

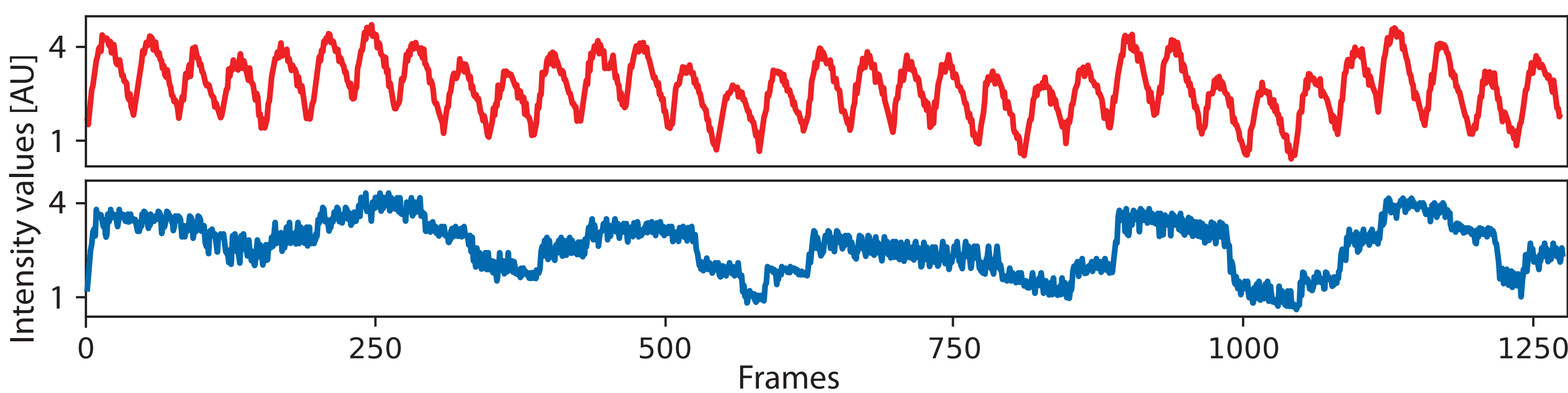
Robust Visual Heart Rate Estimation



Author: Radim Špetlík Advisor: Jan Čech
Center for Machine Perception
Czech Technical University in Prague

Heart Rate Estimation

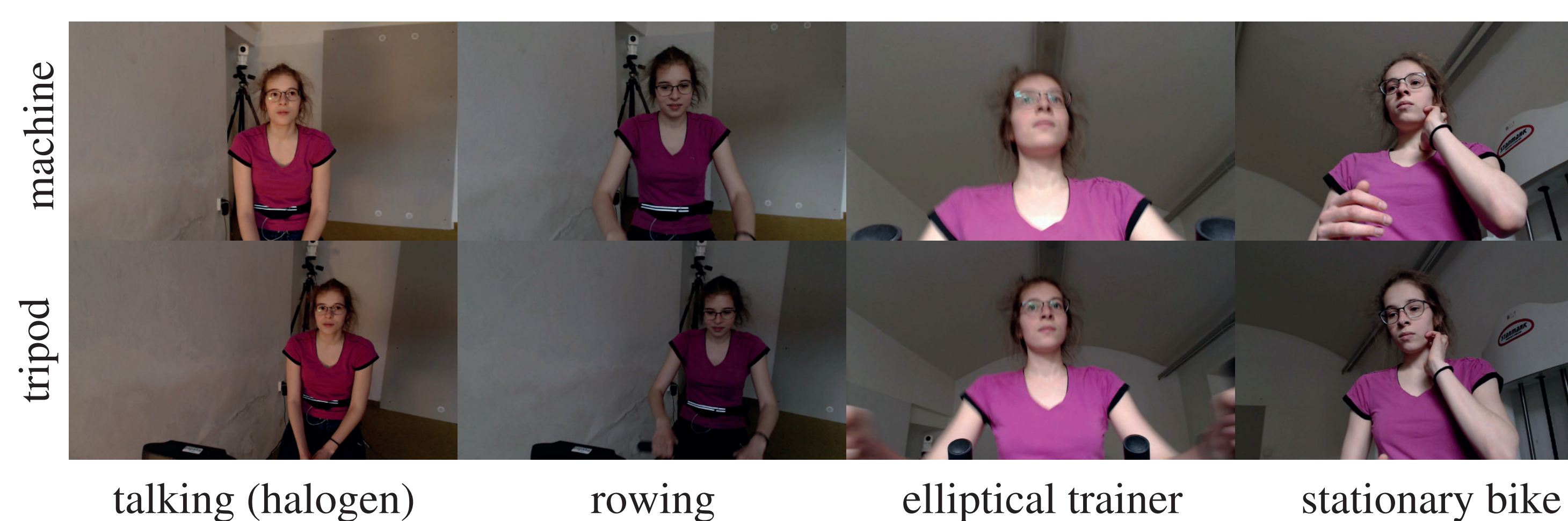
- Heart Rate (HR) is a basic parameter of cardiovascular activity.
- HR value is used broadly, its measurement is performed precisely with expensive contact devices (ECG, pulse oximeters, ...).
- Visual HR estimation, i.e. HR estimation from a video, delivers precise measurement using consumer webcams.
- Accuracy of visual HR estimation depends on recording conditions – prior visual HR methods are sensitive to motion and light interference, requiring subject's cooperation.



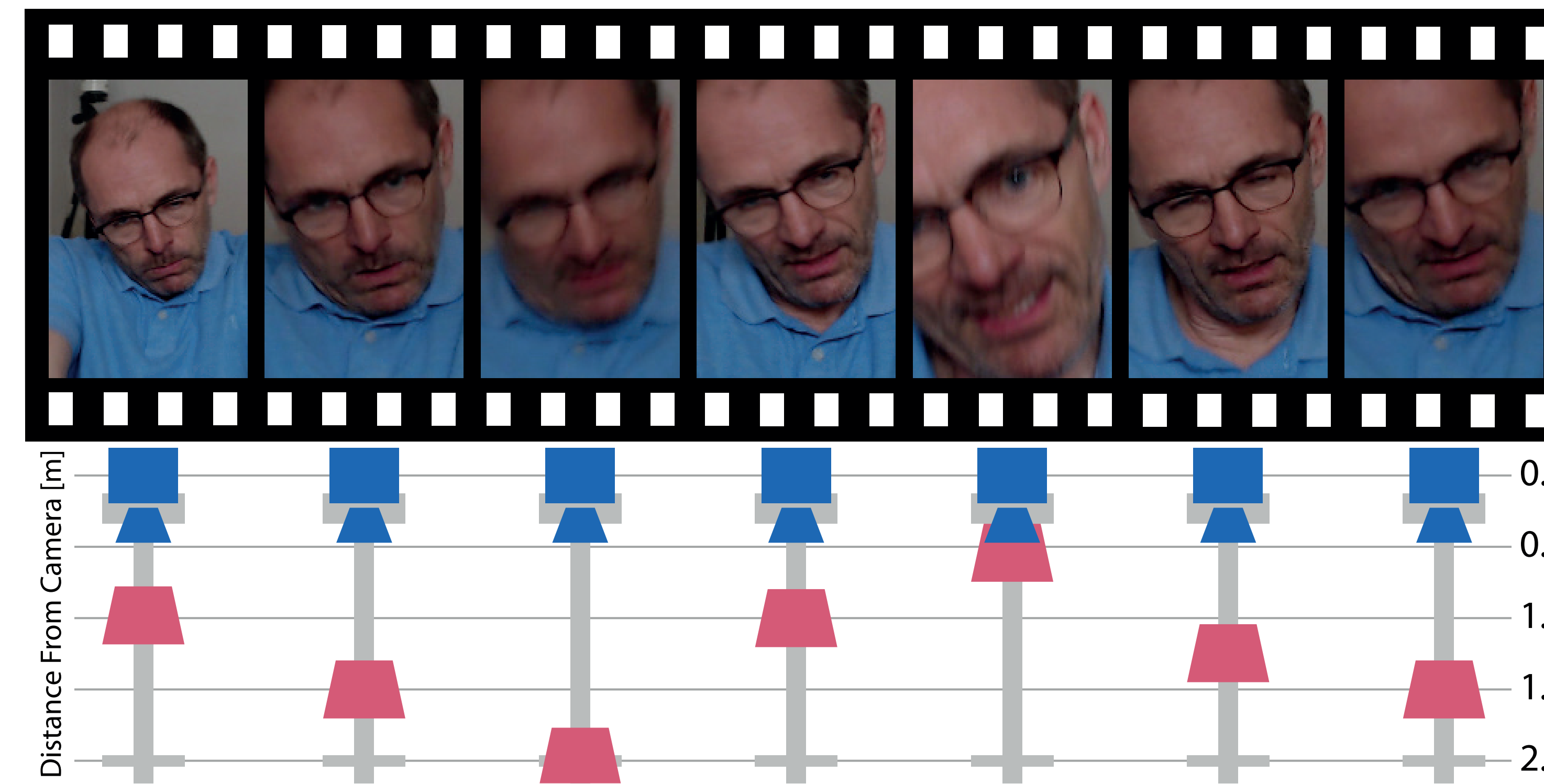
HR signal recovered from a video with a cooperating subject (top), and with a non-cooperating subject (bottom).

ECG-Fitness Dataset

- New, realistic & publicly available dataset of subjects performing physical exercises – 1080p RAW 30fps videos + 100Hz ECG recording.
- 207 videos – 17 subjects, 6 videos per subject, 2 cameras.
- HR (bpm) – min: 56, max: 159, mean: 108.96, std: 23.33.



Two cameras: one attached to a tripod, the other to the fitness machine. 4 activities, 2 lighting setups (daylight, halogen).

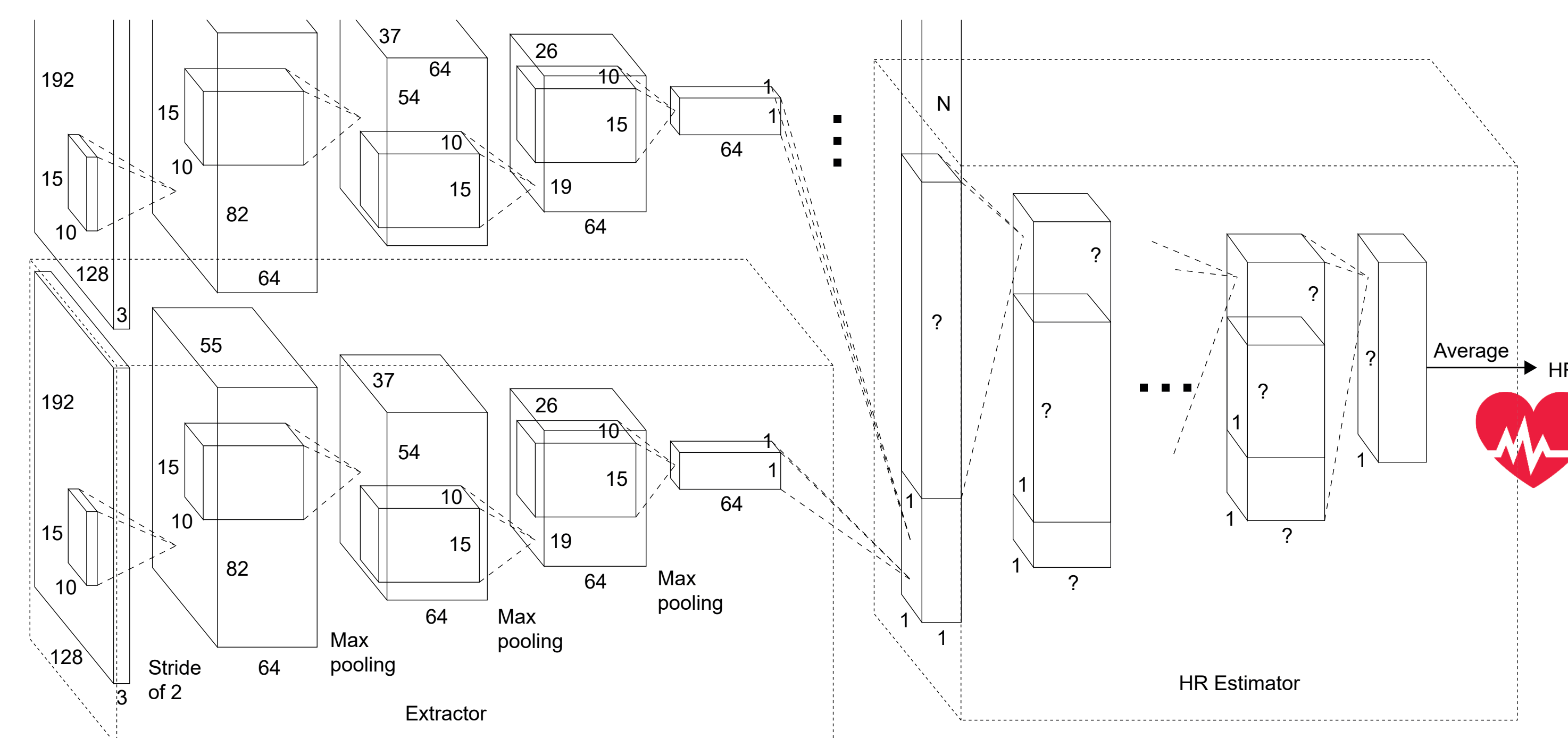


Facial images from a rowing session video of a subject from the ECG-Fitness dataset. Pink - the subject's position, blue - the camera.

- Dataset challenges: (i) large subject's motion, (ii) motion blur, (iii) facial expressions, (iv) glasses, (v) non-uniform lighting, (vi) light interference, (vii) atypical non-frontal camera angles.

Proposed Method

- HR-CNN: a two-step convolutional neural network.
 - Extractor is run over an image sequence of faces.
 - Estimator predicts the HR from the output of the Extractor.



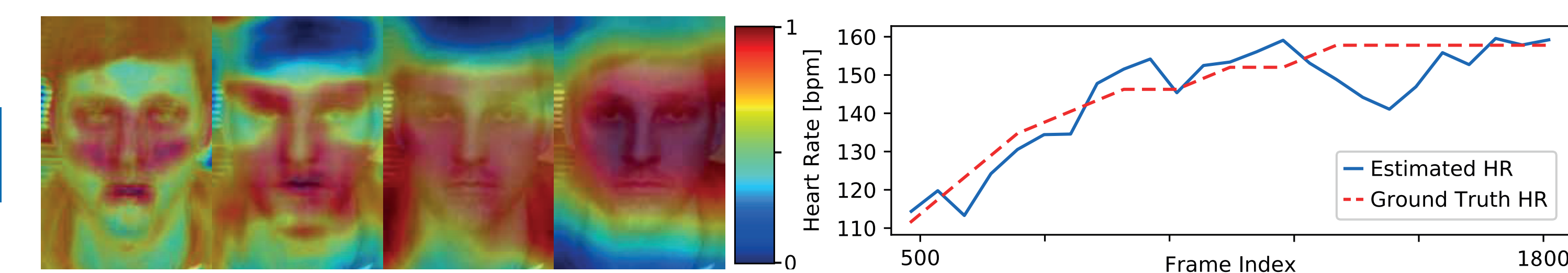
Spetlik, R., Cech, J. and Matas, J., (2018) Non-Contact Reflectance Photoplethysmography: Progress, Limitations, and Myths. In Automatic Face & Gesture Recognition (FG 2018), 2018 13th IEEE International Conference on (pp. 702-709). IEEE.
Spetlik, R., Franc, V., Cech, J. and Matas, J. (2018) Visual Heart Rate Estimation with Convolutional Neural Network, In Press.

Experiments

	COHFACE	ECG-Fitness	MAHNOB	PURE	PURE MPEG-4 Visual	
Pearson's corr. coeff.	baseline	—	—	—	—	
	2SR	-0.32	0.06	0.06	0.98 (2)	0.43
	CHROM	0.26 (2)	0.33 (2)	0.21	0.99 (1)	0.55 (2)
	LiCVPR	-0.44	-0.58	0.45 (2)	-0.38	-0.42
	HR-CNN	0.29 (1)	0.82 (1)	0.51 (1)	0.98 (2)	0.70 (1)
MAE [bpm]	baseline	8.98	17.35 (2)	9.19	9.29	9.29
	2SR	20.98	43.66	17.37	2.44	5.78 (1)
	CHROM	7.80 (1)	21.37	13.49	2.07 (2)	6.29 (2)
	LiCVPR	19.98	31.90	7.41 (2)	28.22	28.39
	HR-CNN	8.10 (2)	9.46 (1)	7.26 (1)	1.84 (1)	8.72

Test sets: COHFACE, ECG-Fitness, MAHNOB and PURE databases for three baseline methods and the proposed method. The baseline always outputs a constant HR – the average HR of the training set.

Conclusion



Grad-Cam heatmaps of the four output example of the HR convolutional layers, left to right. estimator for a challenging video.

- HR-CNN was tested on three publicly available datasets against three published methods achieving state-of-the-art HR prediction.
- Challenging publicly available dataset ECG-Fitness with 60 second videos of subjects performing physical exercises was introduced.
- The proposed HR-CNN method yields significantly the best on the realistic ECG-Fitness dataset.

<http://cmp.felk.cvut.cz/~spetlrad/ecg-fitness/>

