Efficient and Robust Face Alignment under Significant Head Rotation

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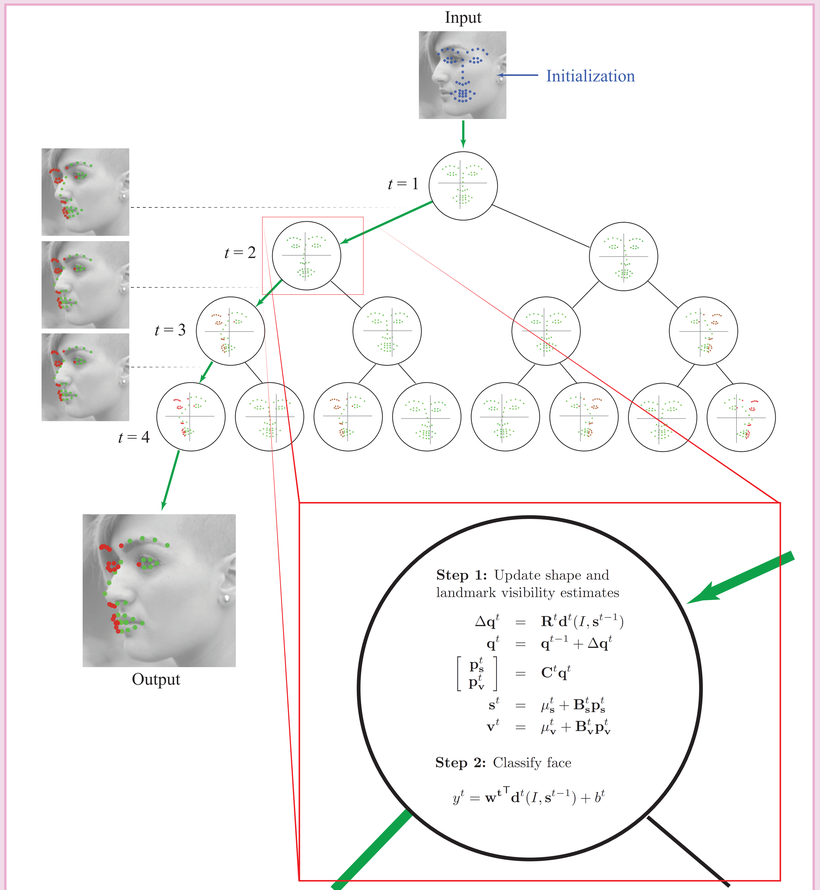
Motivation

Despite much interest in face alignment recently, the large majority of work has focused on near-frontal faces. Algorithms typically break down on profile faces, or are too slow for real-time applications.

Approach

We propose an efficient approach to face alignment that can handle 180 degrees of head rotation. The foundation of our approach is cascaded shape regression (CSR), which has emerged as the leading strategy. We propose a generalization of conventional CSRs that we call *branching cascaded regression* (BCR). Conventional CSRs are single-track; that is, they progress from one cascade level to the next in a straight line, with each regressor attempting to fit the entire dataset. We instead split the regression problem into two or more simpler ones after each cascade level. Intuitively, each regressor can then operate on a simpler objective function (i.e., with fewer conflicting gradient directions).



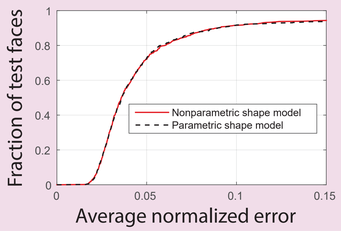
Offline, compute $\mathbf{R}^t$: $\underset{\mathbf{R}^t}{\operatorname{argmin}} \sum_{i \in N_t} \|\Delta\hat{\mathbf{q}}_i^t - \mathbf{R}^t\mathbf{d}^t(I_i, \mathbf{s}^{t-1})\|_2^2 + \lambda\|\mathbf{R}^t\|_2^2$

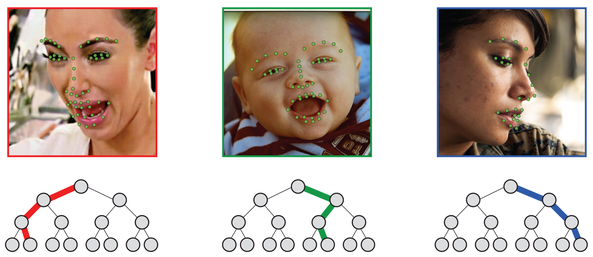
Parametric shape model: $\hat{\mathbf{S}} = \mu_\mathbf{s} + \mathbf{B}_\mathbf{s}\mathbf{p}_\mathbf{s}, \quad \mathbf{S} \approx \hat{\mathbf{S}}$

Parametric vs. Nonparametric Shape Models

Point distribution models (PDMs) have several desirable qualities:

- Far fewer parameters to optimize
- All landmarks are optimized simultaneously
- They generalize well to unfamiliar faces





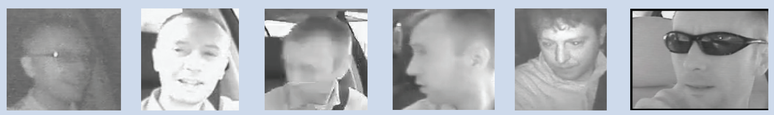
Our branching cascaded regression (BCR) algorithm can handle faces with a wide variety of poses, including full profile.

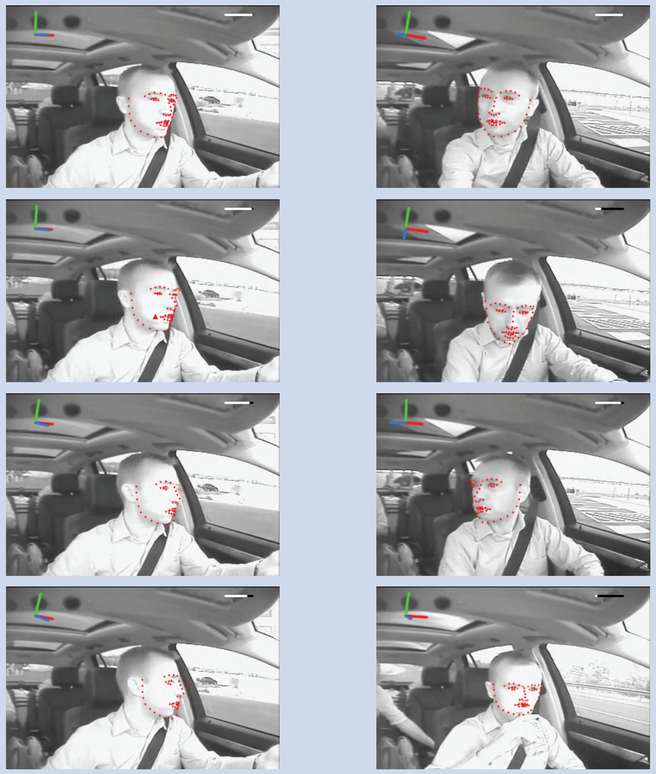
Results

Second Strategic Highway Rsearch Program (SHRP2) Naturalistic Driving Study (NDS)

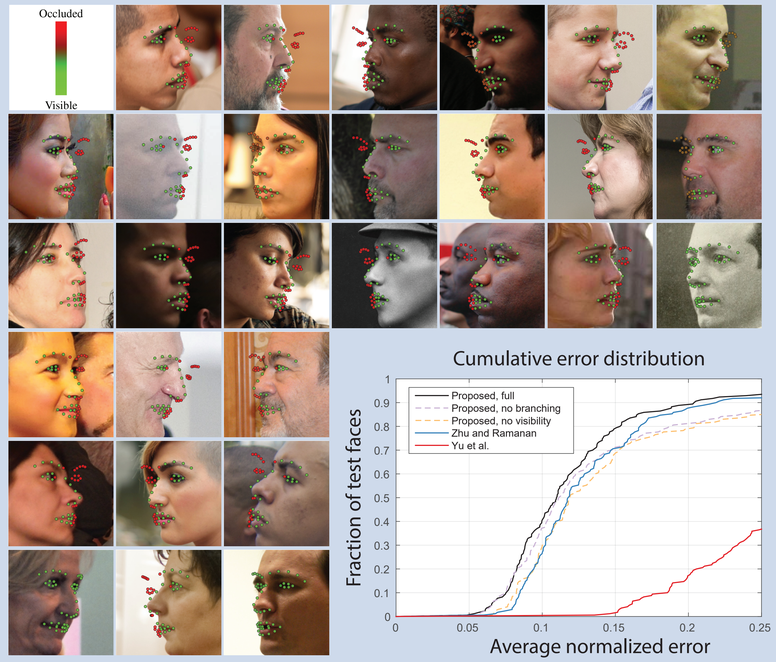
Challenges

Low video quality: resolution, dynamic range, compression
Motion blur
Low light and over exposure
Unpredictable and significant illumination changes
Significant head rotation, including full profile
Occlusion: sunglasses, hats, hands and arms

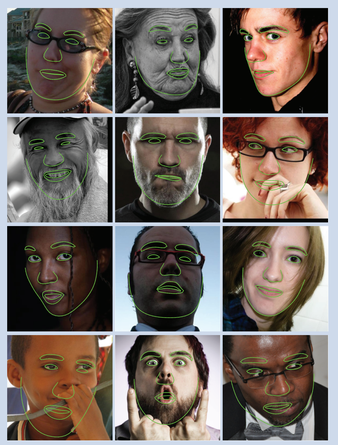




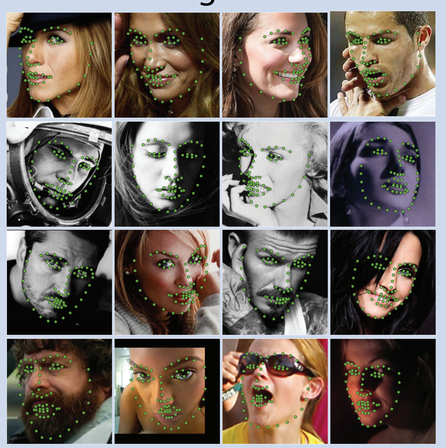
Flickr Profile Faces



Helen Dataset



300 Faces In-the-Wild Challenge Dataset



FERET Profile Faces

Our five worst-fitting FERET results