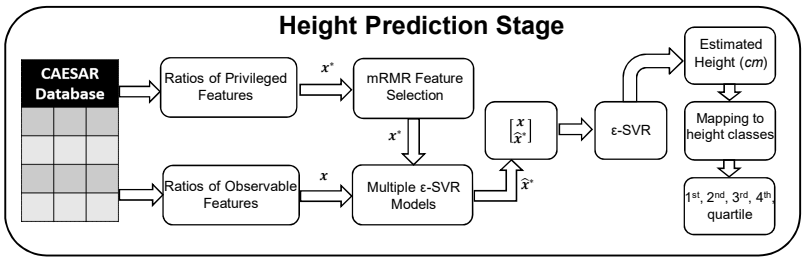
Predicting Privileged Information For Height Estimation

Nikolaos Sarafianos[1], Christophoros Nikou[1,2] and Ioannis A. Kakadiaris[1]

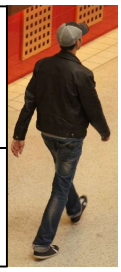
[1]Computational Biomedicine Lab, Dept. of Computer Science, University of Houston, Houston, TX
[2]Department of Computer Science and Engineering, University of Ioannina, Ioannina, Greece

Overview



Training and Prediction
- Observable information
  - Arm length
  - Knee height
  - Waist height
  - Hip breadth

Training Only
- Privileged information
  - Hip circumference
  - Chest circumference
  - Ankle circumference



Introduction

Problem Statement
- Predict the height using human metrology

Motivation
- Explore the use of ratios of anthropometric measurements for gender estimation
- Exploit privileged information available during training
- Predict the privileged information at prediction-time in a regression setup

Background
- Observable features: Information available at both training and prediction
- Privileged features: Information available only at training time

Method

A. Regression

ε-SVR+: $\underset{\substack{w,w_1^*,w_2^*,\\ b,b_1^*,b_2^*}}{\text{minimize}} \left\{\frac{1}{2}\left(||w||^2 + \gamma(||w_1^*||^2 + ||w_2^*||^2)\right) + C\sum_{i=1}^{l}(\langle w_1^*, x_i^*\rangle + b_1^*) + C\sum_{i=1}^{l}(\langle w_2^*, x_i^*\rangle + b_2^*)\right\}$

$$\text{s.t.} \quad \begin{aligned} y_i - \langle w, x_i\rangle - b &\le \varepsilon + \langle w_1^*, x_i^*\rangle + b_1^* \\ \langle w, x_i\rangle + b - y_i &\le \varepsilon + \langle w_2^*, x_i^*\rangle + b_2^* \\ \langle w_1^*, x_i^*\rangle + b_1^* &\ge 0 \\ \langle w_2^*, x_i^*\rangle + b_2^* &\ge 0 \\ i &= 1 \dots l \end{aligned}$$

B. Privileged Information Prediction (PIP)

Algorithm: Privileged Information Prediction (PIP)

Input: Ratios of observable **x** and privileged **x*** features, labels **y**, number of selected features **K**, and estimation error allowed **e,** tolerance **ε**

// privileged feature prediction

1. $\hat{x}_i^* \leftarrow \varepsilon - SVR\ model\ on\ (x, x_i^*), i = 1 \dots K$

// height estimation

2. $h \leftarrow \varepsilon - SVR\ model\ on\ \left([x^T, \hat{x}^{*T}]^T, y\right)$
3. $h_c \leftarrow$ mapping to height classes by allowing error e

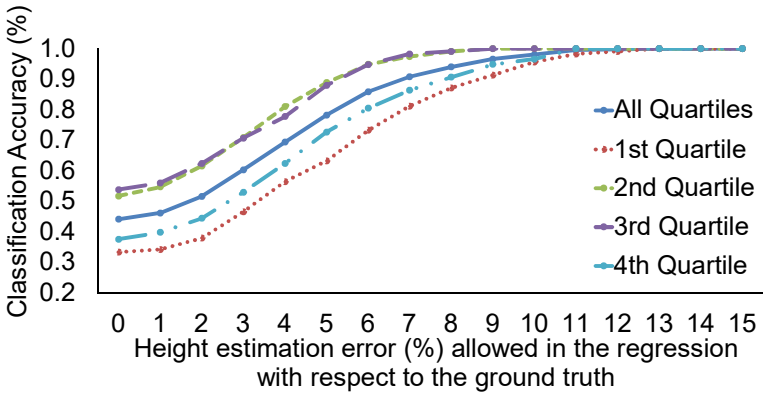
Output: Height ***h*** (cm), $h_c \in \{1^{st}, 2^{nd}, 3^{rd}, 4^{th}\}$ quartiles

Results

Height Estimation Error (%)

Quantile	ε-SVR	ε-SVR+ [1]	PIP
1st	4.21 ± 0.12	4.28 ± 0.33	**3.96 ± 0.34**
2nd	2.62 ± 0.13	**2.50 ± 0.16**	2.65 ± 0.12
3rd	2.92 ± 0.15	2.71 ± 0.19	**2.69 ± 0.11**
4th	4.08 ± 0.17	3.86 ± 0.33	**3.73 ± 0.22**
All	3.48 ± 0.04	3.33 ± 0.10	**3.25 ± 0.12**

Height Classification Accuracy (%)



Contributions

- Proposed a novel method for predicting privileged information at prediction time
- Demonstrated the efficacy of ratios of measurements for robust height estimation
- Provided the implementation of ε-SVR+: www.cbl.uh.edu/repository-code/

References

[1] V. Vapnik and A. Vashist, "A new learning paradigm: Learning using privileged information." Neural Networks, vol. 22, no. 5-6, pp. 544–57, 2009.

Acknowledgements

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