1. Main Ideas

**Motivation**
The face systems should be easy for re-training and scalable to accommodate massive web data.

**Archetype Hull Model**
- A geometric model.
- Archetypes have a representative power.
- Represent all training points as sparse combinations of a compact set of archetype exemplars.

**Archetype Hull Ranking**
- A scalable graph-based ranking scheme.
- Capture query-to-archetype relevance.
- Generate rank vectors over the archetype hull.

2. Archetypes

**Archetype Seeking**

\[
\mathbf{u}_{k+1} = \arg \max_{\mathbf{u}_k} \sum_{j=1}^{k} d_j \left( \alpha_k - \frac{1}{2} \sum_{j=1}^{k} d_j + \frac{1}{2} \sum_{j=k+1}^{k} d_j \right)
\]

A sequential seeking strategy towards simplex volume maximization.

Linear space & time complexities in the training dataset size n.

**Archetype Hull Projection**

1. Reconstruct an input x using archetypes U:
2. Form the data-to-archetype affinity matrix:
3. Compute the optimal rank vector over the archetype hull is

\[
\mathbf{z}(\mathbf{x}) = \arg \min_{\mathbf{z} \in \mathbb{R}^n} \| \mathbf{x} - \mathbf{Uz}(\mathbf{x}) \|^2
\]

\[
\mathbf{z}(\mathbf{x}) \geq 0, \quad 1^\top \mathbf{z}(\mathbf{x}) = 1
\]

3. Comparison

**Face Recognition Task**
- Datasets: Multi-PeF, Pubfig83
- Our method: Unsupervised AHR
- Alignment: 5 key-points affine alignment

**Face Verification Task**
- Datasets: LFW (unsupervised setting)
- Our method: Supervised AHR
- Alignment: Rough alignment (LFW-a)

4. Face Similarity

**Blockwise Similarity Measures**
Divide face into blocks and calculate the similarities between block pairs.

- Unsupervised Archetype Hull Ranking (AHR)
  Compute the block-wise similarity by correlating two archetype representation vectors \( \mathbf{z}(q_1) \) and \( \mathbf{z}(q_2) \) (baseline) or two rank vectors \( \mathbf{r}^*(q_1) \) and \( \mathbf{r}^*(q_2) \).
- Supervised AHR
  Suitable when each subject has adequate images.
  Compute the block-wise similarity by utilizing the identity information of archetypes.

**Face Similarity Measures**
- Aggregate all blockwise similarity measurements into a face similarity measure:

\[
F(q_1, q_2) = \sum_{k=1}^{b} \mathbf{w}_k \mathbf{S}_k
\]
- Identical weights for unsupervised AHR.
- Learned weights for supervised AHR.

5. Flowchart of AHR

1. Feature extraction and archetype representation.
2. Rank over the archetype hull to yield the ranking vectors.
3. Aggregate blockwise similarity to obtain face similarity.

6. Choosing Archetypes

**Type of archetypes**

<table>
<thead>
<tr>
<th>Archetype Type</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>supervised basic AHR</td>
</tr>
<tr>
<td>Random Exemplars</td>
<td>79.4%</td>
</tr>
<tr>
<td>K-Means</td>
<td>82.0%</td>
</tr>
<tr>
<td>Archetype Seeking</td>
<td>86.4%</td>
</tr>
</tbody>
</table>

7. Conclusions
- The geometric archetype hull model first applied to face modeling.
- The scalable archetype ranking framework using the Anchor Graph.
- Superior recognition and verification accuracy over state-of-the-arts.
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