Discriminative Invariant Kernel Features: A Bells-and-Whistles-Free Approach to Unsupervised Face Recognition and Pose Estimation

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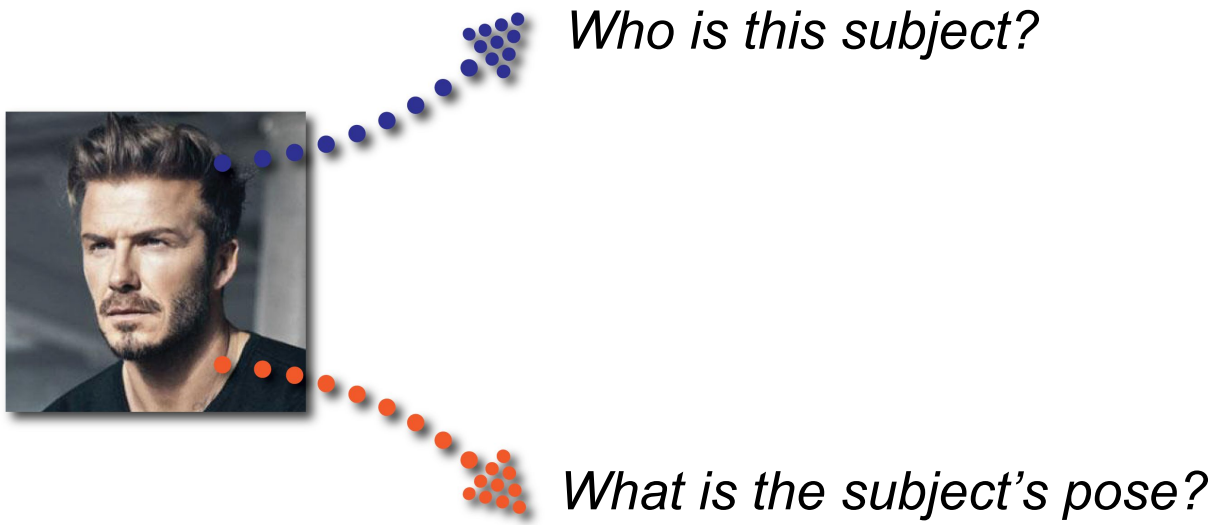
Carnegie Mellon University
CyLab Biometrics Center

The problem

Two complementary tasks

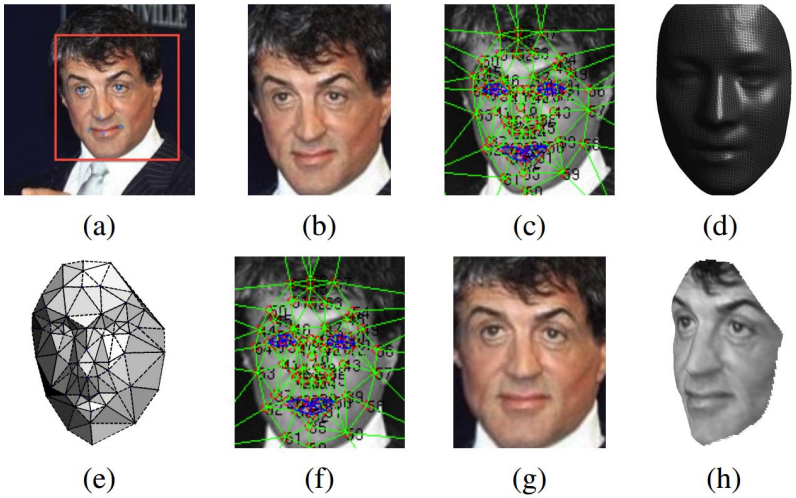
To perform two complementary tasks simultaneously using a single unsupervised feature extractor



The problem
Landmark-free

The paper focuses on dense landmark-free (only two eye center locations) face recognition and pose estimation

Extends to a completely landmark-free approach which is also alignment free



Taigman, Yaniv, et al. "Deepface: Closing the gap to human-level performance in face verification." *CVPR* 2014.

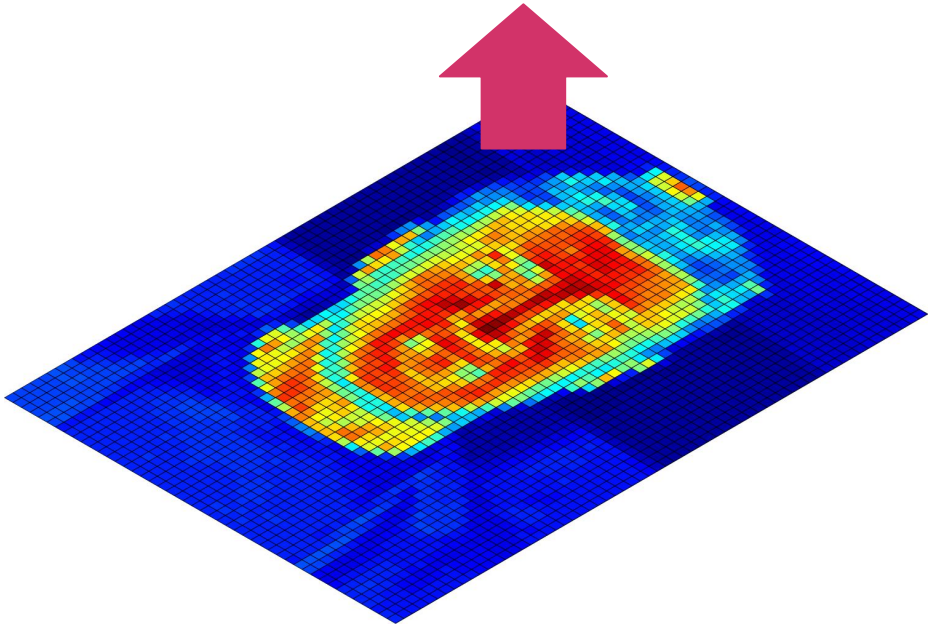
This work:

The problem

Discriminative Invariant Feature

We extract a single highly discriminative provably group invariant non-linear feature for both tasks from raw pixels

Invariant feature extraction from raw pixels.

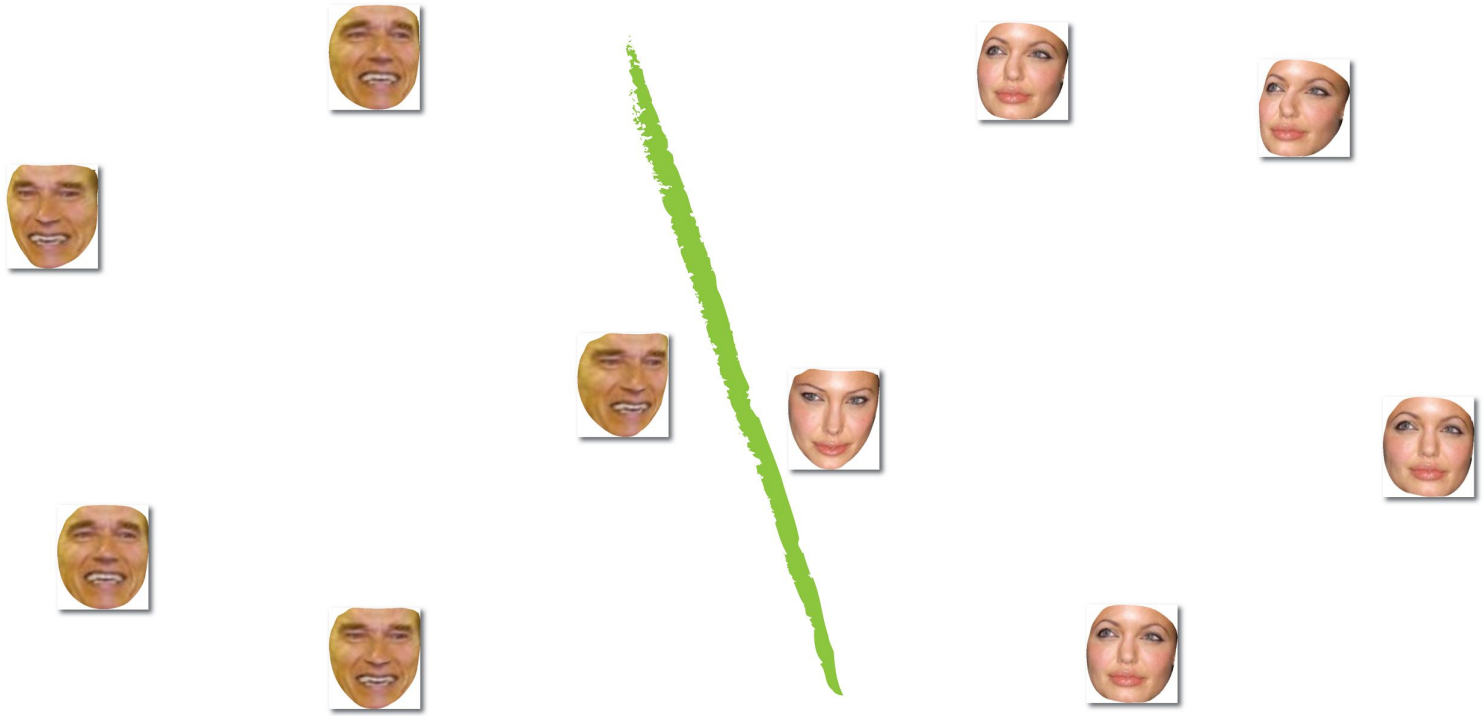


The approach

Invariance to Transformations

Nuisance transformations groups such as the translation, rotation group, increase complexity of the learning problem

Invariance to such transformations can drastically reduce complexity



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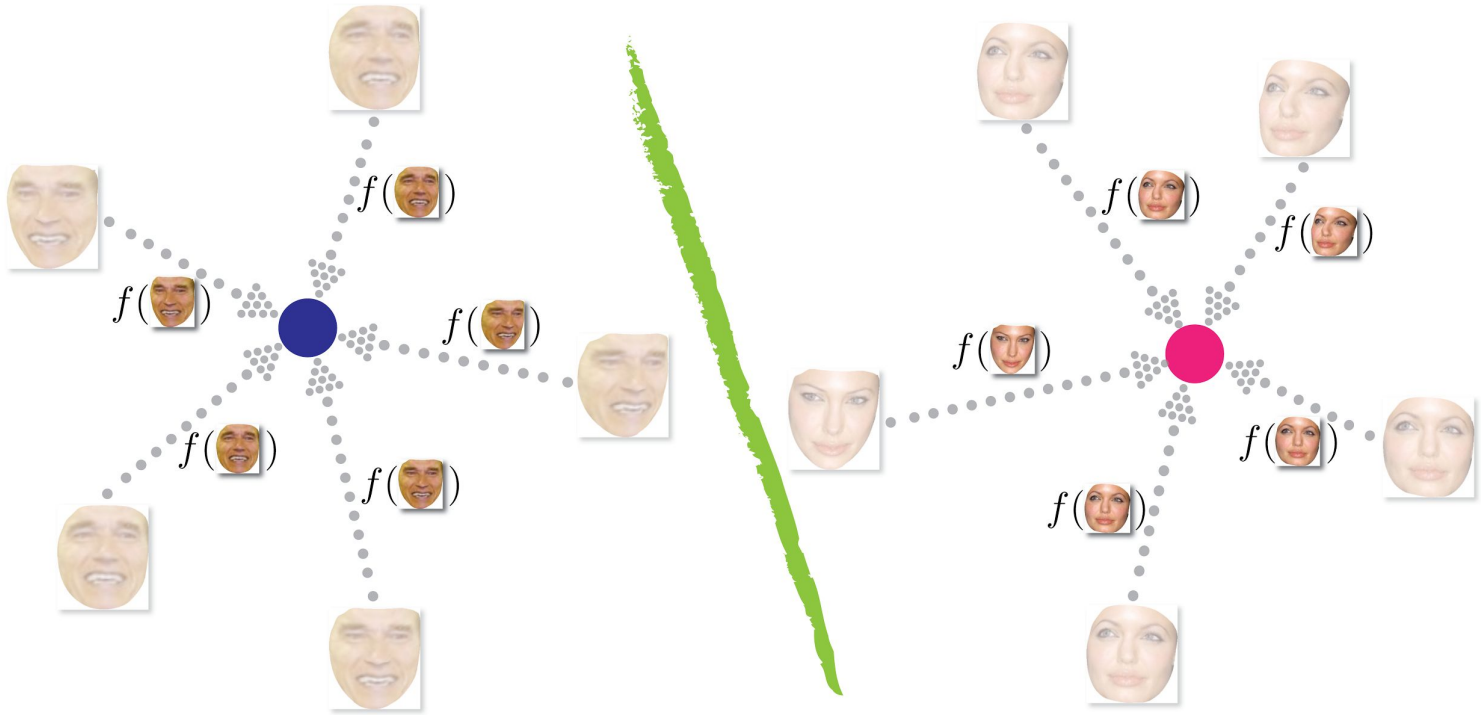

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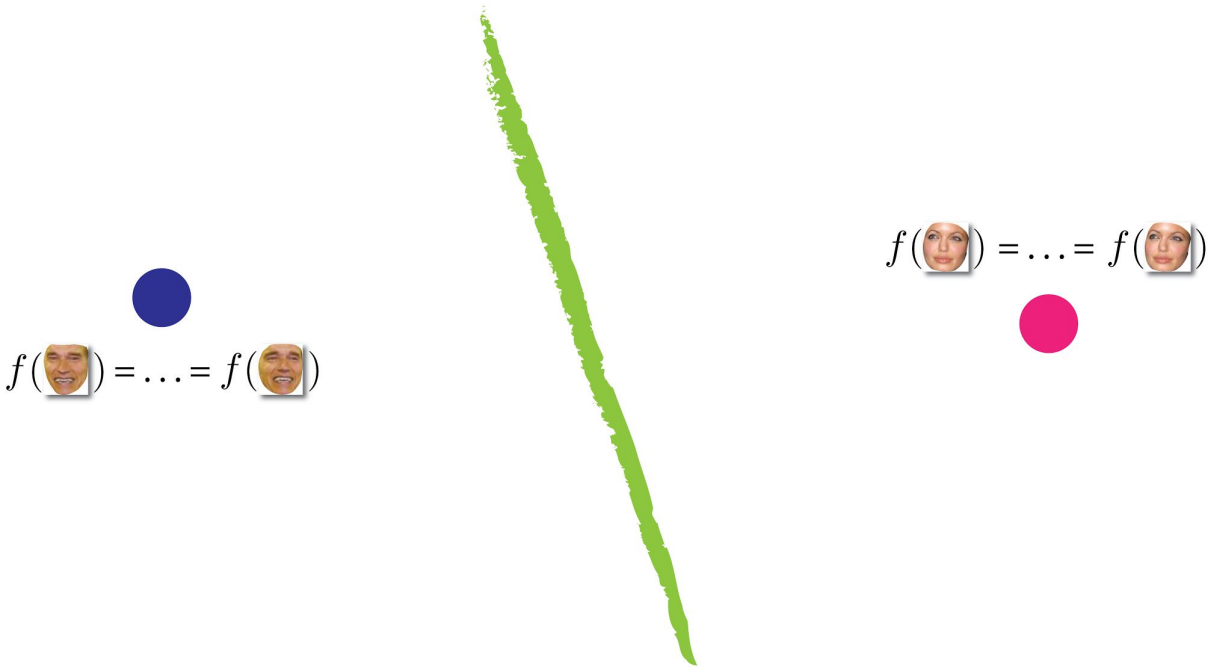
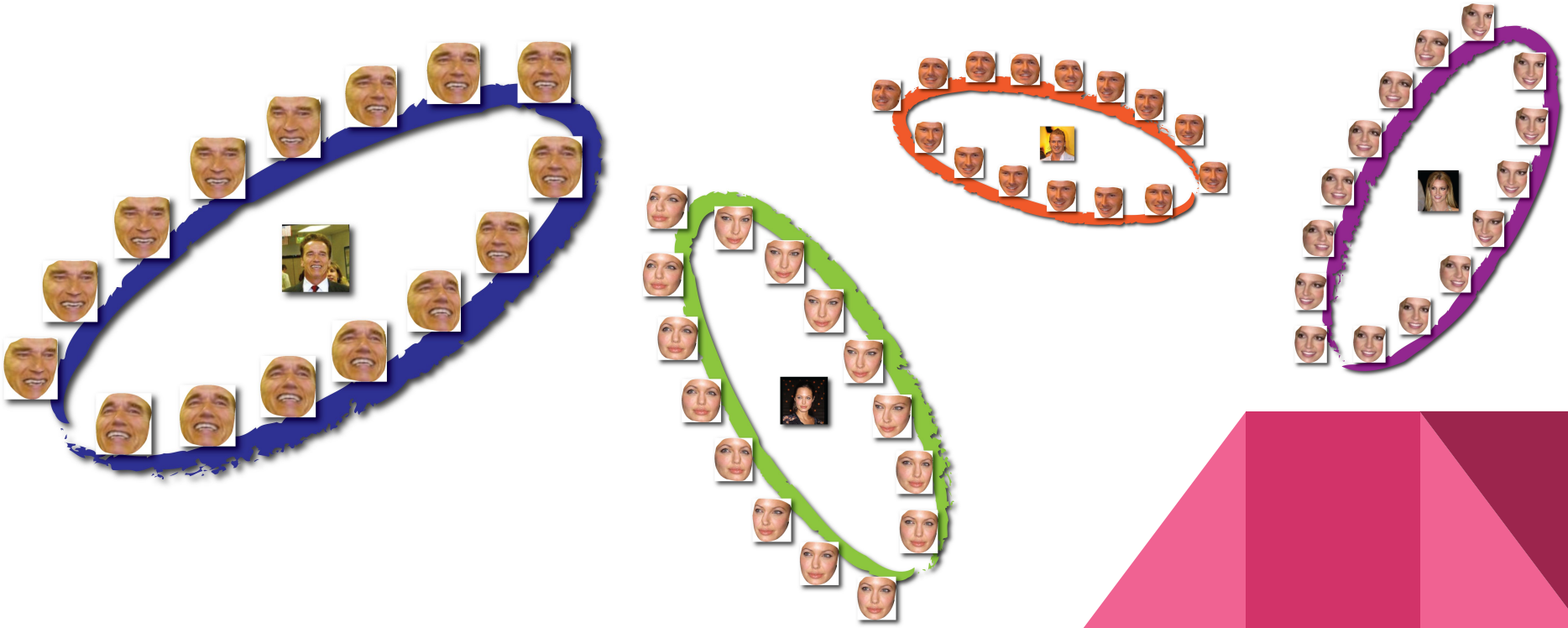


Previous work

Linear Invariant Features

Previous work builds linear invariant that are implicitly (but not explicitly) discriminative

When a group of transformations act on an object, they create an orbit



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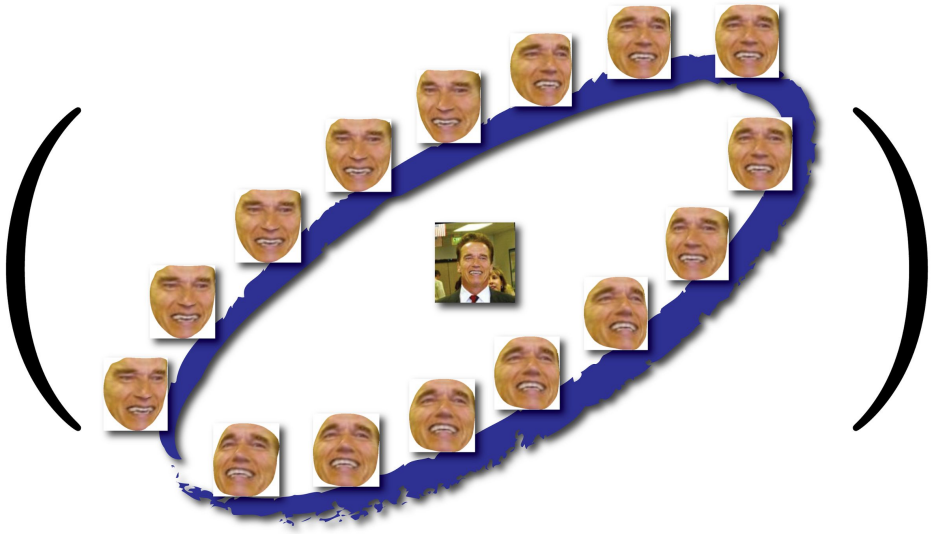
The orbit is unique to the object, and is an invariant to the transformation group



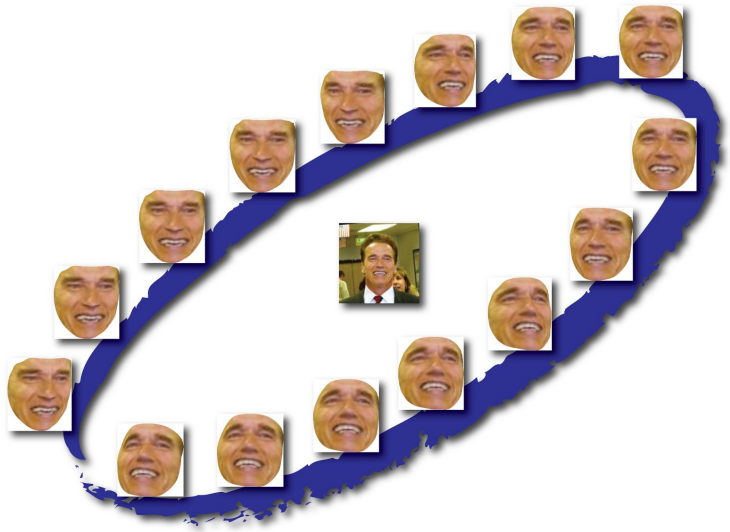
is invariant

Previous work

Linear Invariant Features

Previous work builds linear invariant that are implicitly (but not explicitly) discriminative

Hence any measure of the orbit is an invariant implicitly discriminative feature

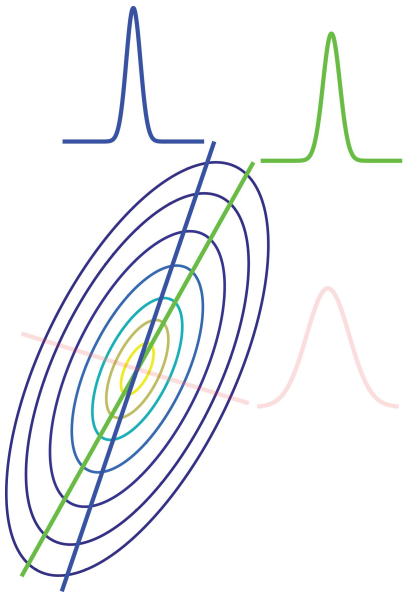
$f($  $)$ is invariant

Our approach

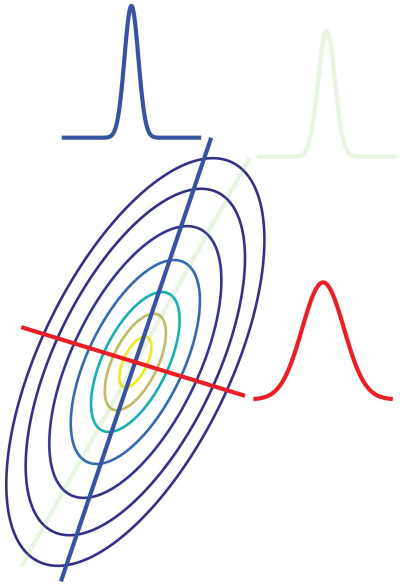
Linear Discriminative Invariance

To characterize the orbit, previously simply sampled templates were used

Explicit discrimination provides better matching. More over the learnt templates still form a group of transformed templates, hence invariance theory holds.



Sampled templates



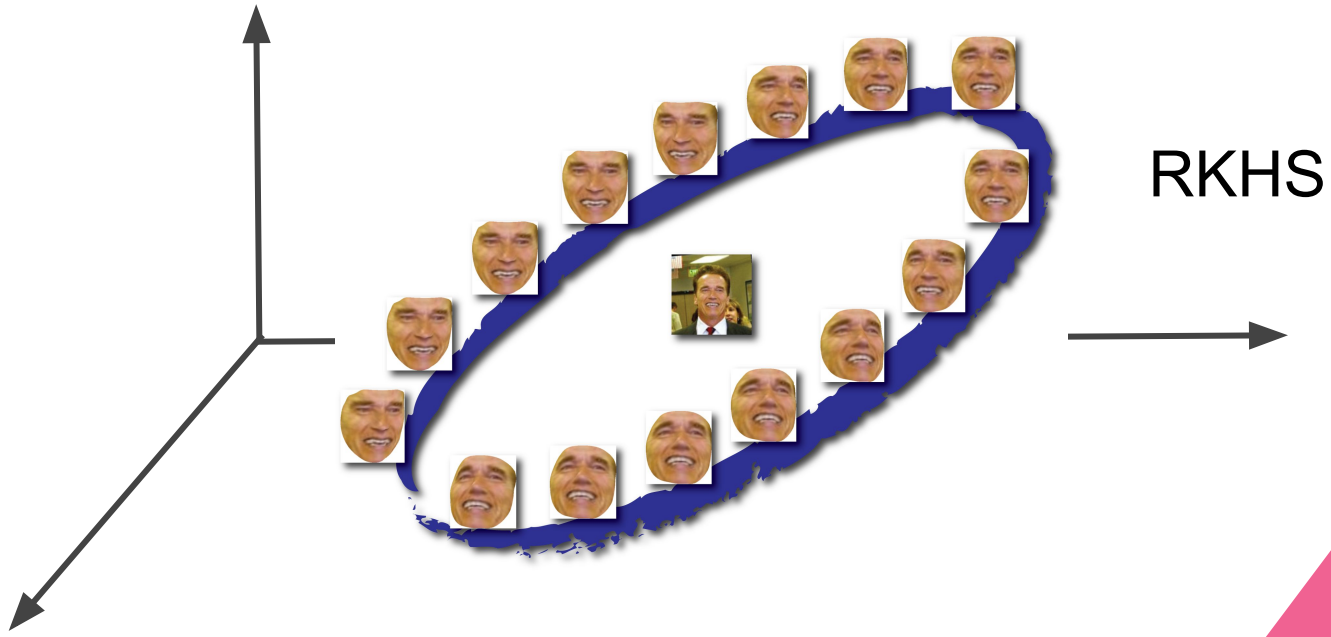
Discriminatively learned templates

Our approach

Non-linear Discriminative Invariance

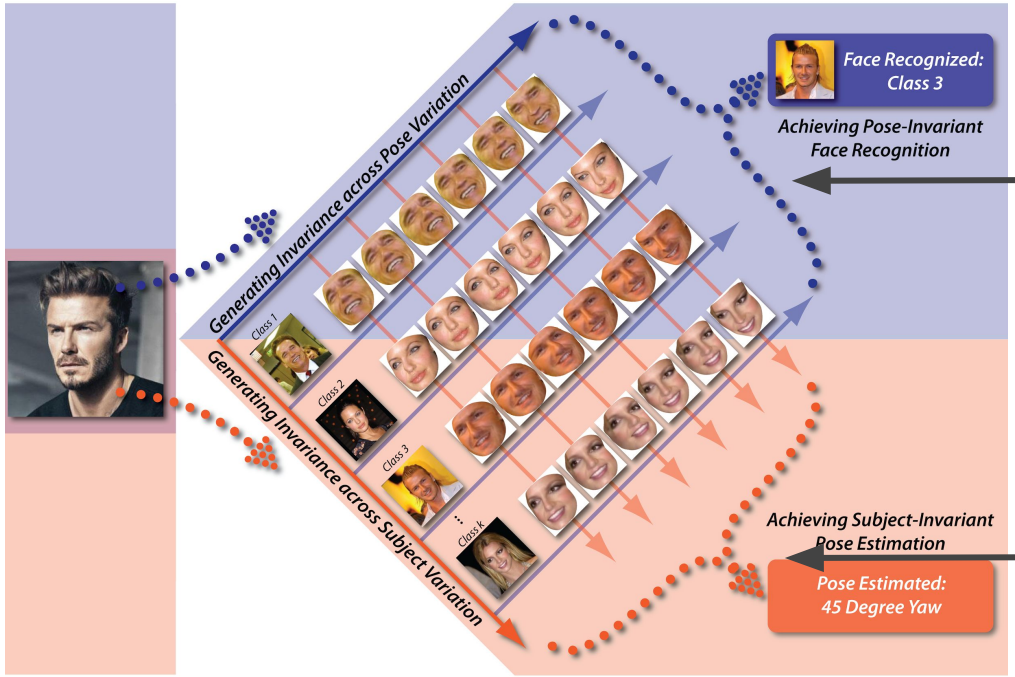
To improve discrimination, we can compute invariant features in the RKHS

We show the discriminative **non-linear** templates form a group in the RKHS, leading to Discriminative Invariant Kernel Features



Our System

Final system is versatile

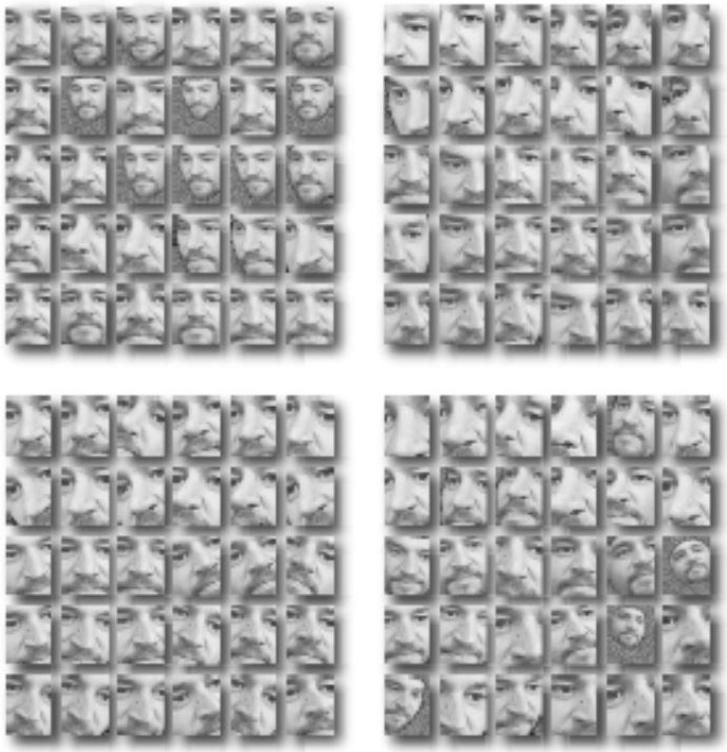


Face recognition sub-feature

Pose estimation sub-feature

A snapshot of results

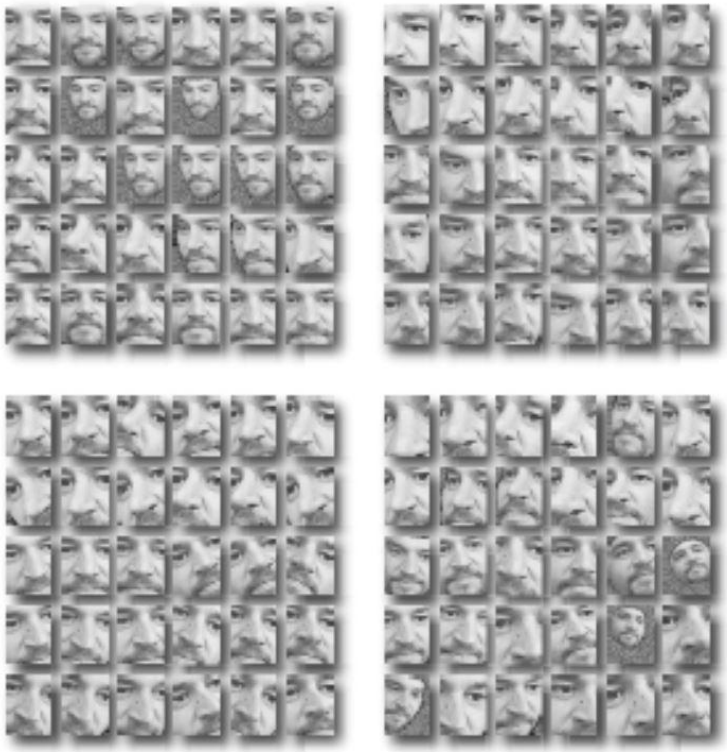
Semi Synthetic Face Data



A snapshot of results

Semi Synthetic Face Data

- ~153,000 semi-synthetic image dataset of 1000 subjects with 153 poses each.



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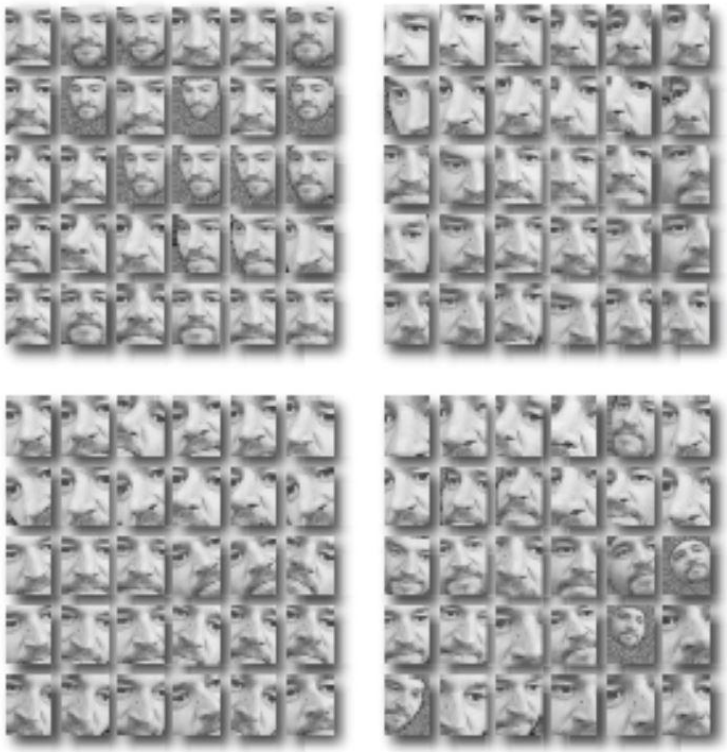
Semi Synthetic Face Data

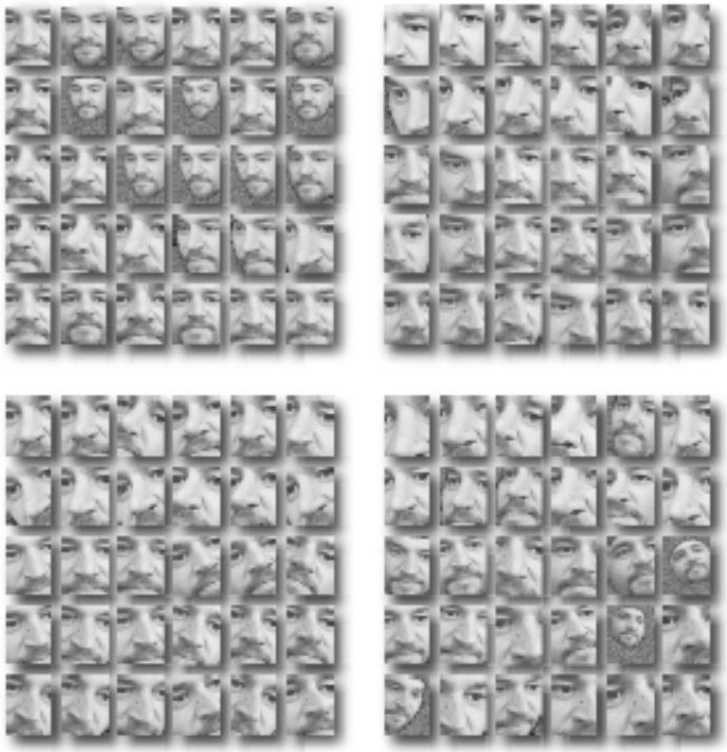
- ~153,000 semi-synthetic image dataset of 1000 subjects with 153 poses each.
- Images rendered from a 3D model with real texture.



A snapshot of results

Semi Synthetic Face Data

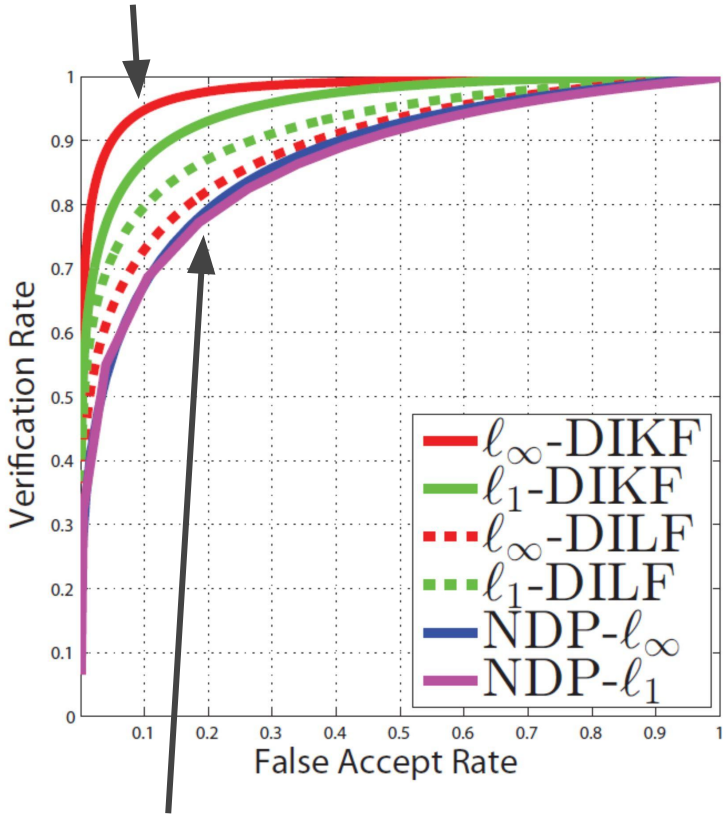
- ~153,000 semi-synthetic image dataset of 1000 subjects with 153 poses each.
- Images rendered from a 3D model with real texture.
- We compare DIKF against sampled templates (NDP) and discriminative linear templates (DILF).



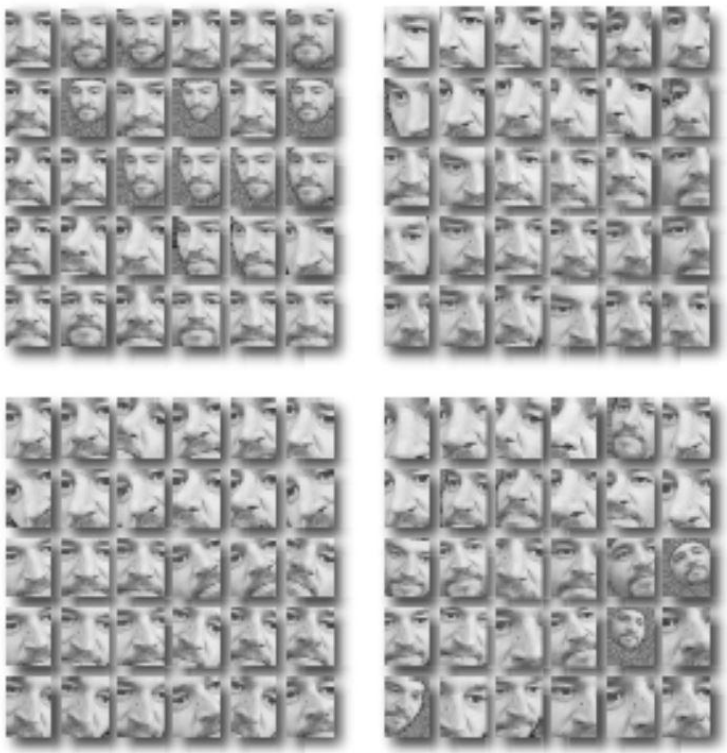
A snapshot of results

Semi Synthetic Face Data

Max Pooled Discriminative Kernel Features



Sampled templates max/mean pooled



A snapshot of results

Labeled Faces in the Wild (LFW)

Max-pooled DIKF matches state-of-the-art results on two LFW protocols, despite being simpler than competing methods and working on raw pixels

Max pooled DIKF (in red)

Unsupervised Protocol

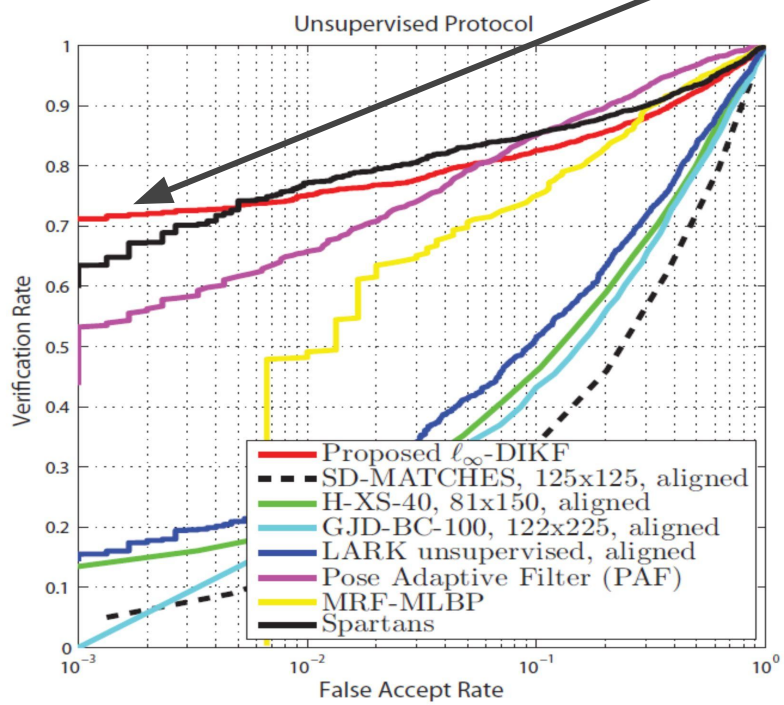
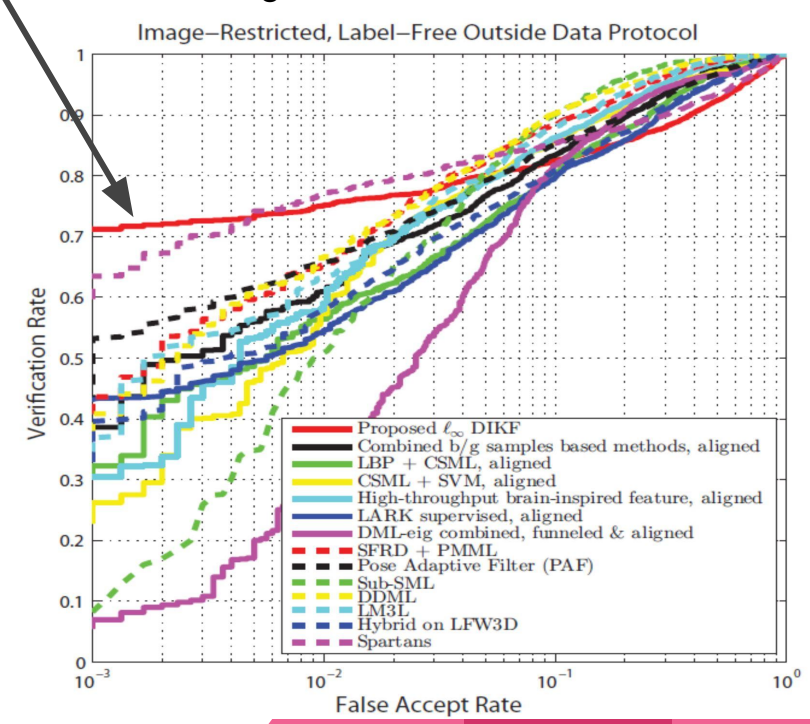


Image Restricted Protocol



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