Deep Convolutional Neural Networks (DCNNs)
- Robust across image conditions (view, illumination, etc.)
- Modeled after primate ventral visual stream [1,2]
  • Early layers -> V1
  • Intermediate layers -> V4
  • Final layers -> IT [3,4]
- Image information (e.g., viewpoint) retained despite identity training [5]
- Distribution of information in top-layer code?
  • Identity, gender (subject variable) [6], viewpoint (image variable) [5]

Features in Primate Visual System
- Low-level visual features retinotopic & semantically interpretable (e.g., edge detectors) [7]
- Face identification -> high-level vision, categorical codes [8]
  • Link between visual receptive fields and features less clear
  • Categorial representation of faces not well understood
  • Neurons tuned to features [9]
  • CNNs “directions in a space” interpretable/meaningful features [10]

Goal
Probe distribution of identity, gender, viewpoint across individual units in DCNN top layer

Approach
- Random feature deletion
- Re-evaluate identity, gender, viewpoint information in subspaces of varying dimensionalities

Network
  • 101-layered ResNet [12], trained on nearly 6 million images of 58,000 identities
  • 512-dimensional final output representation

Methods
- Randomly sampled sets of features from output representation
- Computed ROC curves of each sample on face-identification, gender classification, and viewpoint prediction tasks using the “in the wild” IJB-C database [13]
  • >141,332 images, 5,331 identities

Subspace: Identification
- Identification accuracy maintained when sampling very few randomly chosen features

Subspace: Gender
- Gender prediction accuracy decreases gradually with size of sampled features

Subspace: Viewpoint
- Viewpoint prediction accuracy declines sharply when fewer features sampled

Conclusions
- Top-level feature units spread identity information efficiently
  • All units contain identity information, random combinations of units lead to good performance
- Coding of gender and viewpoint make sense in context of [6]
  • Hierarchy of clustering according to identity/image variables
- Robust code for face identity
- Many sources of identity information, many solutions

References

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