Utilizing Posterior Probability in Age Estimation: Accounting for Mixed Race

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Introduction

Age estimation from face images is a widely studied topic in the field of computer vision and has numerous potential applications in an increasingly technological world. Previous research has shown that age estimation is highly sensitive to race and gender categories [1] , which informed the framework proposed in this project. However as diversity increases within a society, race (as well as gender) becomes less and less clearly defined, presenting an issue for an age estimation model that relies on successful race and gender classification. To account for this issue, this project explores the utilization of posterior probabilities from the race classification step to compute a race-composite age estimate.

Data

The MORPH-II dataset is a collection of 55,134 mugshots, including many of repeat offenders. The below table summarizes the demographic composition of the dataset by number of images:

	Black	**W**hite	**A**sian	**H**ispanic	**O**ther	Total
Male	36,821	7,958	140	1,661	64	46,644
Female	5,756	2,590	13	99	32	8,490
Total	42,577	10,548	153	1,760	96	**55,134**

Given the heavily imbalanced nature of the dataset, only images of Black and White individuals were used in this project. These images were subsetted according to the below scheme:

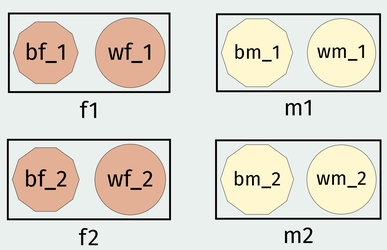


Figure 1: Subset Scheme

In this reduced dataset there are a total of 20,560 images in a 3 to 1 Male to Female ratio. The images for each gender are split into two halves, and every race and gender subgroup is divided similarly (± 1 image). There are no common individuals between subsets.

Pre-processing MORPH-II

Figure 2: Pre-processing stages

Objectives

1. Ensure proper rotation
2. Capture the face (*only*)
3. Standardize the images

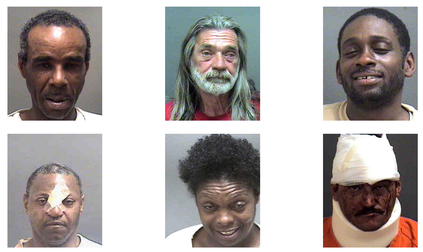
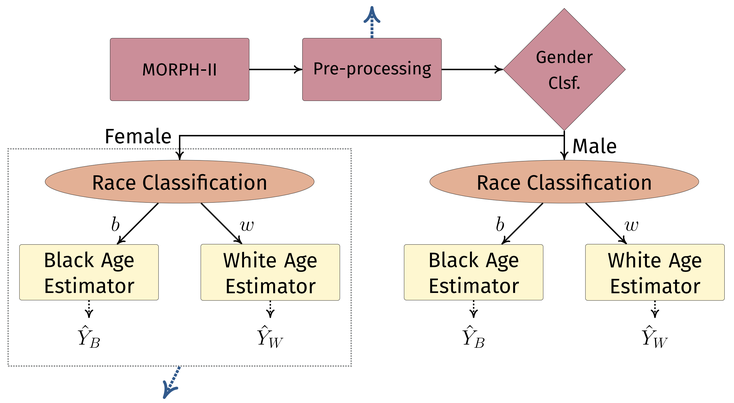


Figure 3: Challenging Images



Utilizing Posterior Probability

Each race classifier outputs the probabilities that an image belongs to the Black and White race categories ($b, w \in [0, 1]$, $b+w = 1$). Using these values to compute a weighted average of the Black and White age estimates returns a new approximation that accounts for mixed race.

$$Y^* = (b * \hat{Y}_B) + (w * \hat{Y}_W) \qquad (1)$$

Methods

Support Vector Machines with linear kernels were used for both race classification and age estimation. The cost parameter was tuned on each training set using a grid search.

Feature extraction was done using Local Binary Patterns. The dimension of the feature vectors was reduced to 400 using Principal Component Analysis (PCA).

Gender classification was not explored in this project - ground truth values were used instead.

Partial (even) Dataset

The Partial (even) dataset was used to test the model before it was applied to the reduced MORPH-II (see *Data*); it contains 1,000 images of 1,000 distinct individuals and is broken down according to the subset scheme shown in Figure 1. It differs from the reduced version of MORPH-II in that the overall age distribution is uniform. Table 1 below shows the results of testing on this dataset:

	MAE	Weighted MAE
bf_1	6.71	**6.695**
bf_2	6.634	**6.45**
wf_1	7.007	**6.535**
wf_2	6.579	**6.461**
bm_1	5.501	**5.475**
bm_2	4.979	**4.799**
wm_1	4.443	**4.434**
wm_2	4.518	**4.498**

Table 1

Here, the indices correspond to the testing set associated with the results. Bolded entries are the lowest mean absolute error (MAE) in their respective rows.

Preliminary Results

	MAE	Weighted MAE
bf_1	6.894	**6.872**
bf_2	**6.316**	6.389
wf_1	5.826	**5.824**
wf_2	**5.791**	5.863
bm_1	5.283	**5.279**
bm_2	**5.359**	5.362
wm_1	4.985	**4.983**
wm_2	**4.971**	4.987

Table 2

Table 2 displays the results on the reduced MORPH-II dataset. As in Table 1, row indices correspond to the testing set and bolded entries are the lowest MAE in their respective rows. Each testing set was passed through a pipeline trained on a fully independent subset. For example, the race classifier tested on bf_1 was trained with subset f_2, and the associated age model was trained on bf_2.

Conclusions

While the results from the Partial dataset seem to show that the composite age estimate is an improvement over the straightforward prediction (from the model with the highest associated posterior probability), the preliminary results from the reduced MORPH-II dataset are mixed. Much more work remains to be done in testing the model on the full dataset.

References

[1] G. Guo and G. Mu.
Human age estimation: What is the influence across race and gender?
In *2010 IEEE Computer Society Conference on Computer Vision and Pattern Recognition - Workshops*, pages 71–78, June 2010.

[2] Karl Ricanek and Tamirat Tesafaye.
Morph: A longitudinal image database of normal adult age-progression.
In *Automatic Face and Gesture Recognition, 2006. FGR 2006. 7th International Conference on*, pages 341–345. IEEE, 2006.

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