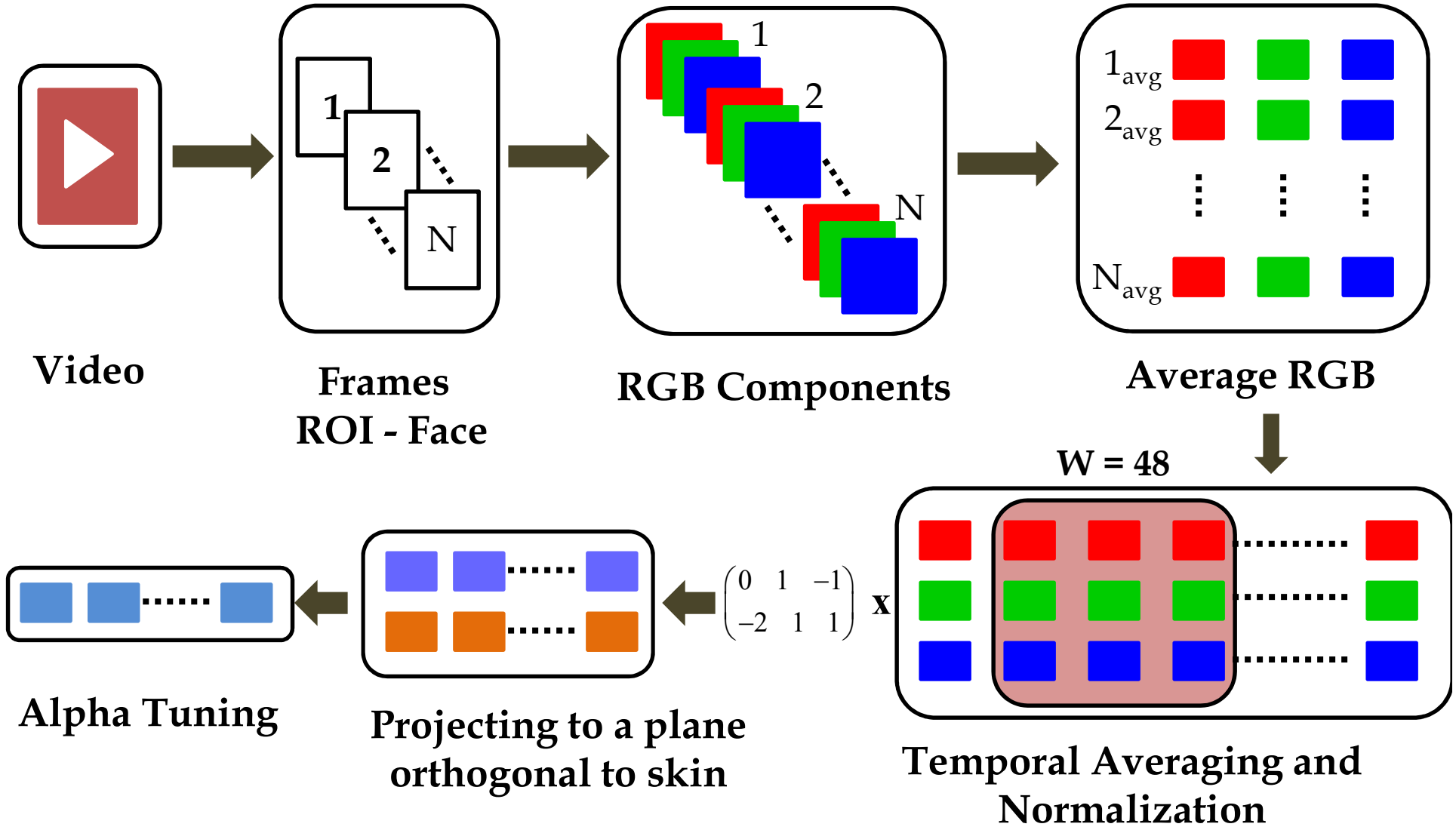
HEART RATE DETECTION

4.Spatial averaging of the pixel values in the three raw RGB signals to reduce noise.
5.Temporal normalization.
6.Projection on plane orthogonal to skin.
7.Conversion of 2D to 1D signal.
8.Power spectral density using Welch method.
9.Finding frequency of maximum power.
10.HEART RATE=60*Max frequency

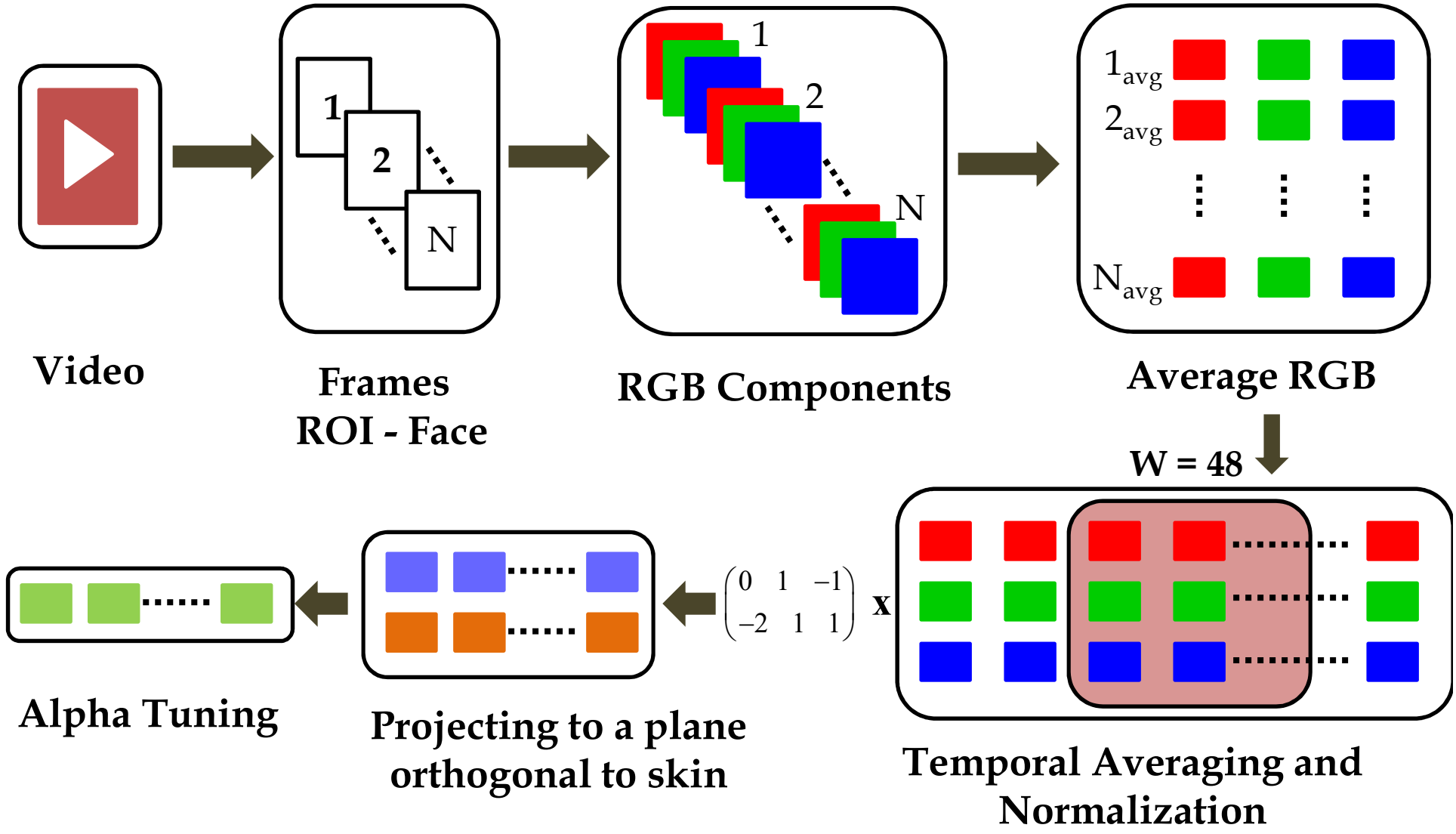
Work Flow


1
2
N
1
2
N
1_{avg}
2_{avg}
N_{avg}
W = 48
x
$\begin{pmatrix} 0 & 1 & -1 \\ -2 & 1 & 1 \end{pmatrix}$
Video
Frames
ROI - Face
RGB Components
Average RGB
Temporal Averaging and
Normalization
Projecting to a plane
orthogonal to skin
Alpha Tuning

Work Flow


Video
1
2
N
Frames
ROI - Face
1
2
N
RGB Components
1_{avg}
2_{avg}
N_{avg}
Average RGB
W = 48
Temporal Averaging and
Normalization
x
$\begin{pmatrix} 0 & 1 & -1 \\ -2 & 1 & 1 \end{pmatrix}$
Projecting to a plane
orthogonal to skin
Alpha Tuning

Work Flow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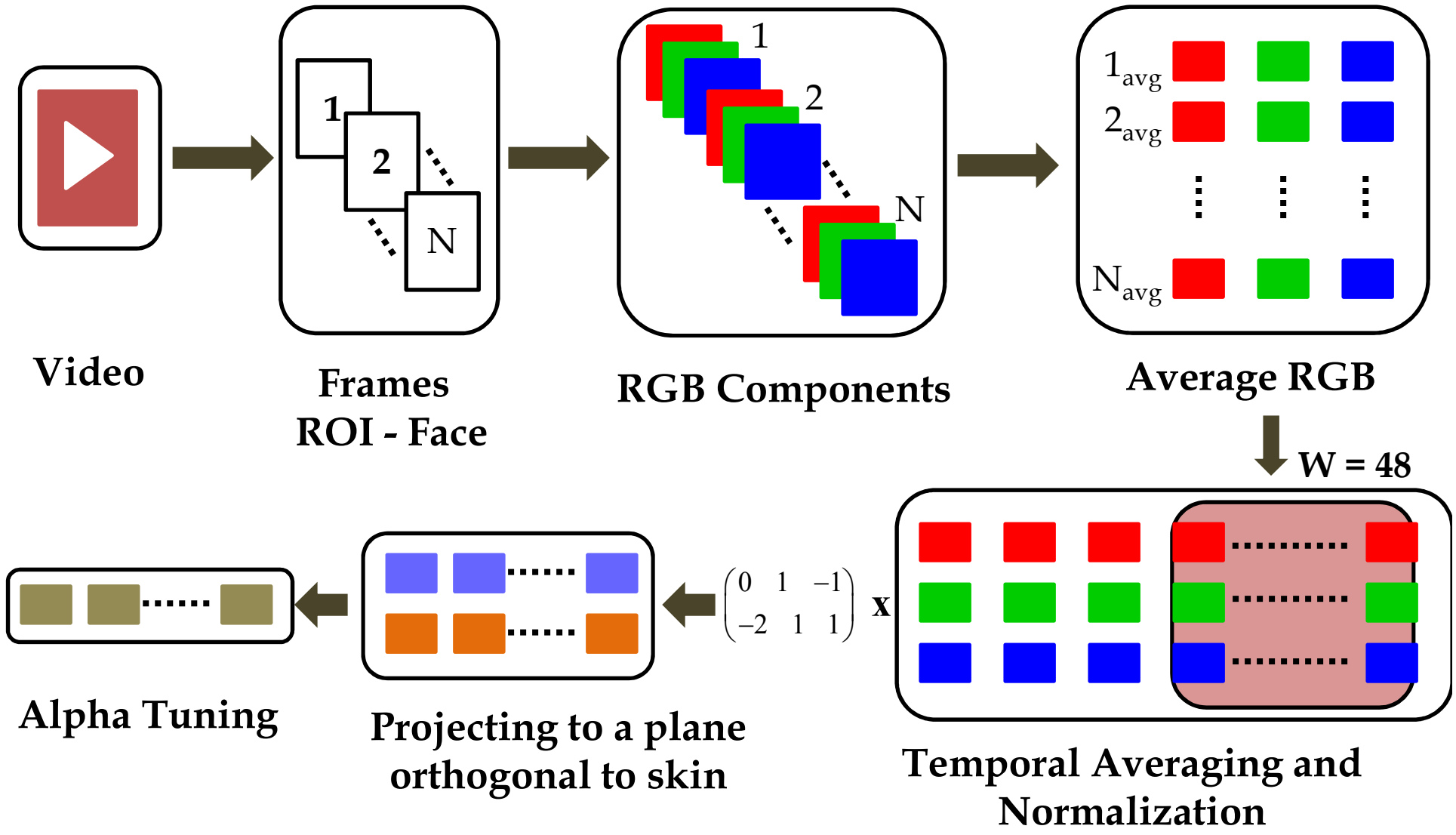
2_{avg}
N_{avg}
W = 48
x
$\begin{pmatrix} 0 & 1 & -1 \\ -2 & 1 & 1 \end{pmatrix}$
Video
Frames
ROI - Face
RGB Components
Average RGB
Temporal Averaging and
Normalization
Projecting to a plane
orthogonal to skin
Alpha Tuning

Work Flow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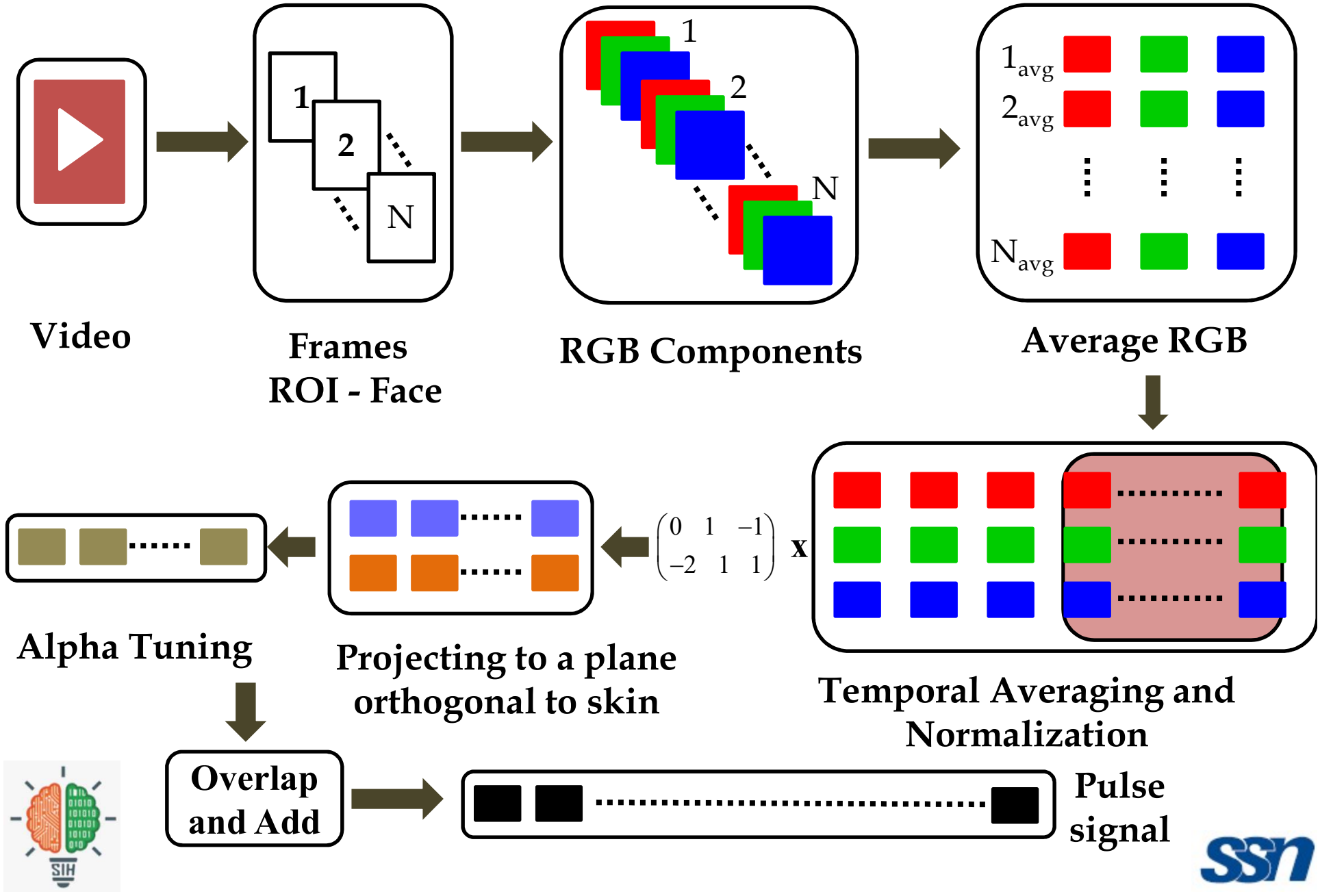
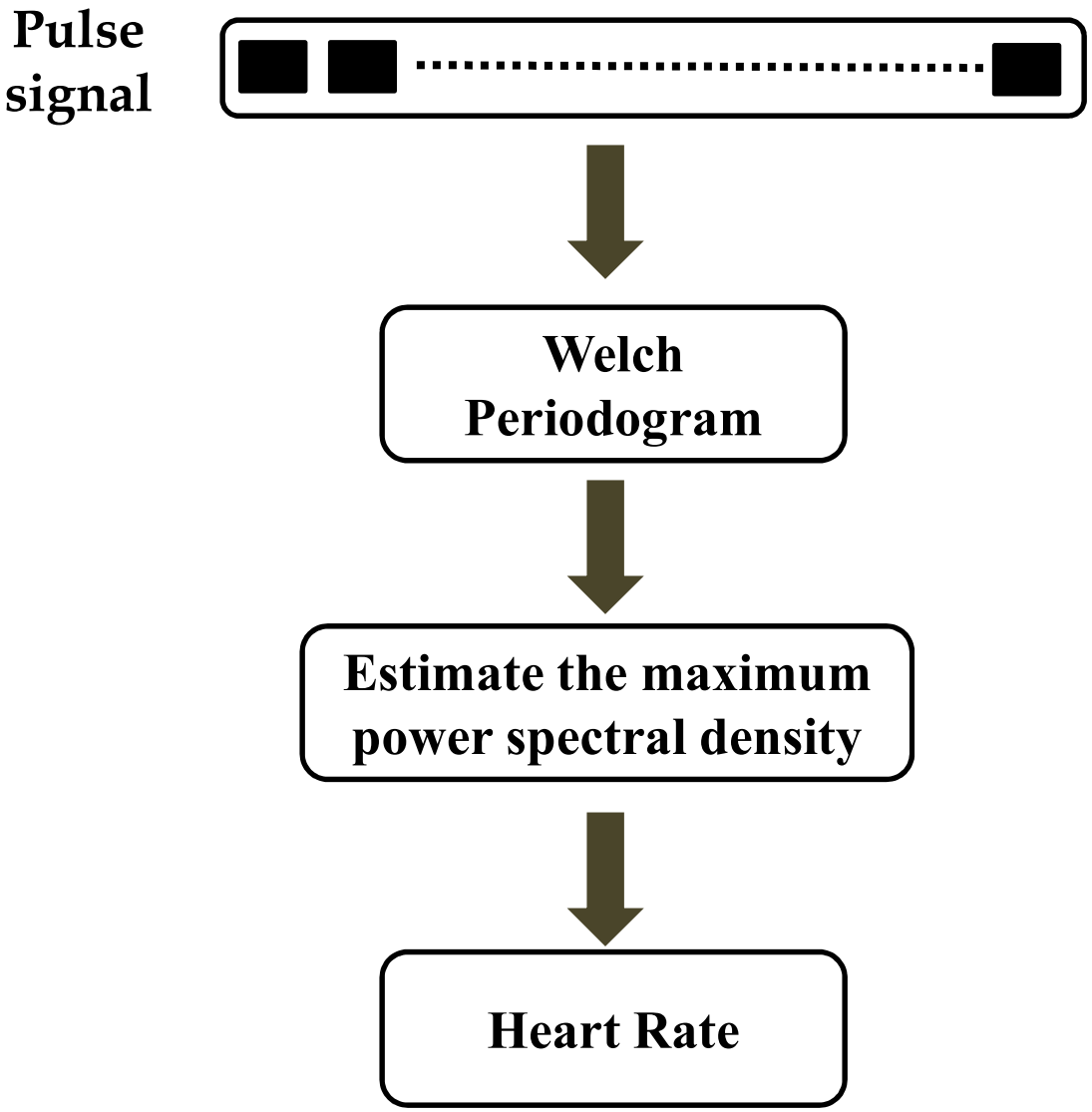
1_{avg}
2_{avg}
N_{avg}
W = 48
x
Video
Frames
ROI - Face
RGB Components
Average RGB
Temporal Averaging and
Normalization
Projecting to a plane
orthogonal to skin
Alpha Tuning

Work Flow


1
2
N
1
2
N
1_{avg}
2_{avg}
N_{avg}
Video
Frames
ROI - Face
RGB Components
Average RGB
Temporal Averaging and
Normalization
x
$\begin{pmatrix} 0 & 1 & -1 \\ -2 & 1 & 1 \end{pmatrix}$
Projecting to a plane
orthogonal to skin
Alpha Tuning
Overlap
and Add
Pulse
signal

Work Flow


Pulse signal
Welch Periodogram
Estimate the maximum power spectral density
Heart Rate

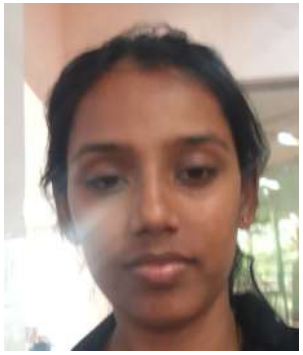
Novelty and Merits

- Contact less monitoring – comfort to user
- Smartphone camera based - very easy to use and requires no training for the user.
- Android based - used on a large variety of mobile phones.
- **Heart rate estimation based on luminance variations.**
- **Lesser computation complexity.**

Data Collection and Analysis

Subject 1

Subject 2



Subject 3

Splitting videos into Frames (30 Frames)

R G B Components after face detection

Data Collection and Analysis

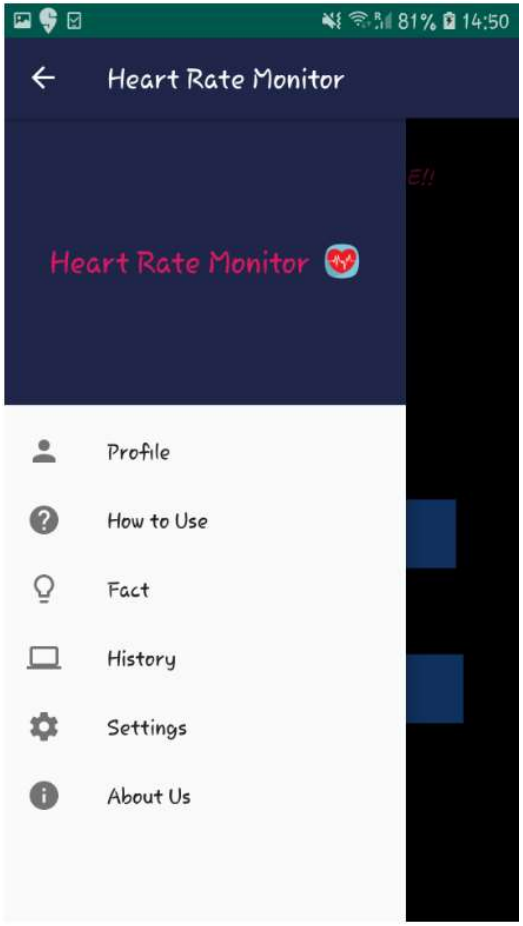
Subjects	Heart Rate in different Lighting Condition (bpm)			Actual Heart Rate using Samsung Health	Standard Deviation		
	Outdoor (sunny)	Outdoor (dim light)	Indoor (dim light)				
S1	78.26	78.26	75	66	12.26	12.26	9
S2	80	76.6	80	86	6	9.4	6
S3	90	75.45	71	91	1	15.55	20

Data Collection and Analysis

Subjects	Heart Rate in different Lighting Condition (bpm)			
	Outdoor (sunny)	Outdoor (dim light)	Indoor (dim light)	Mean
S1	78.26	78.26	75	77.17
S2	80	76.6	80	78.87
S3	90	75.45	71	78.81

Subjects	Heart Rate in different Lighting Condition (bpm)			
	Algorithm		Samsung Health	
	Heart Rate	Standard Deviation	Heart Rate	Standard Deviation
S1	67	10.17	66	11.17
S2	88	9.13	86	7.13
S3	92	13.19	91	12.19
Average		**10.83**		**10.16**

Heart Rate Monitor App



Heart Rate Monitor App

Click on exercise or resting button

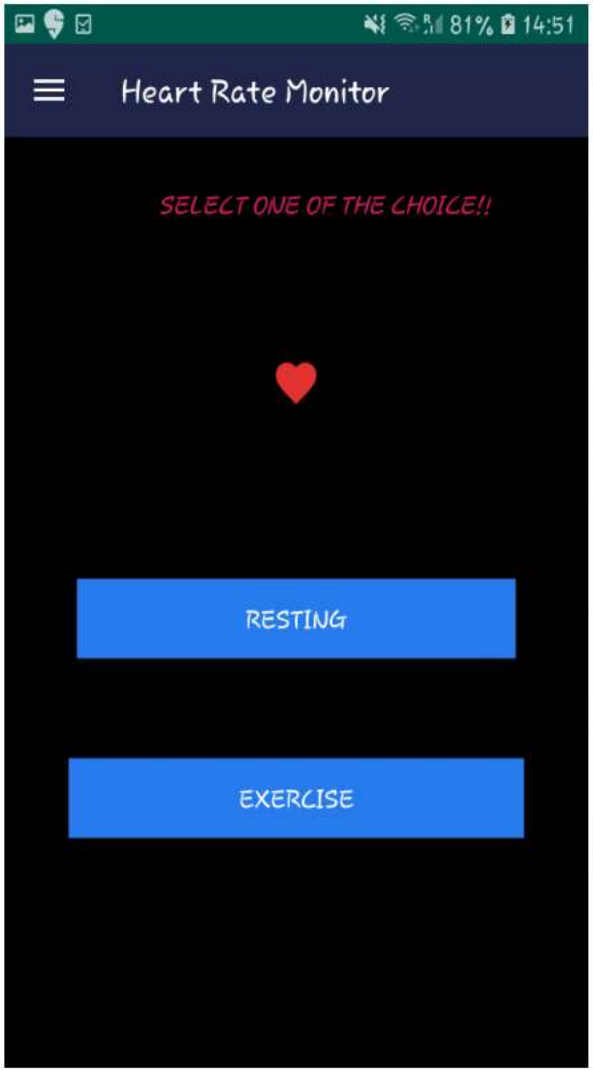
For recording click on record video button

Take a video for 10sec with less movements

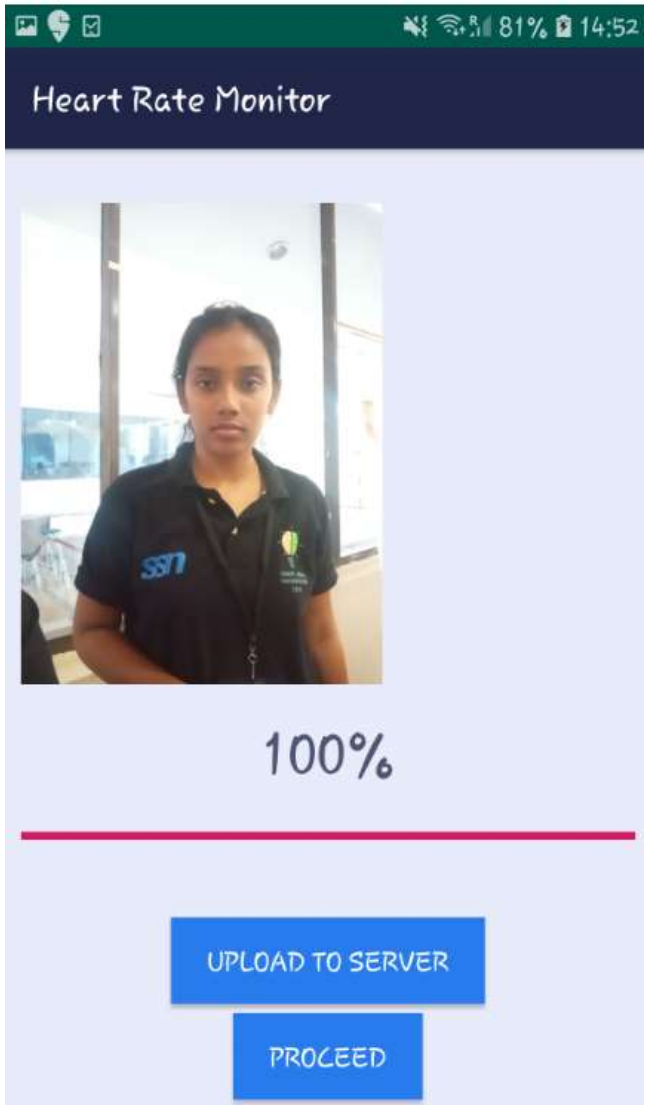
Conform video uploading

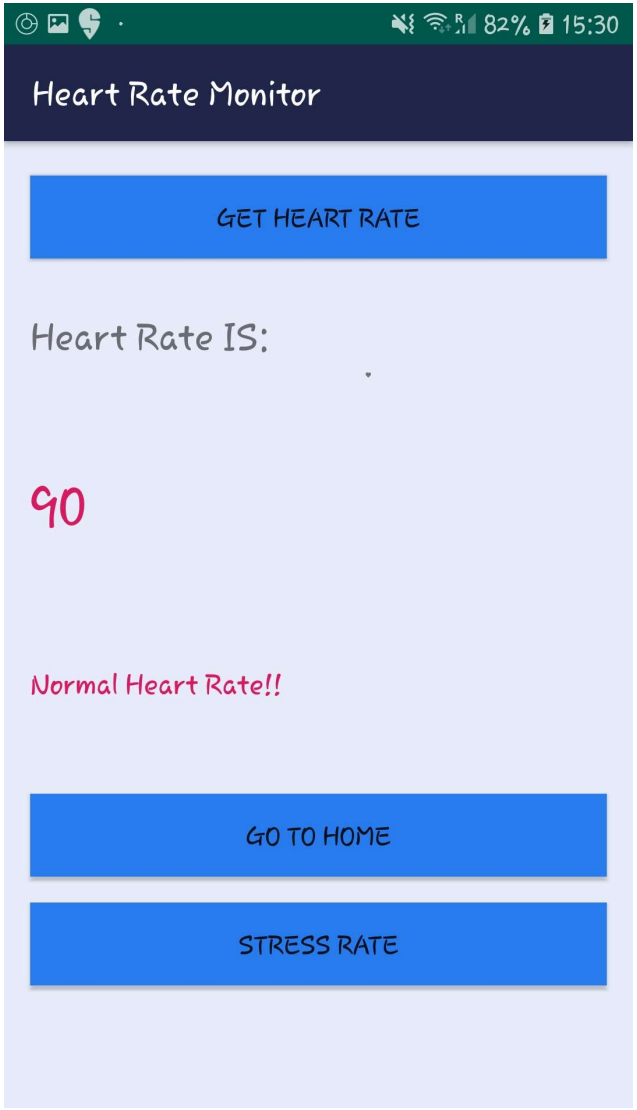
Click on upload and proceed button to get heart rate

Click heart rate to get bpm

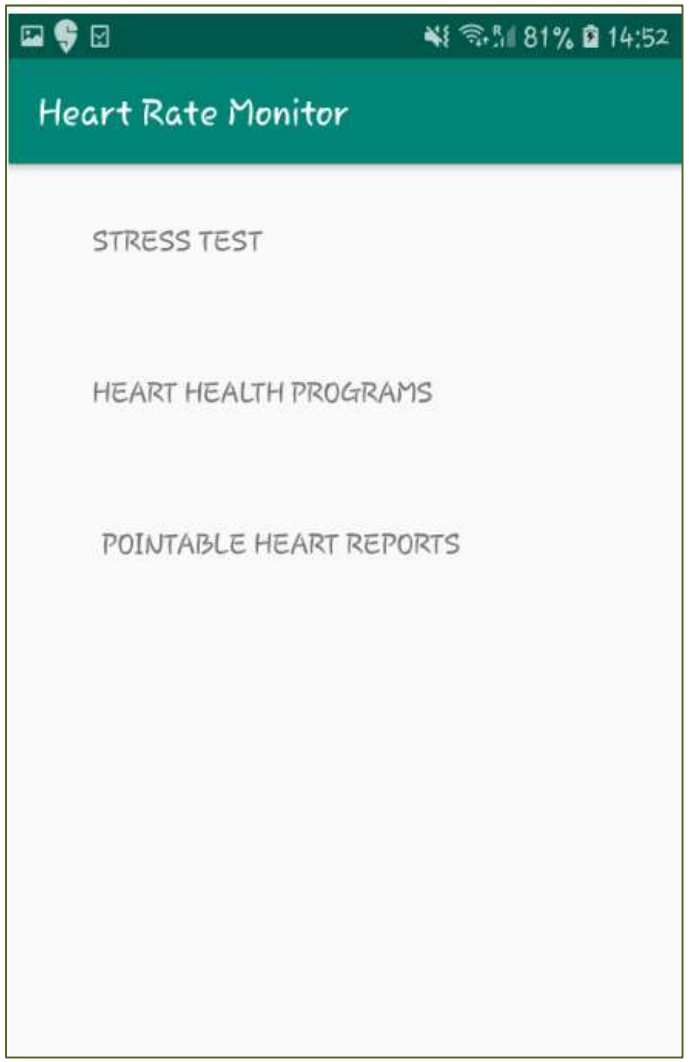


Heart Rate Monitor App





Use Cases



- Stress test Analysis
- Heart Health Programs
- Printable Heart Reports

Conclusions and Future Work

- Heart rate estimation based on luminance intensity variations, thereby suppressing the effects due to specular reflection, diffuse reflection and camera sensor noise.
- The estimated heart rate is compared against the Samsung Health as ground truth.
- The standard deviation of the heart rate monitor app is found to be 10.83 and the standard deviation with respect to the ground truth is found to be 10.16 on an average.
- Learning techniques can be incorporated to reduce the variance.
- Emotion analysis can be included.

Thank You

SSN