Comparing Human and Deep Convolutional Neural Network Performance on Twin Identification

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Introduction

- deep convolutional neural networks (DCNNs) achieve human-level accuracy on face-recognition tests [1]
- high performance across variable images
- rarely tested on highly-similar identities
- What about identical twins?
  - extreme case of high similarity
  - simulates large-scale face recognition with highly-similar identities
- previous face-recognition algorithms - front-facing, same lighting, same day [3, 4, 5, 6]

Goals

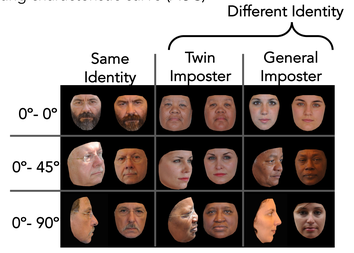
Human and machine comparison for a face-identification task involving highly-similar identities (i.e., identical twins).

Face-identification performance for twins across variation in viewpoint.

Procedure

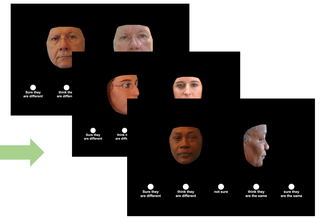
- face-matching task over viewpoint change that includes identical twins
  - **viewpoint conditions (between subjects):** 0°-0°, 0°-45° and 0°-90°
  - **imposter type (within subjects):** twin imposter or general imposter
  - **dependent variable:** area under the receiver operating characteristic curve (AUC)

Stimuli: ND-TWINS-2009-2010
- 200 identities - 120 pairs
- neutral expression
- same-identity (N = 40)
- twin-imposter = twin siblings (N = 40)
- general-imposter = two unrelated individuals (N = 40)



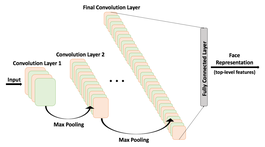
Identity-Matching Task:
- Humans: 5-point scale
  - "sure different" to "sure same"
- DCNN:
  - similarity between DCNN embeddings of images in each pair
  - cosine between embeddings
- performance measured using AUC

Correct responses:	False alarms:
same-identity image pairs	either *twin-imposter* or *general-imposter* image pairs

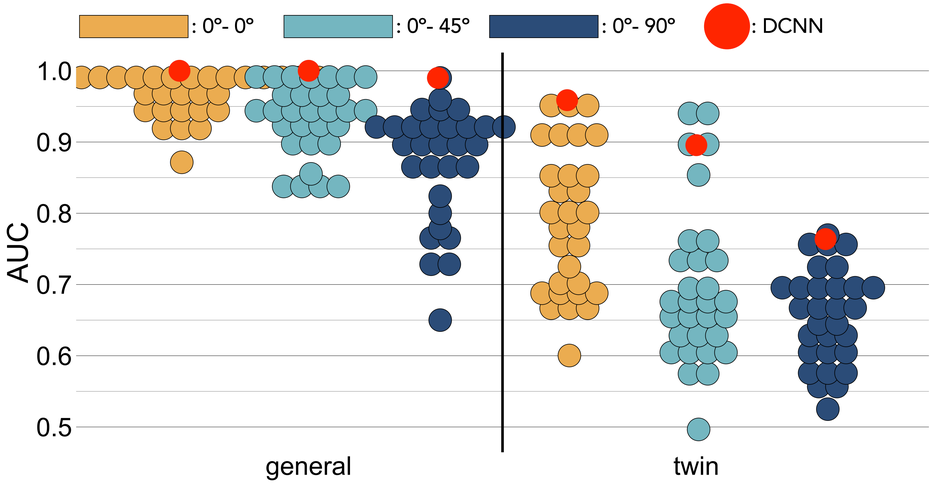


DCNN Methods

- DCNN trained for face identification [7]
  - trained with approximately 5.6 million images of 58,000 identities [8]
  - ResNet-101 based architecture
  - Crystal Loss function, alpha parameter set to 50
- generate DCNN embedding for each image
  - embedding: **512 dimensions**



Face-Matching Accuracy: Human Participants and DCNN



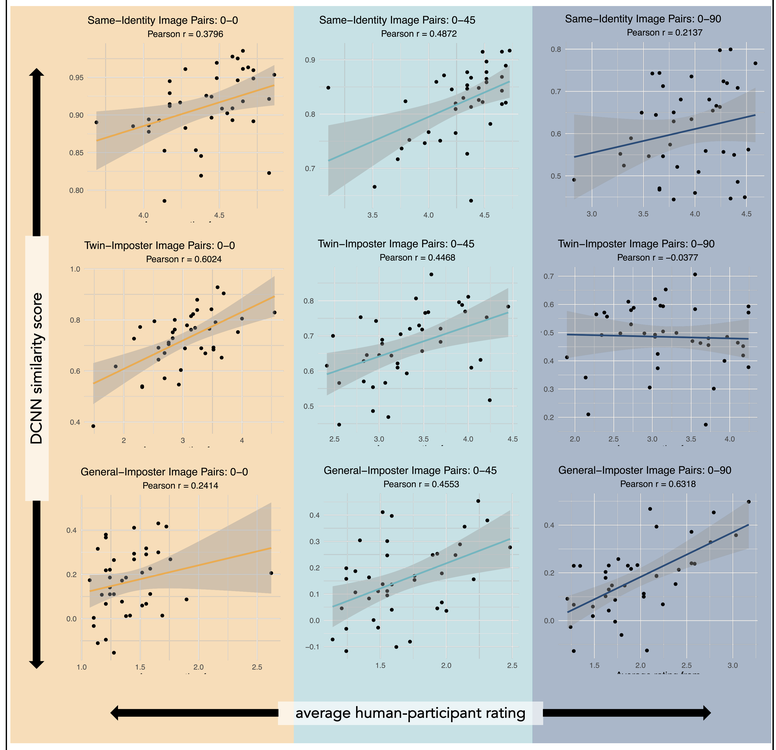
Face-Identification Accuracy

- accuracy greater for general-imposter image pairs than twin imposter image pairs
  - $F(1, 84) = 649.841$, $p \approx 0.001$, generalized $\eta^2 = 0.671$
- performance affected by change in viewpoint
  - $F(2, 84) = 22.802$, $p \approx 0.001$, generalized $\eta^2 = 0.286$
- interaction: viewpoint effects identification of twin-imposter pairs more than general-imposter pairs
  - $F(2, 84) = 3.708$, $p < 0.05$, generalized $\eta^2 = 0.023$

Correlation between human and machine performance

- perceived similarity for each image pair
- **human participants**: average rating response across all participants
- **DCNN**: cosine similarity between embeddings
- significant correlation for 8 of 9 comparisons
  - n.s. for twin-imposter, 0°-90°
- evidence for overlap in perceived similarity for human participants and a DCNN

Correlating Human and DCNN Responses by Image-Pair Type



Conclusions

A DCNN trained for face identification outperforms human participants on a face-matching task that includes identical twins

Human participants and the DCNN exhibit a similar decrease in face-identification accuracy as the difference in viewpoint between images increases

Summary

DCNNs now achieve state-of-the-art performance on benchmarks used for human participants when recognizing identical twins. This increased performance generalizes across changes in viewpoint. This indicates that accurate performance can be maintained even in large-scale applications. In addition, there is overlap in the perceived similarity between image pairs for human participants and a DCNN.

Acknowledgements

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