EFFICIENT REAL-TIME CAMERA BASED ESTIMATION OF HEART RATE AND ITS VARIABILITY ♥

MARIAN BITTNER* [VICARVISION, TU DELFT]
MARIAN@VICARVISION.NL

AMOGH GUDI* [VICARVISION, TU DELFT]
AMOGH@VICARVISION.NL

ROELOF LOCHMANS [TU EINDHOVEN]
R.H.LOCHMANS@STUDENT.TUE.NL

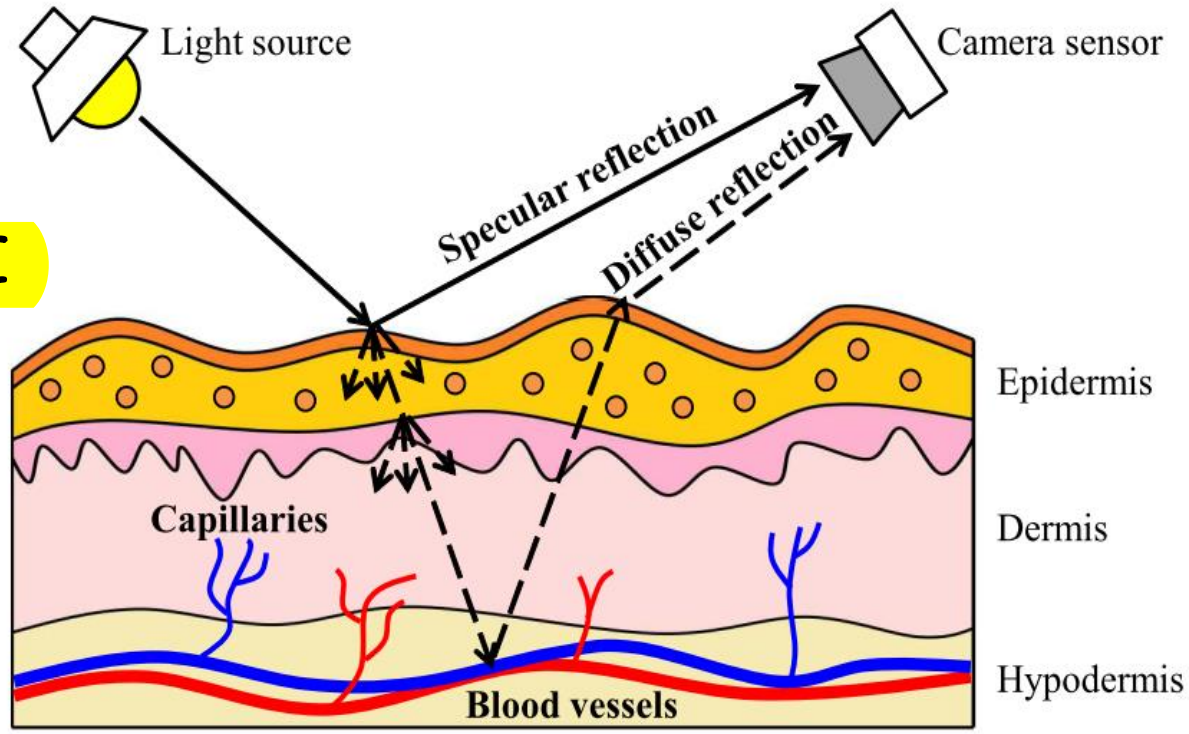
JAN VAN GEMERT [TU DELFT]
J.C.VANGEMERT@TUDELFT.NL

A (VERY SHORT) INTRODUCTION TO RPPG

*REMOTE PHOTOPLEYTIMOGRAPHY.

*TRACKS CHANGES OF BLOOD VOLUME UNDER SKIN VIA REFLECTANCE.

*MEASURES HEART RATE (AND MORE) USING SIMPLE R.G.B. CAMERA.



WANG, WENJIN, ET AL. "ALGORITHMIC PRINCIPLES OF REMOTE PPG." *IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING* 64.7 (2016): 1479-1491.

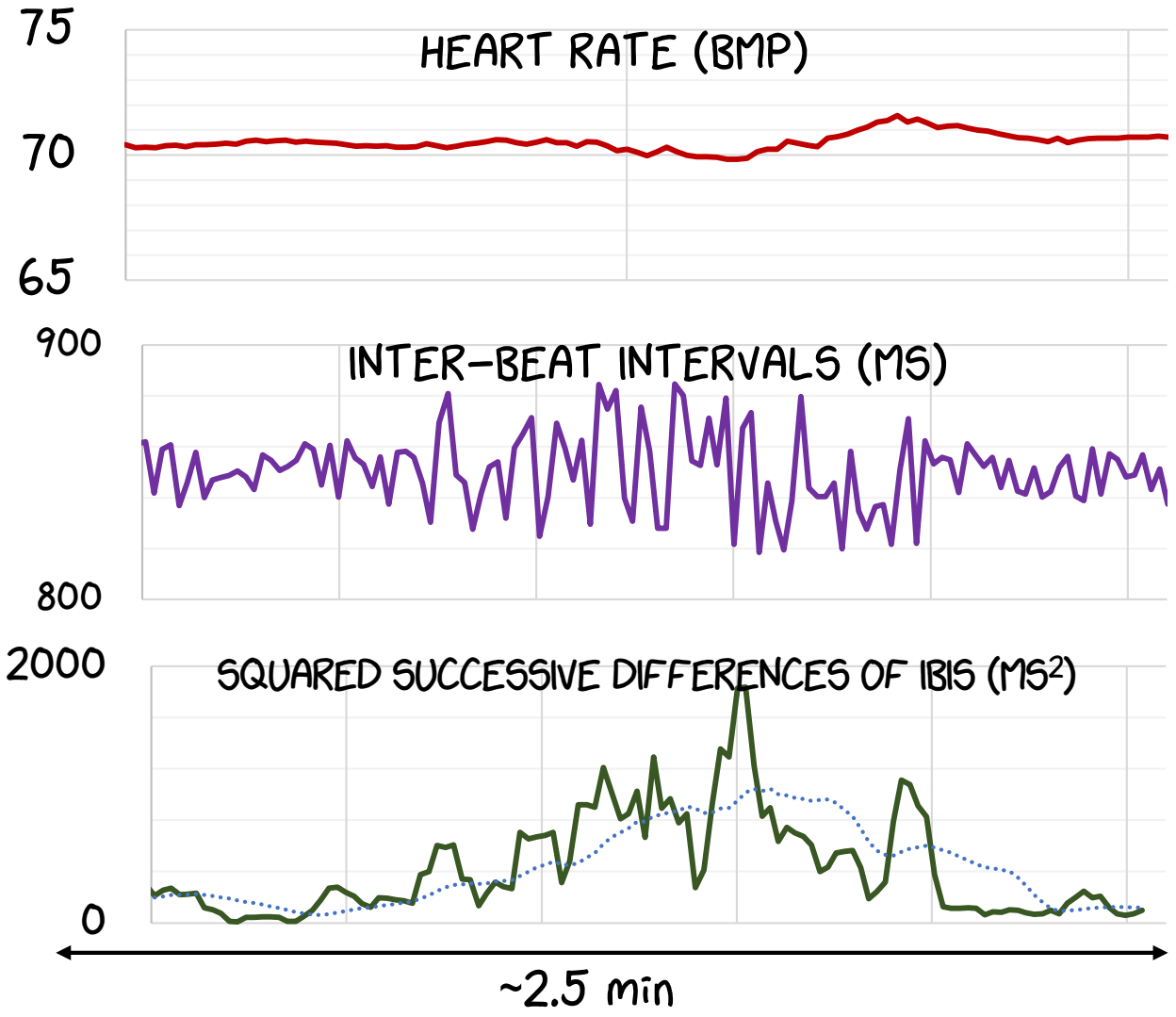
CONTRIBUTIONS

- REFINED & EFFICIENT SIGNAL-PROCESSING PIPELINE.
  (NO TRAINING + WORKS IN REAL-TIME!)

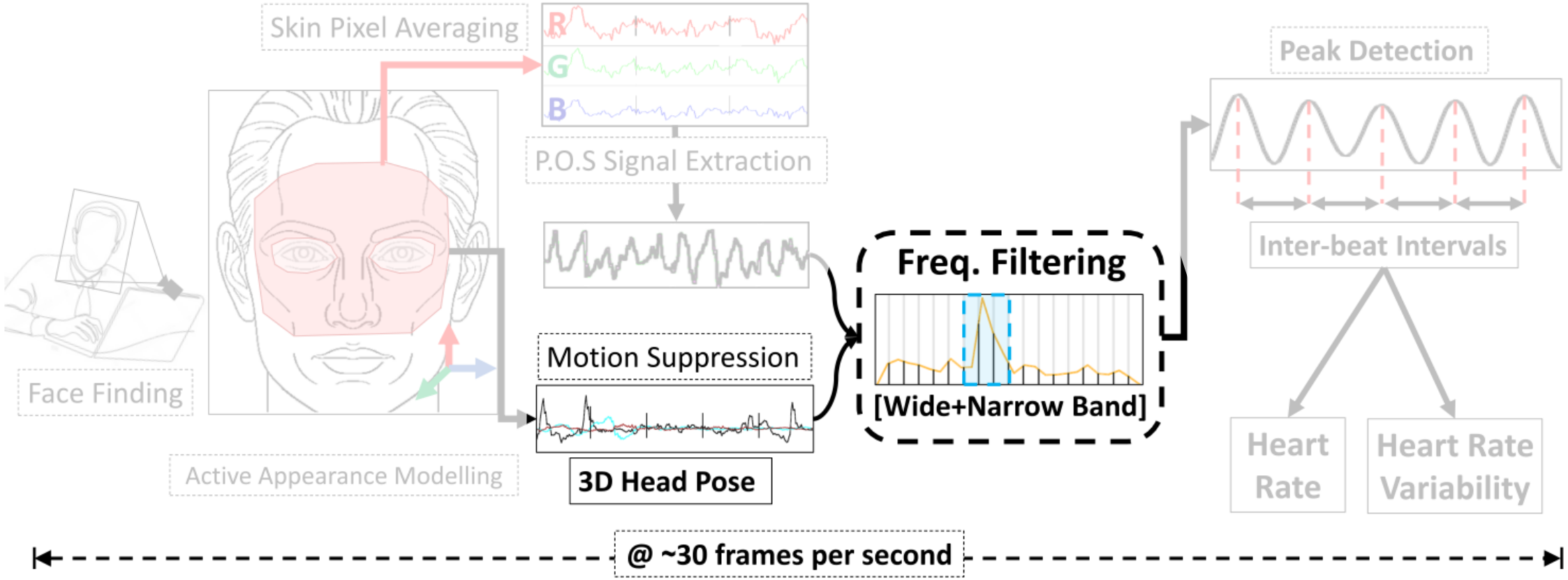
- TEPORALLY LOCALIZES INDIVIDUAL HEART BEATS. THUS, CAN ALSO COMPUTE HEART RATE VARIABILITY (H.R.V.).
  - SETS FIRST BENCHMARK ON VICARPPG AND PURE DATASETS.

- STATE OF THE ART RESULTS ON TWO PUBLIC DATASETS.
  - INTERESTING RESULTS ON OTHERS.

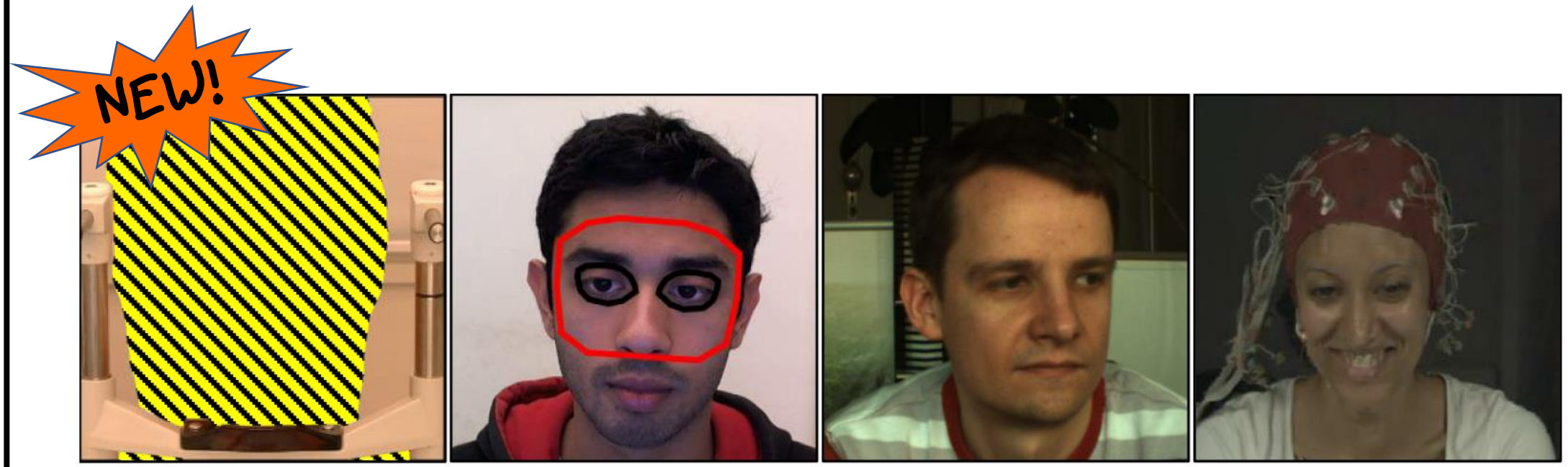
HEART RATE VARIABILITY?



PIPELINE


Skin Pixel Averaging
R
G
B
P.O.S Signal Extraction
Face Finding
Motion Suppression
Active Appearance Modelling
3D Head Pose
Freq. Filtering
[Wide+Narrow Band]
Peak Detection
Inter-beat Intervals
Heart Rate
Heart Rate Variability
@ ~30 frames per second

DATASETS



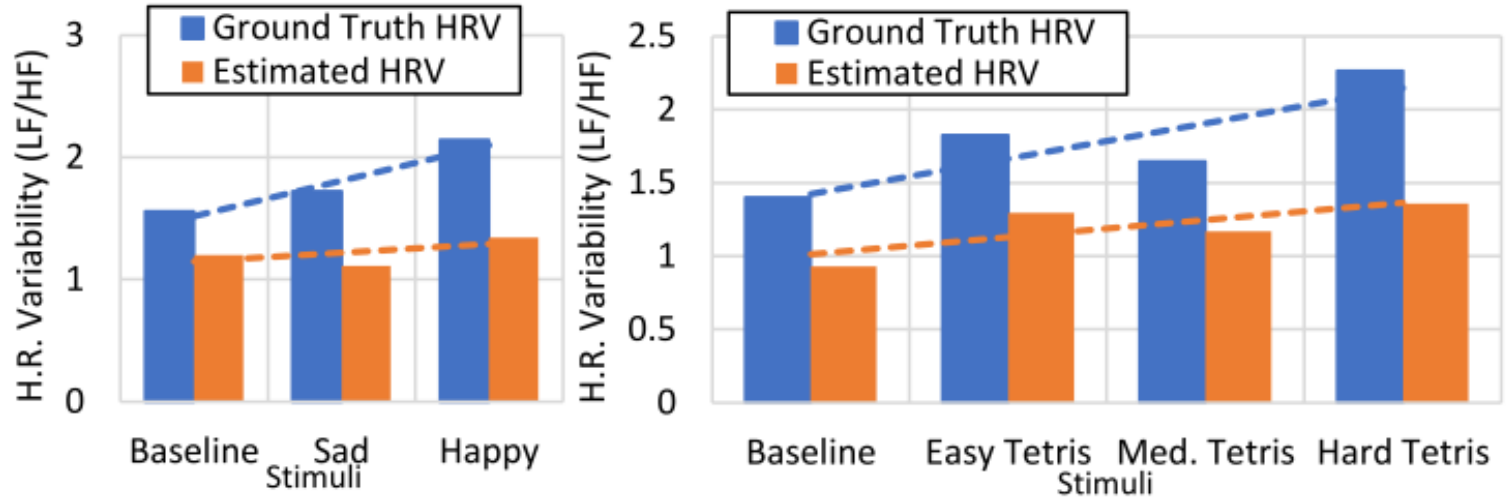
RESULTS (HEART RATE)

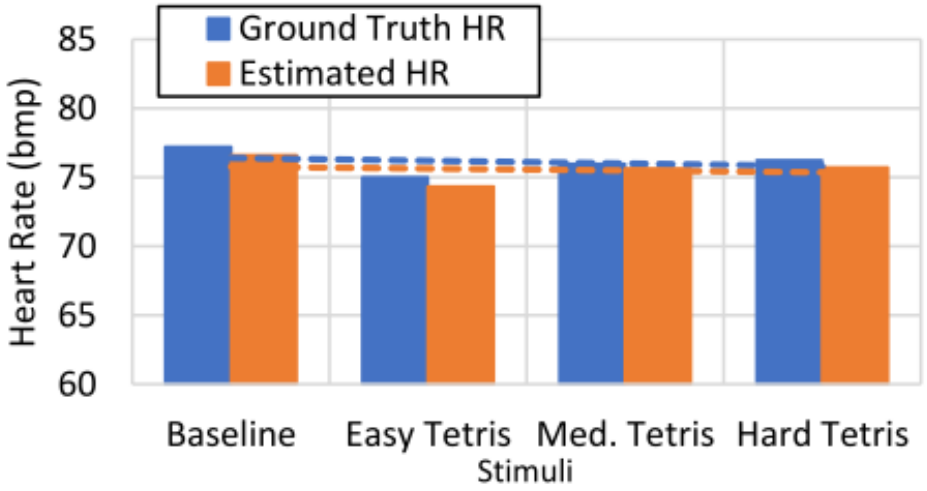
	Methods	StableSet	VicarPPG	PURE	MAHNOB-HCI
	Baseline (mean)	8.67 ± 6.01	17.5 ± 7.36	15.6 ± 17	9.53 ± 13.9
	Ours	**1.02** ± 1.4	**2.64** ± 6.32	**0.3** ± 0.51	12.8 ± 11.89
Signal Processing Methods	Basic/EVM [35][28]		5.60 ± 10.1	-	-
	Tasli *et al.* [28]		4.20 ± 7.7	-	-
	ICA [17][7]		-	24.1 ± 30.9*	-
	NMD-HR [7]		-	8.68 ± 24.1*	-
	2SR [34][22]		-	2.44	13.84
	CHROM [5][22]		-	2.07	13.49
	LiCVPR [12][22]		-	28.2	7.41
DL Methods	HR-CNN [22]		-	1.84*	7.25
	DeepPhys [4]		-	-	4.57
	Head-motion [8]		-	-	**≤3.85**

IN DEPTH RESULTS

	VicarPPG Dataset		PURE Dataset					
Condition	At Rest	Post Workout	Steady	Talking	Slo. Translation	Fast Translation	Small Rotation	Med. Rotation
HR (bpm)	0.7 ± 0.72	4.57 ± 8.87	0.16 ± 0.11	0.77 ± 0.76	0.12 ± 0.06	0.18 ± 0.26	0.288 ± 0.56	0.32 ± 0.7
HRV RMSSD (ms)	10.54 ± 8.20	7.15 ± 5.39	10.59 ± 7.73	27.55 ± 15.56	11.98 ± 7.67	14.02 ± 8.46	12.07 ± 6.63	23.82 ± 13.59

MORE RESULTS





DICUSSION & CONCLUSION

* EFFICIENT AND ROBUST SIGNAL PROCESSING PIPELINE (REAL-TIME + NO TRAINING).

* NON-TRIVIAL FACE DEFORMATIONS STILL A CHALLENGE (LIKE TALKING).

* SIGNAL PROCESSING METHODS STRUGGLE WITH HIGH COMPRESSION, WHILE DEEP LEARNING SEEM TO OVERCOME THIS. (LEARNS COMPRESSION NOISE?)

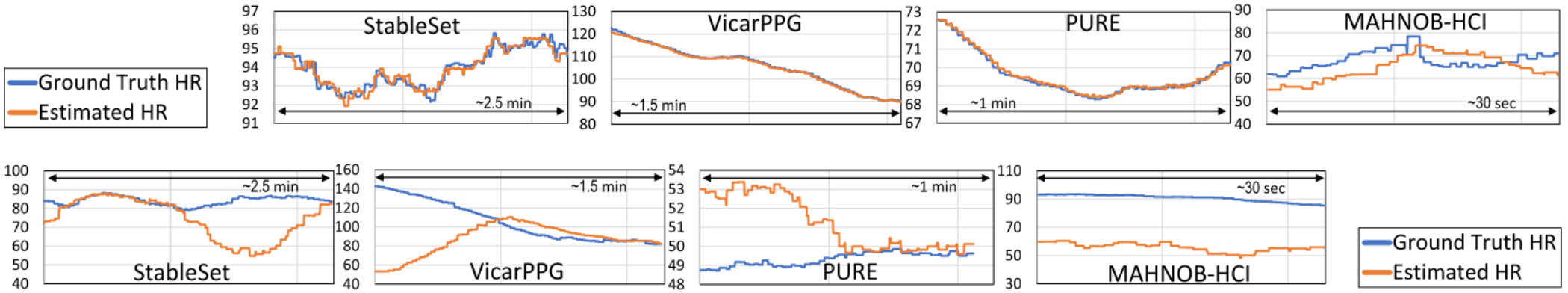
* HOWEVER, THIS SIGNAL PROCESSING METHOD PERFORMS BETTER THAN DEEP LEARNING WHEN COMPRESSION IS LOW. (PRIOR KNOWLEDGE ADVANTAGE?)

* H.R.V. IS HARD TO MEASURE PRECISELY, BUT STILL QUITE POSSIBLE WITH RPPG.

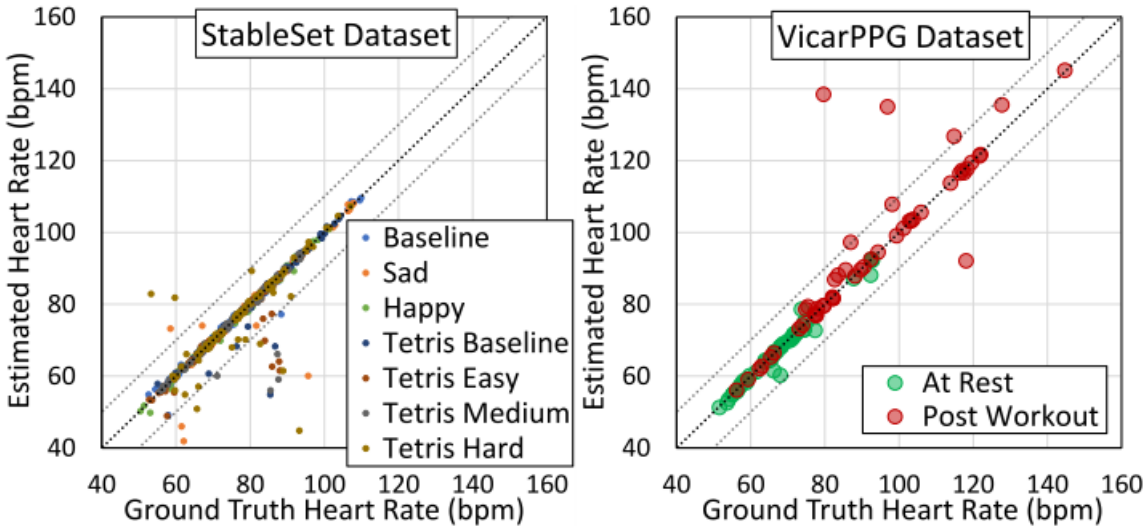
THANK YOU FOR
YOUR ATTENTION!

FONT CREDIT: xkcd

RESULTS HEART RATE

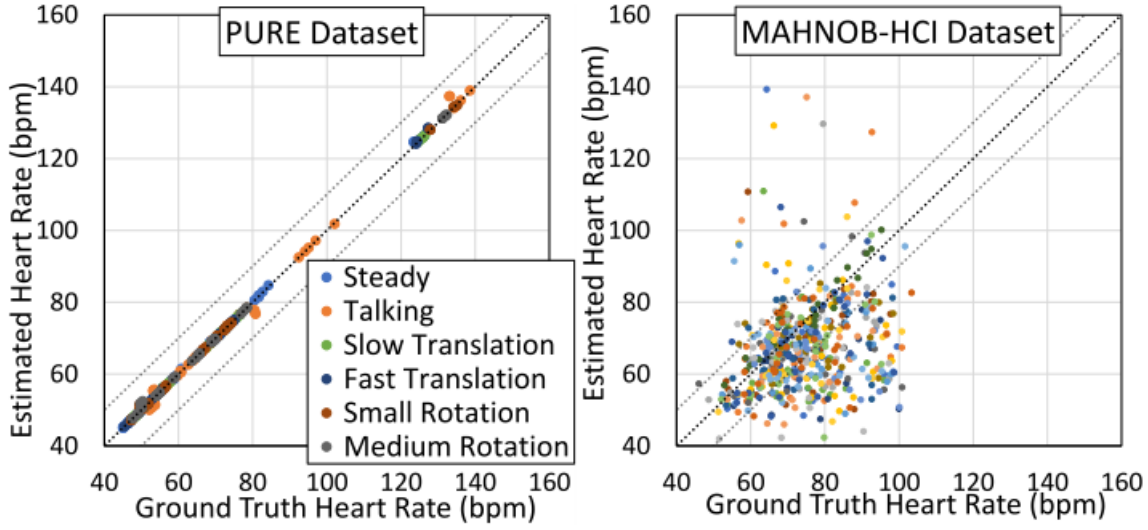


RESULTS HR



(a) StableSet

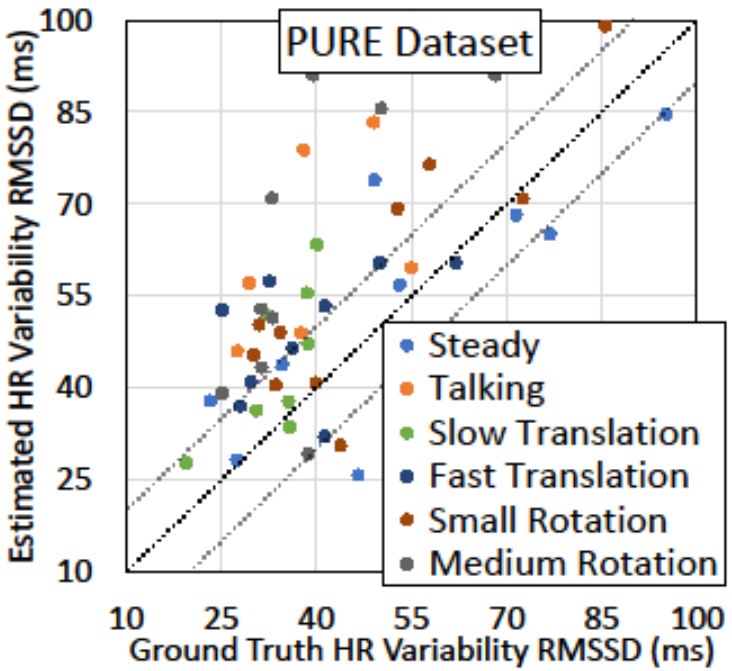
(b) VicarPPG

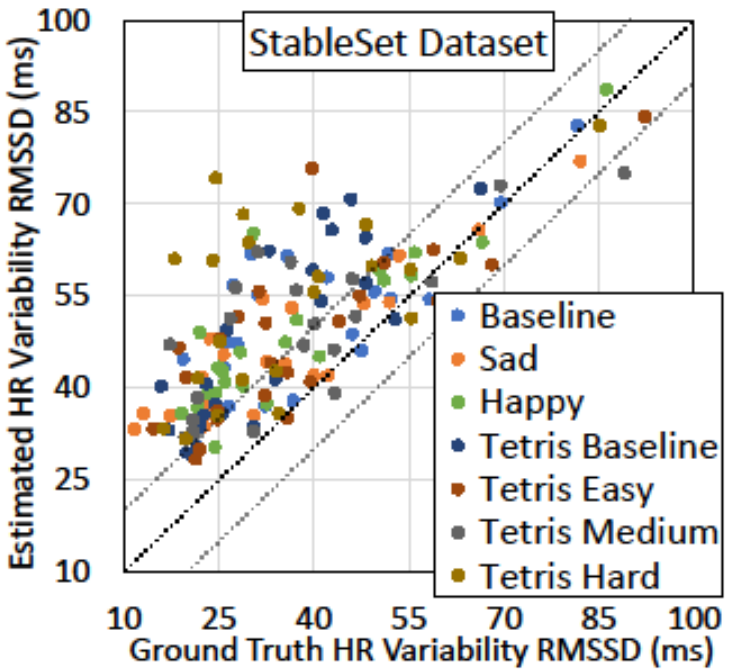


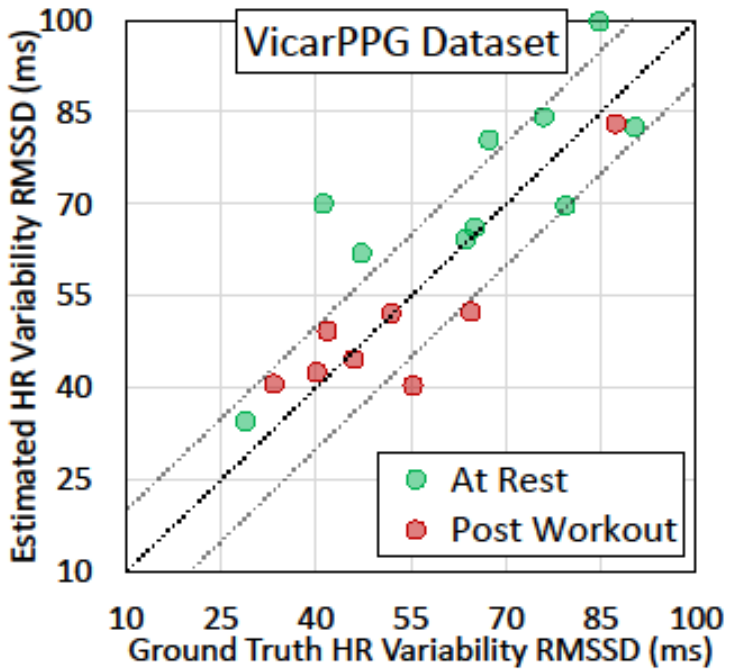
(c) PURE

(d) MAHNOB-HCI

RESULTS HRV


PURE Dataset
Estimated HR Variability RMSSD (ms)
Ground Truth HR Variability RMSSD (ms)
10
25
40
55
70
85
100
Steady
Talking
Slow Translation
Fast Translation
Small Rotation
Medium Rotation


StableSet Dataset
Estimated HR Variability RMSSD (ms)
Ground Truth HR Variability RMSSD (ms)
10
25
40
55
70
85
100
Baseline
Sad
Happy
Tetris Baseline
Tetris Easy
Tetris Medium
Tetris Hard


VicarPPG Dataset
Estimated HR Variability RMSSD (ms)
Ground Truth HR Variability RMSSD (ms)
10
25
40
55
70
85
100
At Rest
Post Workout