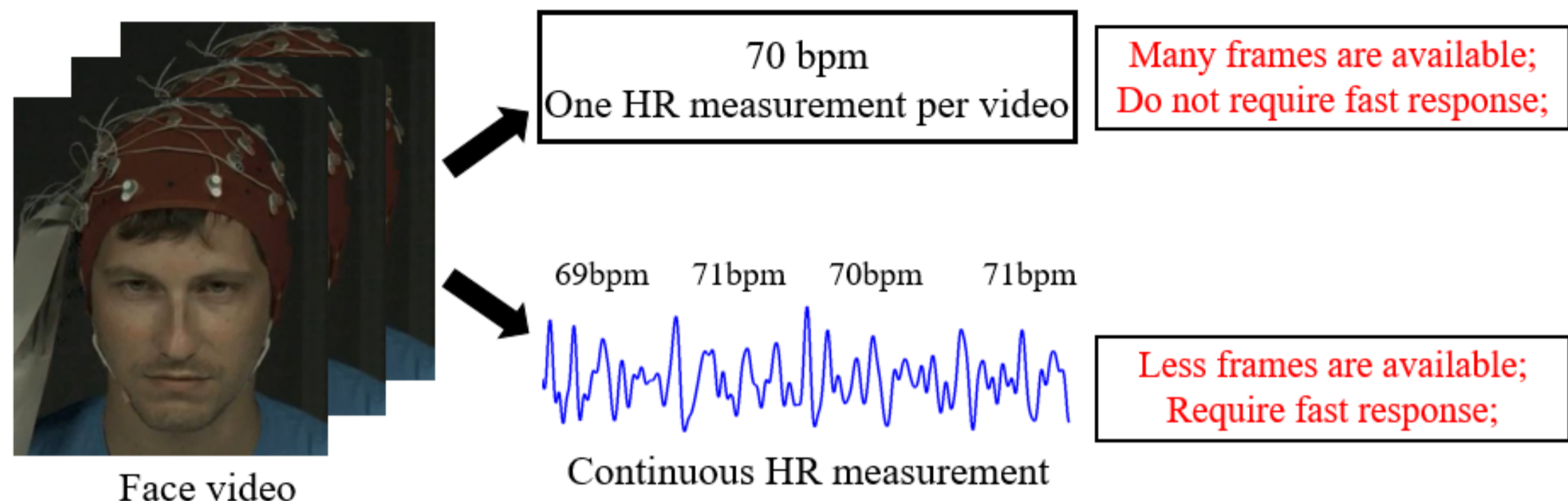


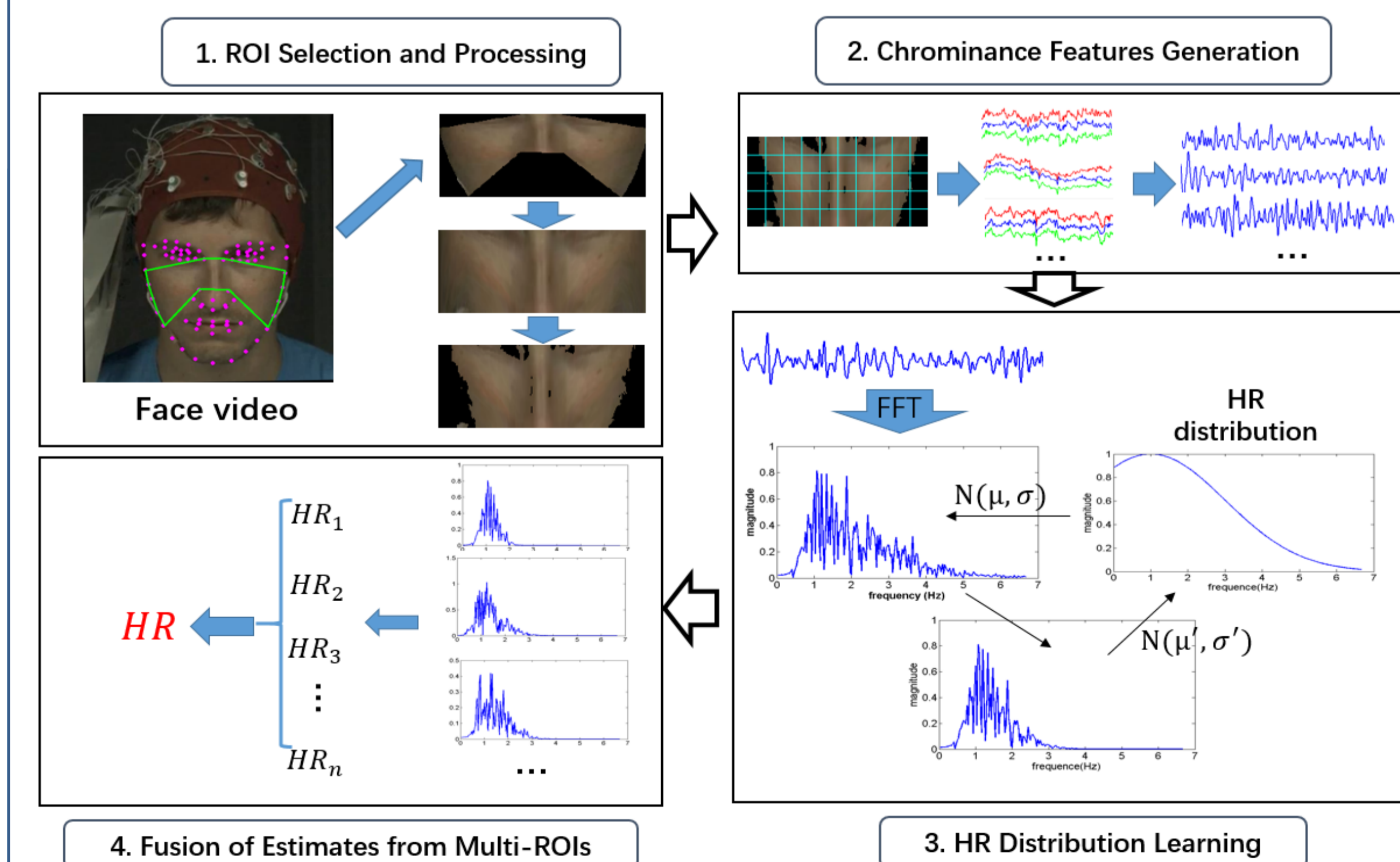
1. Motivation



- Remote PPG (rPPG) signal can be easily influenced by face movement and illumination variations
- The HR of a subject is often stable within a short period of time (i.e., does not change abruptly)

2. Approach Overview

- Our continuous heart rate (HR) measurement consists of four parts: (1) ROI selection and processing; (2) chrominance features generation; (3) HR distribution learning, and (4) fusion of estimations from multi-ROIs



3. Details

- ROI selection and processing
 - Face and landmark detection : VIPL face detector
 - ROI Wrapping: piece-wise linear wrapping

- Chrominance features generation

$$\mathbf{X} = I_c(\rho_{Cdc} + \rho_{Cac})M, \quad \mathbf{X} \in \{\mathbf{R}, \mathbf{G}, \mathbf{B}\}$$

$$X = 3R_n - 2G_n$$

$$Y = 1.5R_n + G_n - 1.5B_n$$

$$\alpha = \frac{\delta(X_f)}{\delta(Y_f)}$$

$$\mathbf{S} = X_f - \alpha Y_f$$

- Motion affects can be effectively reduced using chrominance feature
- HR distribution learning
 - Assumption: The pulse distribution of a subject follows a Gaussian distribution

$$p(\omega_i) = \frac{1}{(\sigma_{HR} + \sigma_0)\sqrt{2\pi}} e^{-\frac{(\omega_i - \mu_{HR})^2}{2(\sigma_{HR} + \sigma_0)^2}}$$

Balance parameter

$$\hat{F}(\omega) = P(\omega) \circ \hat{F}(\omega)$$

Historical influence Current frequency

- Fusion of Estimates from Multi-ROIs

- Sort all the estimations, and choose the median $2l+1$ estimations as the stable estimations

$$hr = \frac{\sum_{i=[\frac{k}{2}] - l}^{[\frac{k}{2}] + l} hr_i}{2l + 1}$$

4. Experimental Results

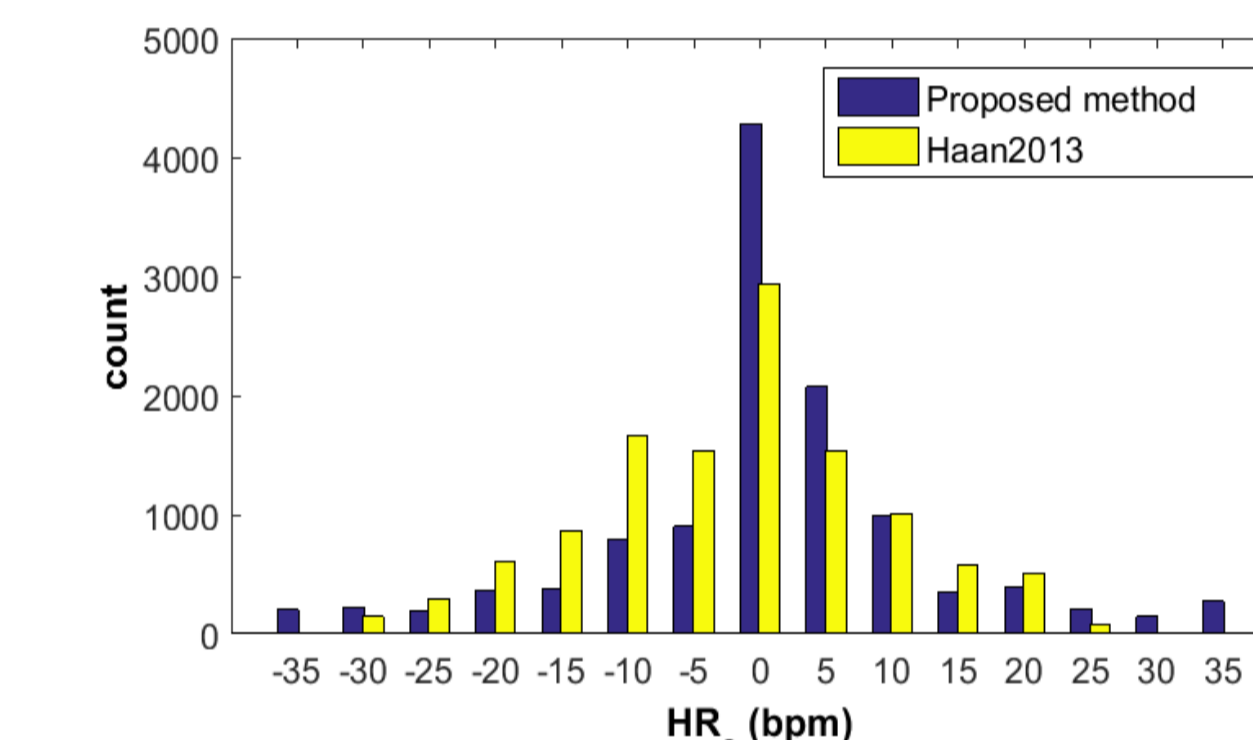
- Database



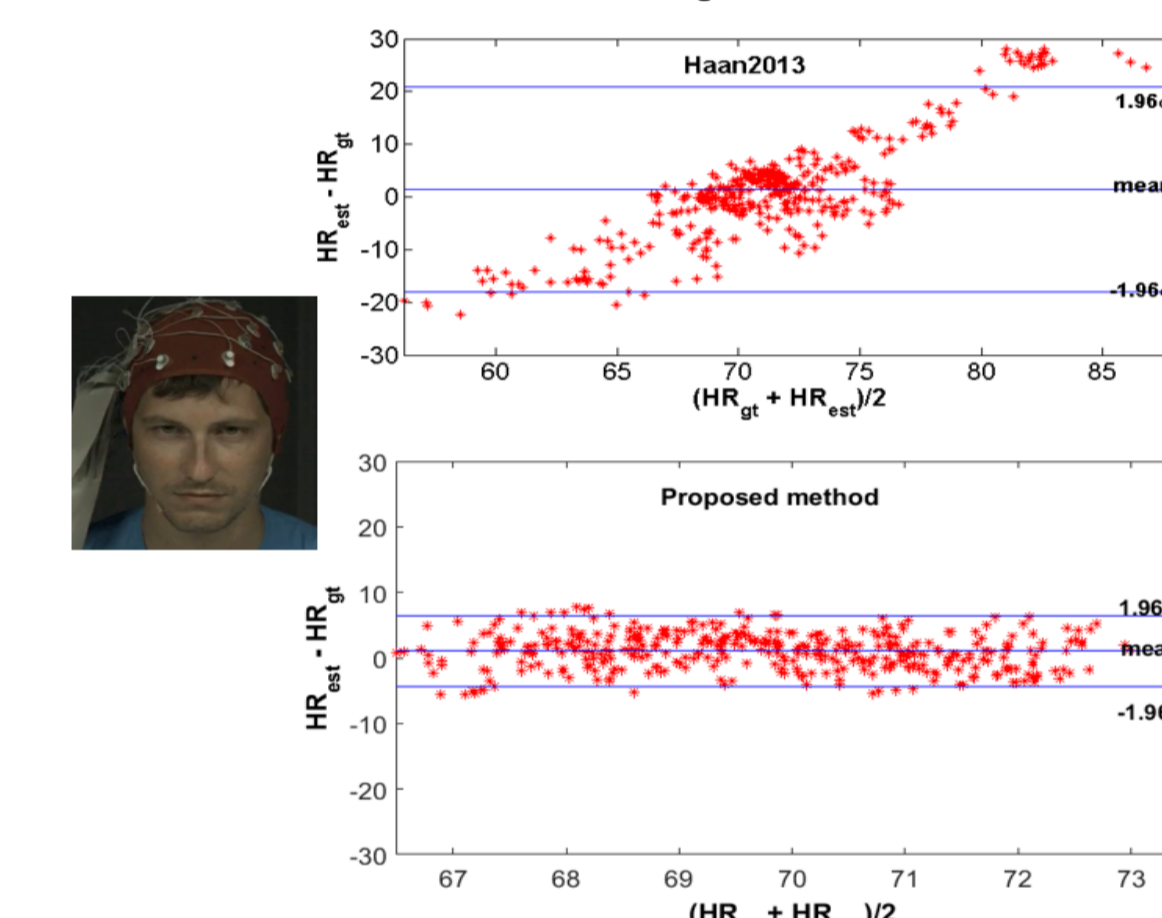
Mahnob-HCI

- 27 subjects 416 videos
- Use frame 306 to 5490 (90s)
- Use the first 30s to learn the HR distribution.

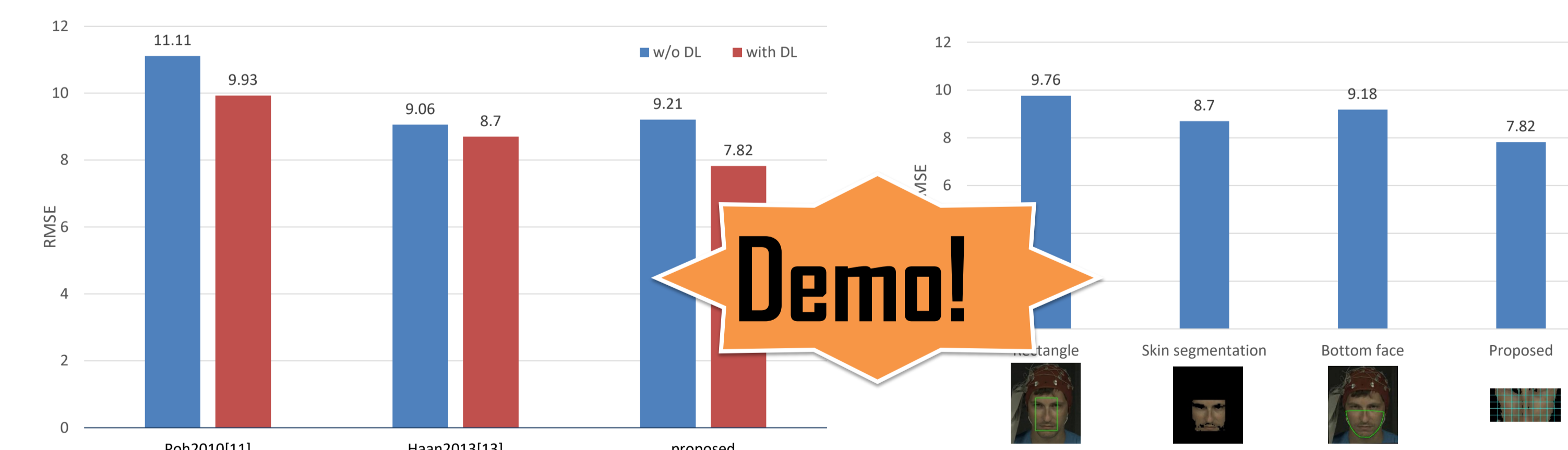
- HR estimation error distributions



- Bland-Altman plots



- Effectiveness of distribution learning
- Effectiveness of proposed ROI



5. Conclusions

- An effective framework for robust remote heart rate estimation using face video
- Heart rate distribution learning strategy for robust continuous heart rate estimation