1. Main Idea

- **Motivation**
  - Illustration of the superiority of our random path (RP) measure over other measures (e.g., Euclidean (E) measure and the shortest path (SP) measure). Due to the large intra-personal variations (e.g., pose, illumination, and expression), there may be underlying structures in face space (detected by the red and blue clusters). For three face images A, B, and C of two different persons, the distances \( d_{x}^E < d_{y}^E < d_{x}^A \) measured by Euclidean measure (solid green line) and the shortest path measure (solid yellow line), in other words. A is more similar to B than to C.\( d_{x}^E > d_{y}^E > d_{x}^A \) is measured by Euclidean measure (solid green line) and the shortest path measure (solid yellow line), in other words. A is more similar to B than to C.

- **Proposed Idea**
  - Random Path (RP) Measure: it includes all paths of different lengths in the network, which enables it to capture more discriminative information in faces and significantly reduce the effect of noise and outliers.
  - In-face network: it captures the local information of face images.
  - Out-face network: it captures the global information of face images.

2. Approach Overview

- **In-face Network**
  - Obtain Patch Correspondence and Their Overlapping Neighborhood
  - Construct KNN Graph based on Patch Features (Showing Appearance)
  - Compute Patch Similarities using the Random Path Measure

- **Out-face Network**
  - Construct the Global Network
  - Calculate the ambiguity

3. Approach Details

- **Path Centrality**: \( C_G = \frac{1}{N} \sum_{i=1}^{N} (I - zP)^{-1} \), where \( z < \frac{1}{\rho(P)} \) and \( \rho(P) \) is the spectral radius of \( P \).

- **Random Path Measure**: \( \Phi_G(u,v) = C_G(u,v) - (C_G(u) + C_G(v)) \), is regarded as the similarity between two networks \( G_i \) and \( G_j \).

4. Comparison to Existing Measures

- **Multi-PIE**: this dataset contains face images from 337 subjects under 15 view points and 19 illumination conditions in four recording sessions.

- **LFW**: this dataset contains 13,233 uncontrolled face images of 5,749 public figures of different ethnicity, gender, age, etc.

5. Tuning Parameters

- **Face Recognition rate on Multi-PIE**
  - | Network | LBP | HOG | Color | FT |
  - |-------|-----|------|-----|
  - | Enfield | 79.0 ± 0.6 | 72.6 ± 0.7 | 72.6 ± 0.6 | 70.1 ± 0.7 |
  - | Oulu | 90.9 ± 0.4 | 70.3 ± 0.6 | 72.6 ± 0.6 | 71.0 ± 0.6 |
  - | HappyFace | 75.4 ± 0.7 | 72.6 ± 0.6 | 71.0 ± 0.6 | 71.0 ± 0.6 |
  - | Face++ | 61.8 ± 0.7 | 70.3 ± 0.6 | 72.6 ± 0.6 | 71.0 ± 0.6 |
  - | Sorted Pairwise | 71.0 ± 0.6 | 70.3 ± 0.6 | 72.6 ± 0.6 | 71.0 ± 0.6 |
  - | Our in-face | 78.5 ± 0.6 | 70.3 ± 0.6 | 72.6 ± 0.6 | 71.0 ± 0.6 |
  - | Our out-face | 78.5 ± 0.6 | 70.3 ± 0.6 | 72.6 ± 0.6 | 71.0 ± 0.6 |

6. Result on LFW Benchmark

- **Random Path (RP) Measure**

7. Conclusion

- **Random Path (RP) Measure**
- **Two types of networks on face data: the in-face network and the out-face network**
- **Extensive experiments on the Multi-PIE and LFW face databases validate our approach.**