PARTIAL FACE RECOGNITION: A SPARSE REPRESENTATION-BASED APPROACH

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Motivation

Task: Recognition with partial observations.

(a) Training: **holistic** data

(b) Testing: **partial** data

Problem Statement

Challenges:

- Alignment info. is unknown
- The test sample has limited information
- Major distinguished futures are missing
- There is No hope for recovery

Solution:

- Learn a better representation using supervised dictionary learning(SDL) framework [1]
- Propose simultaneous alignment and sparse coding Procedure
  Here: matching with sparse penalty,
  In [2]: a more complicated method.
- Study the performance limit

Illustration

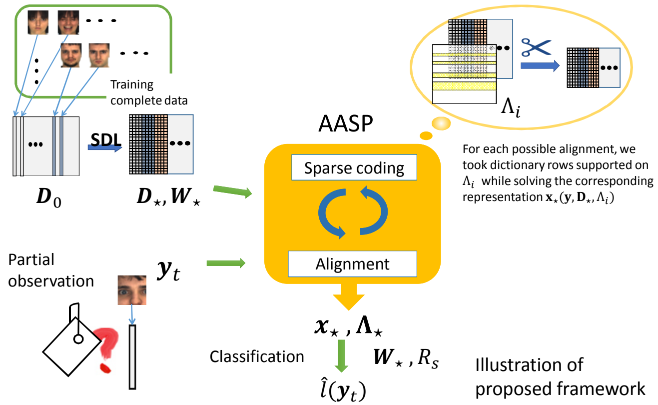
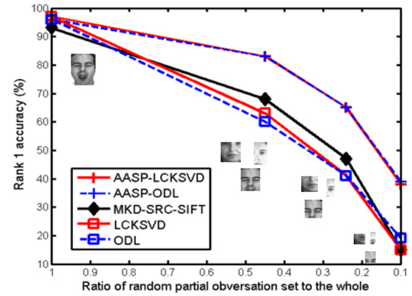


Illustration of proposed framework

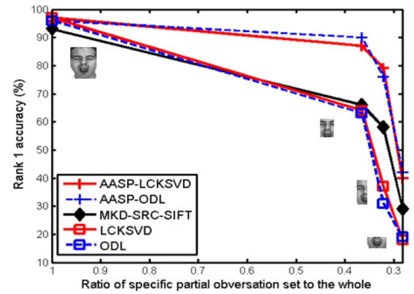
Experiments

Dataset: AR dataset

Comparisons: MKD-SRC (feature based [4]); SDL with the same initialization.



Rank 1 accuracy on 3 random partial patterns



Rank 1 accuracy on 3 specific partial patterns

The larger Λ be, the higher classification accuracy obtains!

Methods

- **Supervised Dictionary Learning**

Given training data $(y_i, l_i) \in \mathbb{R}^m \times \mathbb{R}, i \in T_1$, find the optimal dictionary $D_\star$ and classifier parameter $W_\star$ that yield a good representation & low regression loss R_s

$$(X_\star, D_\star, W_\star) = \arg\min_{x_i, D, W} \sum_{i \in T_1} R_s(l_i, f(x_i(y_i, D), W)) + \beta ||y_i - Dx_i||_2^2 + \rho \text{ sparsity}(x_i), \ \beta > 0.$$

- **Alternating Alignment and Sparse Coding Procedure (AASP)**

For test data y_t, seek the best alignment $\Lambda_\star$ among the set of all hypothesis S as well as sparse representation $x_\star(y_t, D_\star)$

$$(x_\star(y_t, D_\star), \Lambda_\star) = \arg\min_{x \in \mathbb{R}^n, \Lambda_i \in S} \frac{1}{2} ||y_t - (D_\star)_{\Lambda_i} x||_2^2 + \rho \text{ sparsity}(x).$$

- **Classification:** Find a label among L that minimizes the regression loss

$$\hat{l}(y_t) = \arg\min_{l_i \in L} R_s(l_i, f(x_\star(y_t, D), W_\star))$$

Analysis

Data Model

Assume that $\exists\, D, x, ||x||_0 = s < n$ is sparse such that $y = Dx + z$ (z is some noise process and $\mathbb{E}(z^T z) < \infty$) and Λ is the observation set.

❖ We also assume that D, Λ, x can be obtained from some algorithms if unknown.

Q: Can classification based on y_Λ give the same result as on y ?

The noiseless case

$|\Lambda| \geq \text{rank}(D)$ in general cases;

$|\Lambda| \geq \mathcal{O}(s \log n)$ the lower bound will become sharper if Compressed Sensing assumptions in [3] is satisfied.

The noisy case

Lemma: Under squared loss, $x_\star^p = \arg\min 1/2 ||y_\Lambda - D_\Lambda x||_2^2 + \rho ||x||$, if $x_\star^p$ also solves $\min ||y_{\Lambda^c} - D_{\Lambda^c} x||_2^2$, then classification from partially observed data y_Λ is just as accurate as with complete data.

Conclusions & References

- Performance limit is analyzed based on exact recovery.
- Our method is robust especially in the case of severe information missing.

References

[1] J. Mairal, J. Ponce, G. Sapiro, A. Zisserman, and F. R. Bach, "Supervised dictionary learning," NIPS2009
[2] X. Sun, N. Nasrabadi, and T. Tran, "Sparse coding with fast image alignment via large displacement optical flow,"ICASSP, 2016
[3] E.J. Candes, J. Romberg, and T. Tao, "Robust uncertainty principles: Exact signal reconstruction from highly incomplete frequency information," Info. Theory 2006
[4] S. Liao and A. K. Jain, "Partial face recognition: An alignment free approach," in Biometrics IJCB 2011

We gratefully acknowledge that this work was in part supported by NSF (NSF-DMS-1222567, NSF-CCF-1117545, NSF-CCF-1422995, NSF-EECS-1443936) and AFOSR (FA9550-12-1-0136).