Modeling Stylized Character Expressions via Deep Learning

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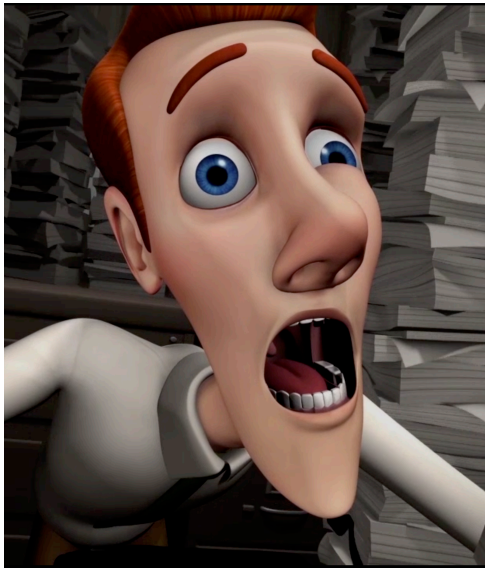
ACCV '16

Facial expressions : The art of non-verbal communication

Source: https://www.globalintelconsultants.com/02-13-16-facial-expressions--the-art-of-non-verbal-communication.html

Stylized character expressions

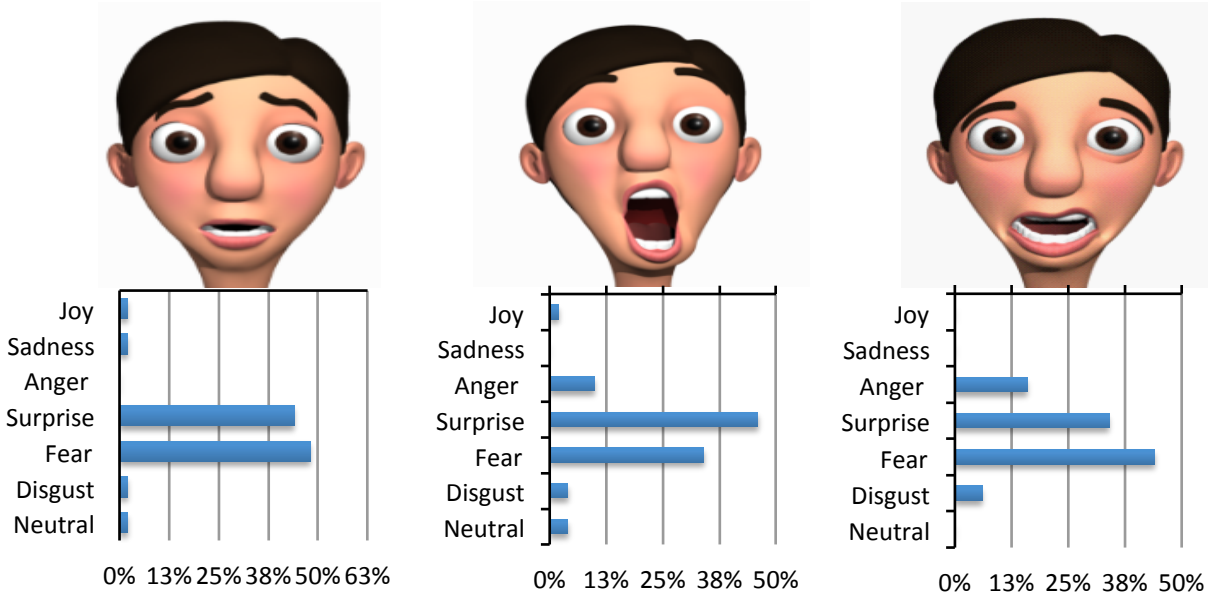


Animated Shorts from Animation Research Labs, University of Washington.

Creating recognizable expressions

- Accurate facial expression depiction is critical and **difficult** for storytelling.

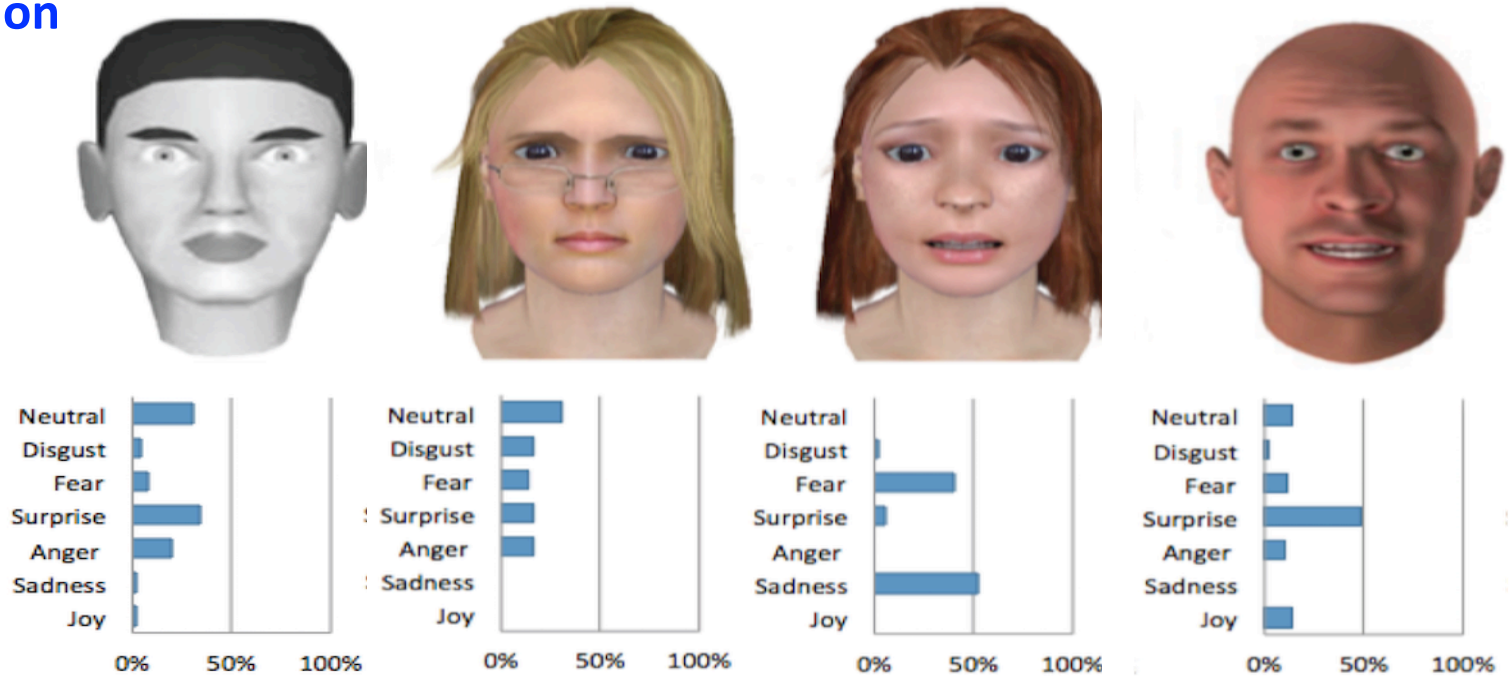
- We asked professional animators to make this character look surprised.
  - None of the expressions achieved above 50% recognition on Mechanical Turk.



Geometric Mapping

Intended Expression

MPEG – 4	HapFACS	HapFACS	FACSGen
Anger	Anger	Fear	Fear



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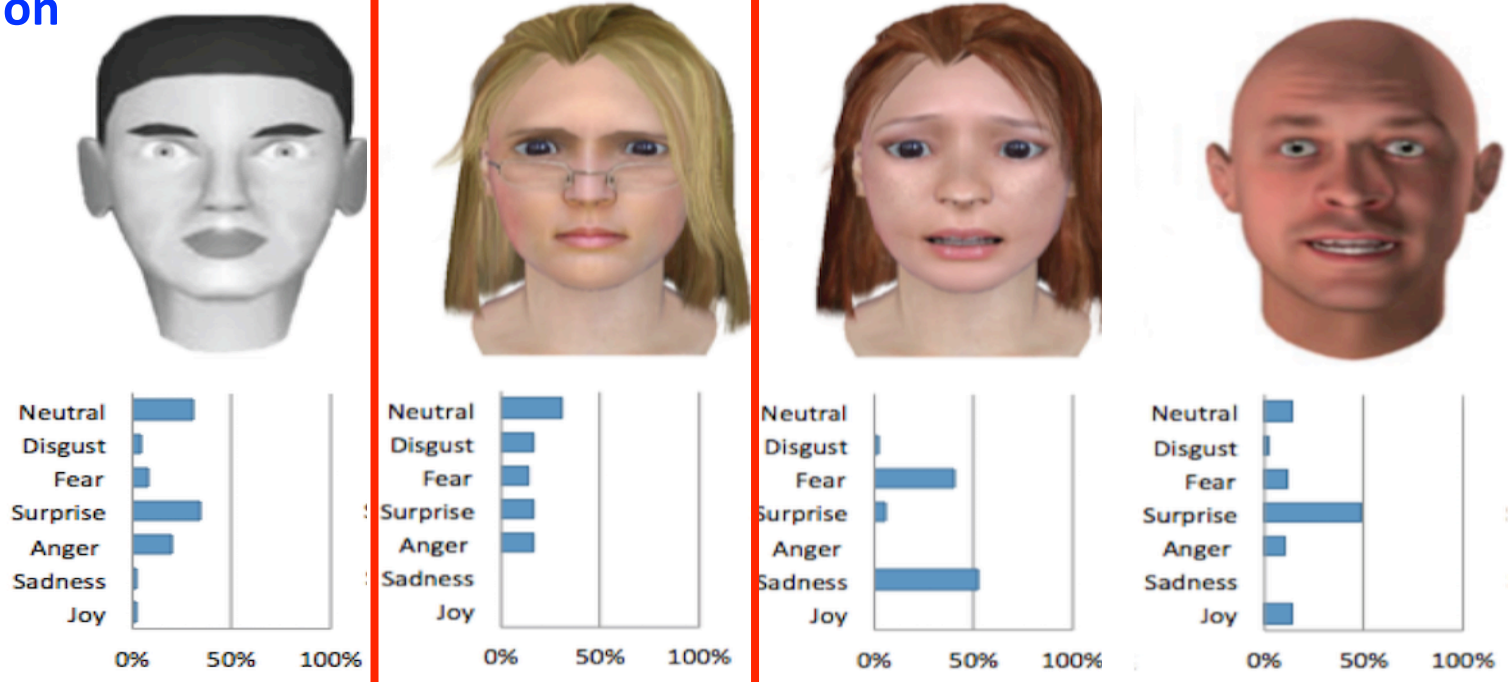

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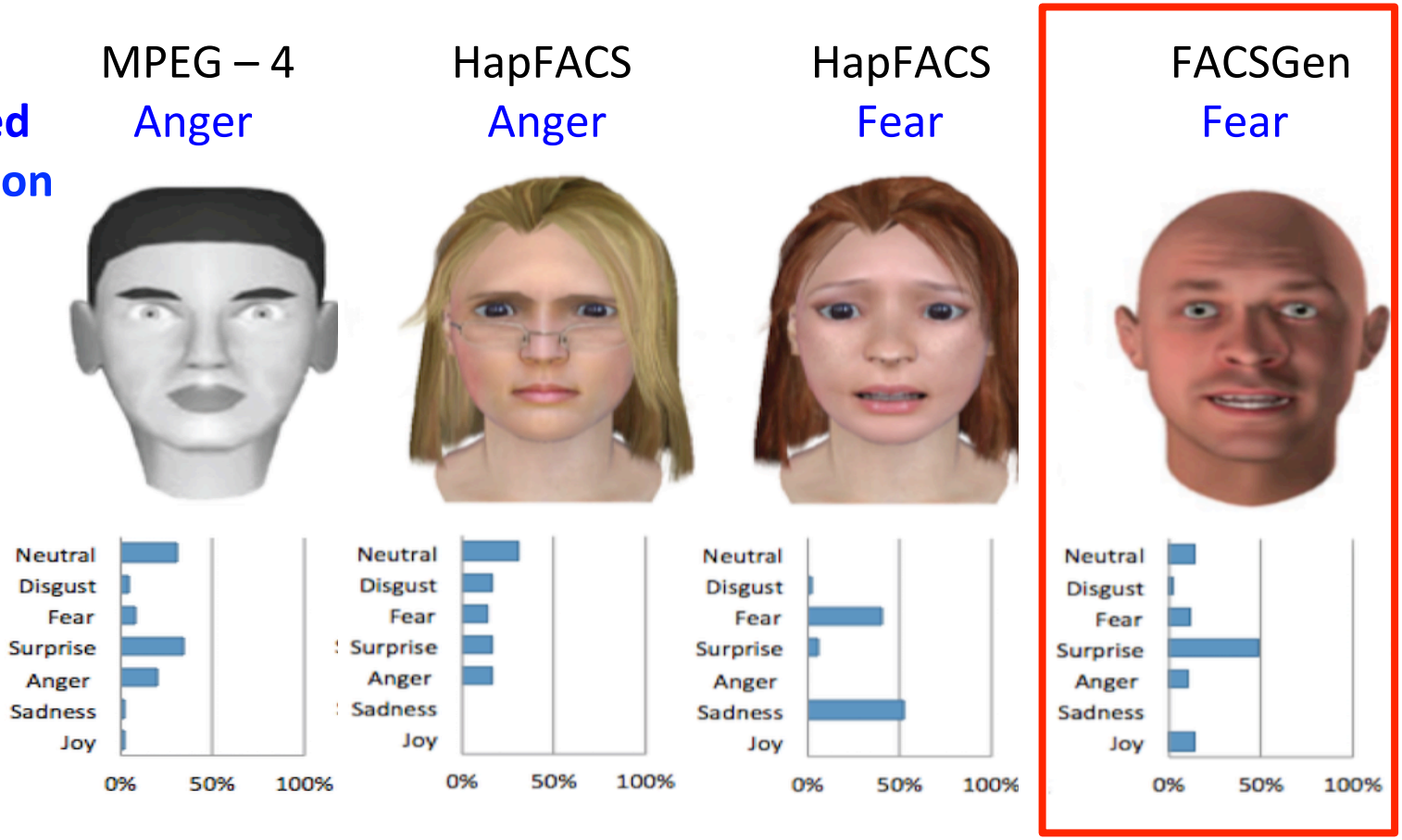

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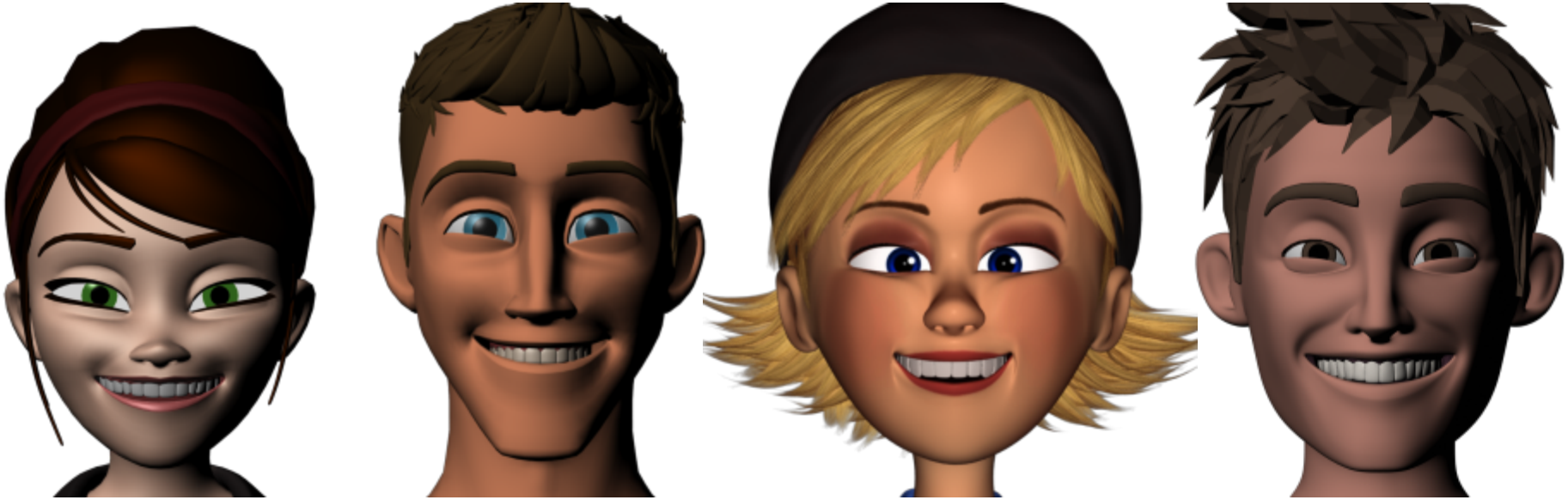


Contributions

- A data-driven **perceptual** model of facial expressions.
- A novel stylized character data set **(FERG-DB)** with cardinal expression annotations.
- A mechanism to accurately **retrieve plausible character expressions** from human expression queries.
  - Validated the results (Expert and Mechanical Turk)

Our Approach

Retrieve characters using

perceptual model mapping
and human geometry

- Use deep learning to learn mappings between
  - **Human expressions and characters expressions**
  - Humans and humans
  - Characters and characters

- This is not only geometric mapping
  - It is perceptual modelling of expressions!

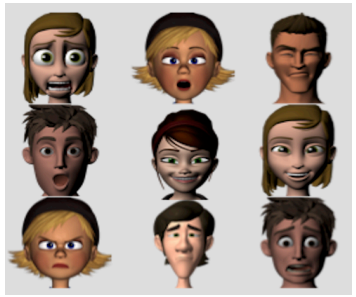
Expression Retrieval

Step 1

Use deep learning to create a perceptual model of human expressions

Human feature space

$f($  $)$



Step 2

Learn analogous character model

Character feature space

$f'($  $)$

$f($  $)$

Step 3

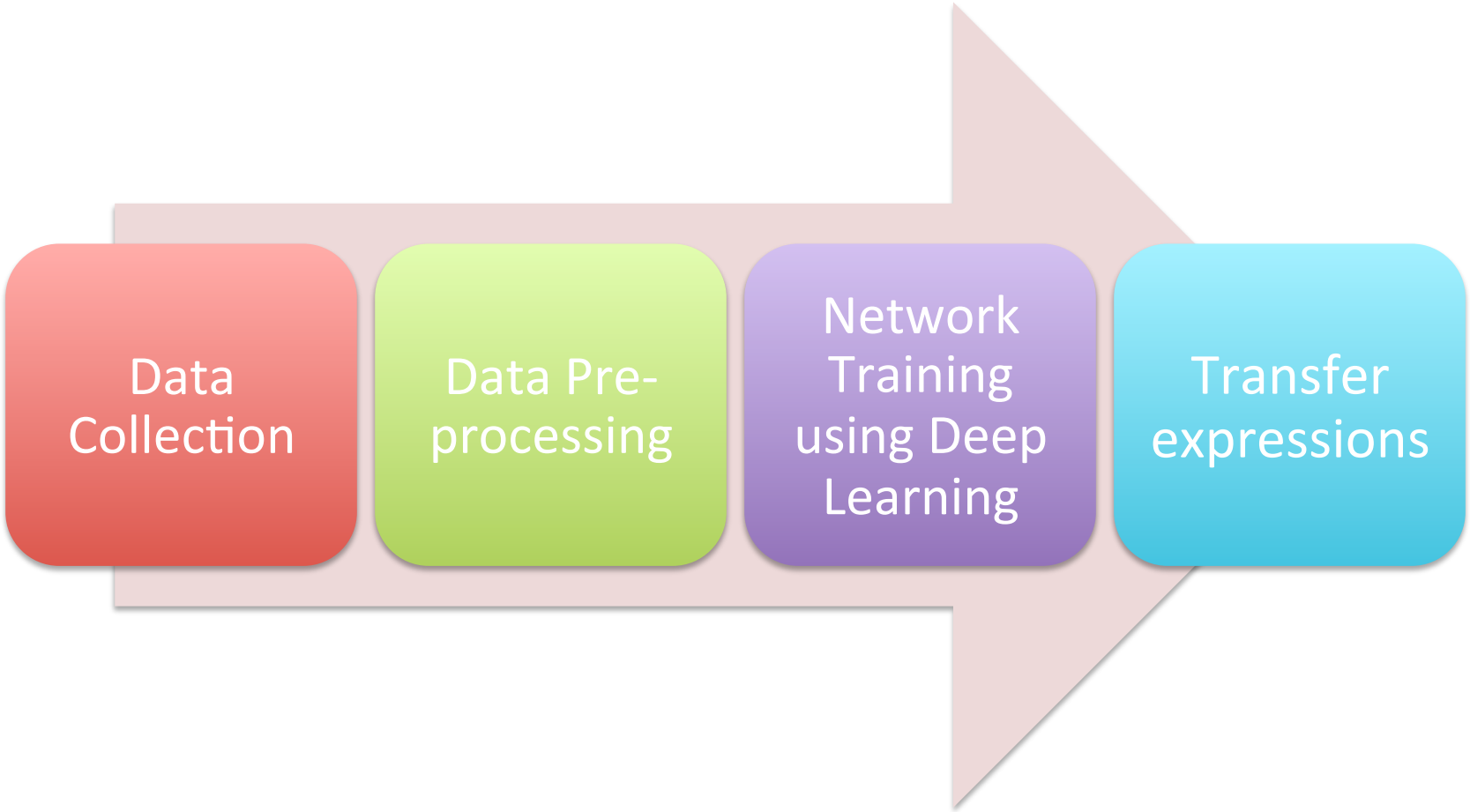
Learn Mapping

$f'($  $)$

Step 4

Retrieve characters using perceptual model mapping and human geometry

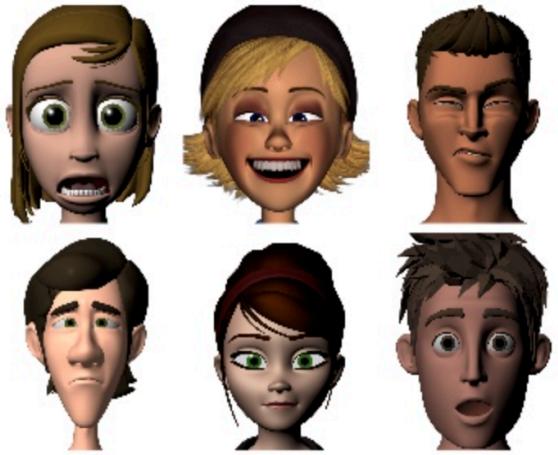
Steps


Data Collection
Data Pre-processing
Network Training using Deep Learning
Transfer expressions

Training Data

- Seven classes : Anger, Disgust, Fear, Joy, Neutral, Sad and Surprise

- Stylized Characters expression database
  - Total of 70K images
  - **Facial Expression Research Group (FERG-DB) is publicly available.**



- Human expression database
  - Total of 75K images

FERG-DB Stylized character expression database: http://grail.cs.washington.edu/projects/deepexpr/ferg-db.html

Human Database

- CK+: The Extended Cohn-Kanade -309 images
- DISFA: Denver Intensity of Spontaneous Facial Actions 60,000 images
- KDEF: The Karolinska Directed Emotional Faces 4900 images
- MMI: 10,000 images

- Total of 75K images - We balanced out the final number of the samples for training our network to avoid any bias towards any particular expression.

Stylized Character Database

- Six stylized characters (adding two more characters soon!)
  - The animator created the key poses for each expression and labeled via MT to populate the database initially
  - Key poses having **70%** MT test agreement and then interpolated between the key poses
- We only used the expression key poses having **70%** MT test agreement among 50 Turkers for the same pose. Interpolating between the key poses resulted in **70K images** (around 8,000 images per character).

Data Pre-processing

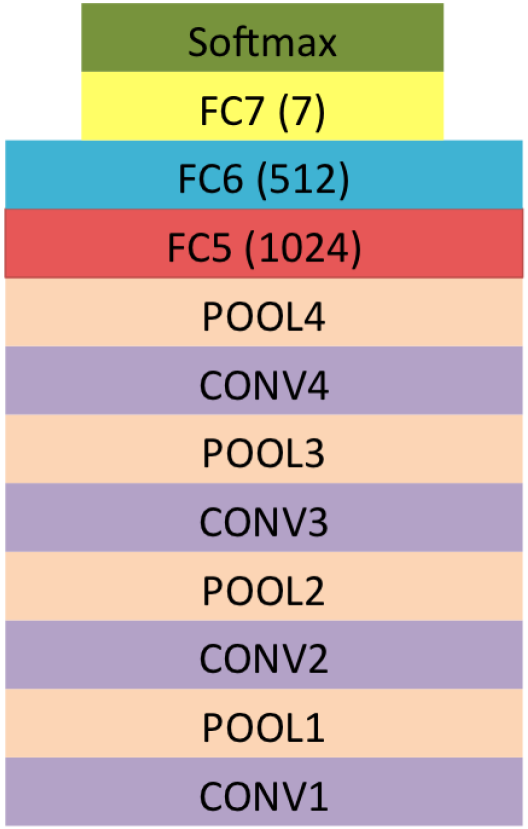
Extract Face 49 landmarks (Intraface)

Register faces to an average frontal face via an **affine transformation**

Face bounding box selection

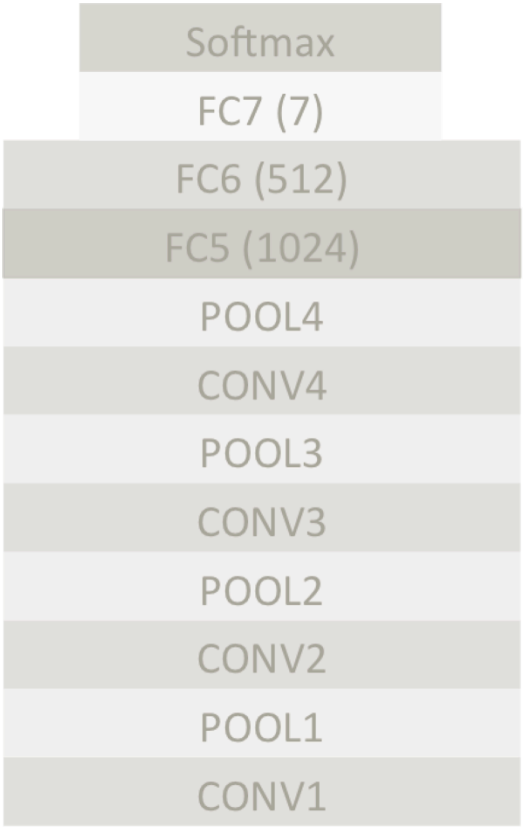
Re-size to 256x256 pixels for analysis

Network Architecture



Human CNN (HCNN)

Network Architecture



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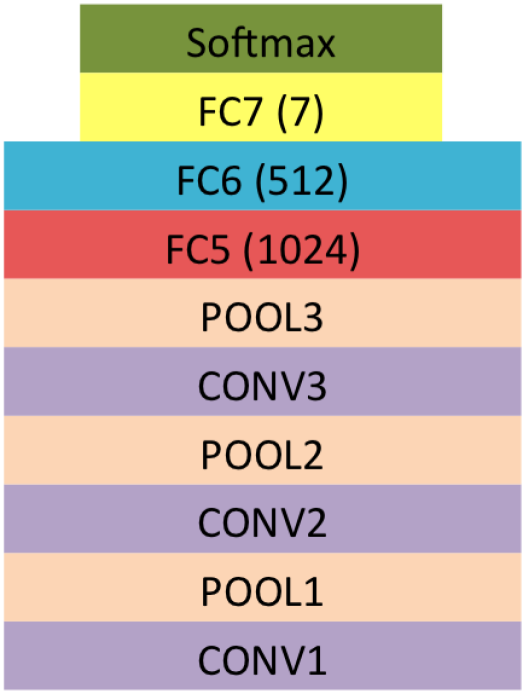
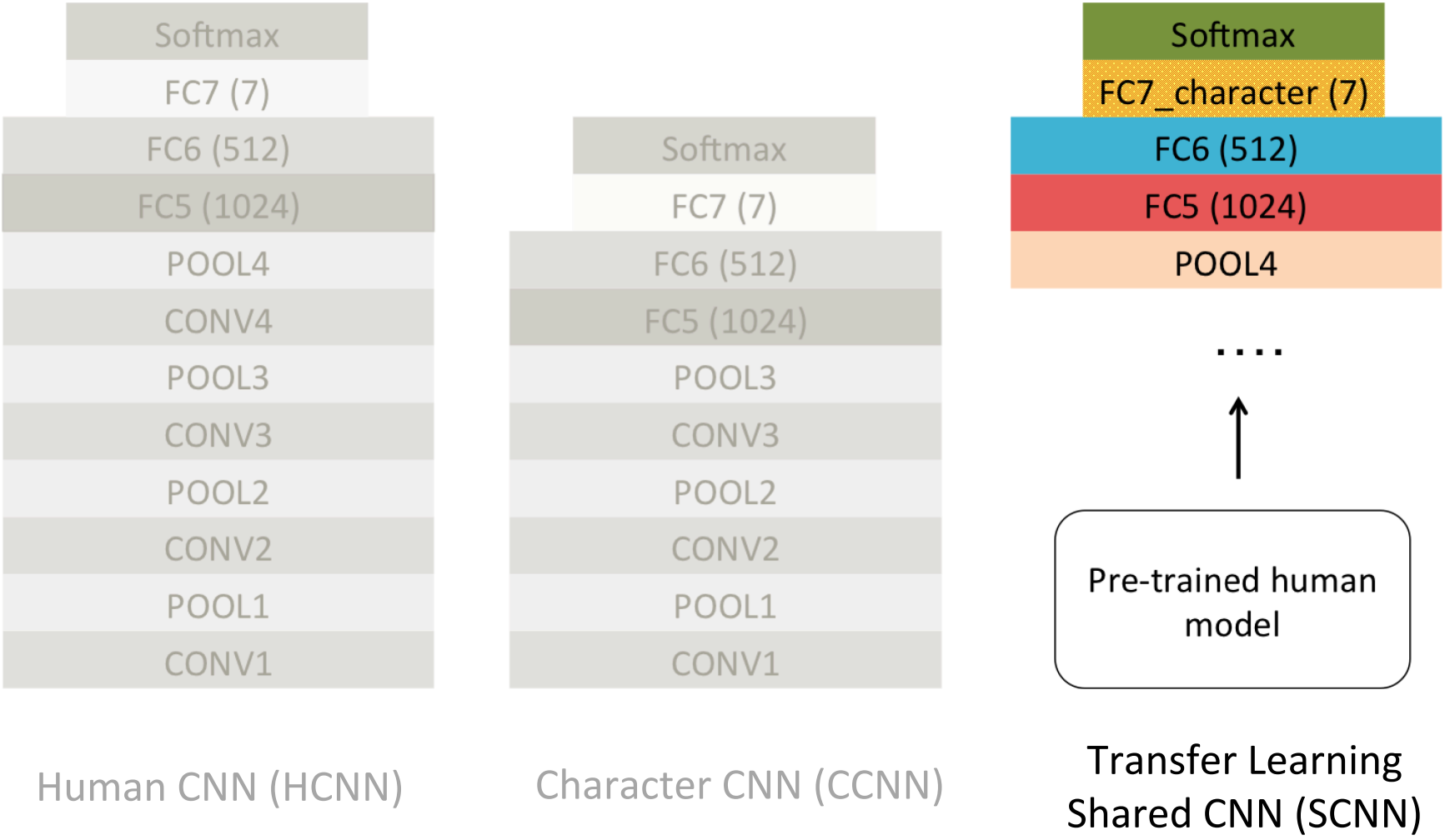
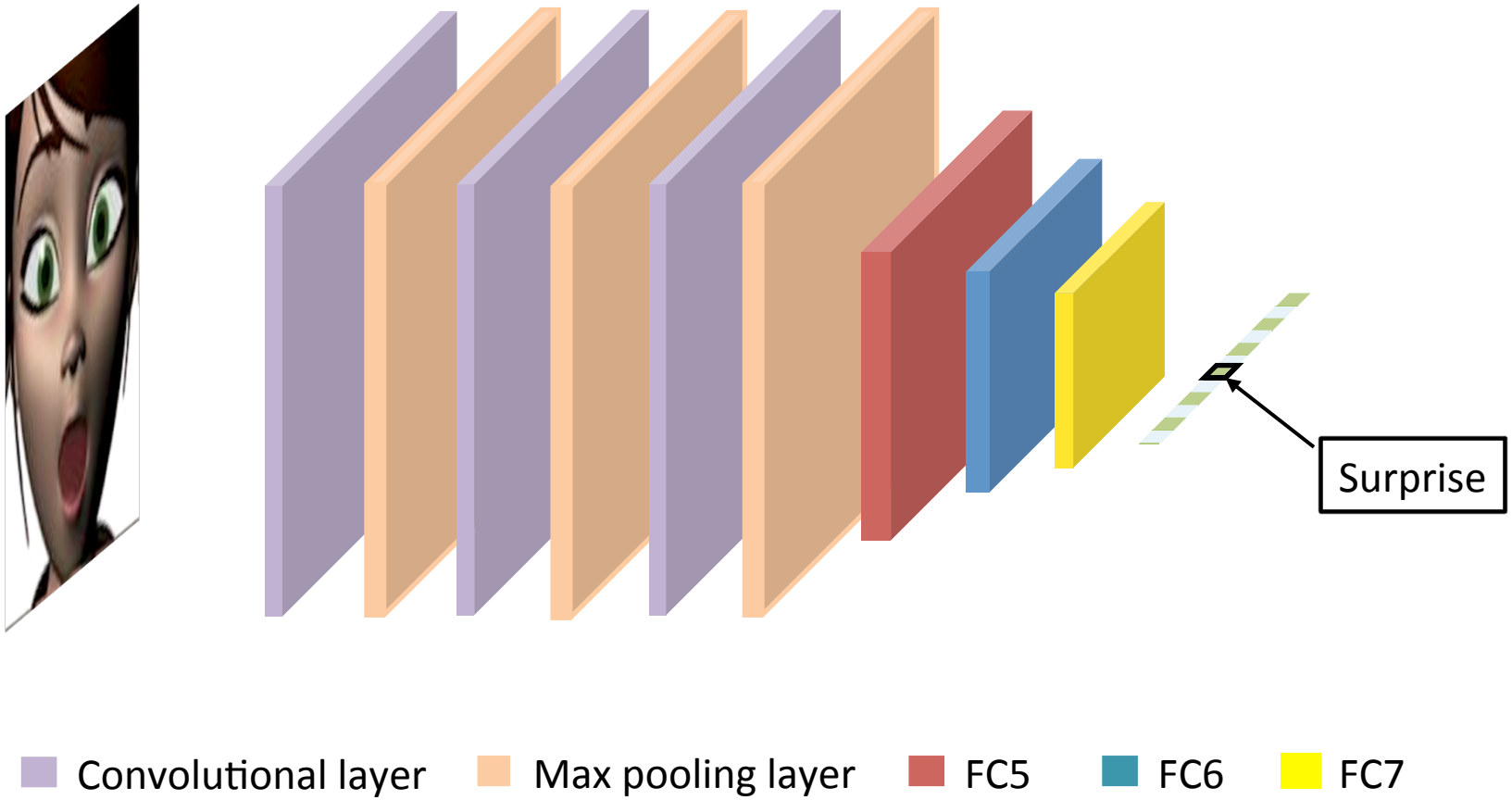


Character CNN (CCNN)

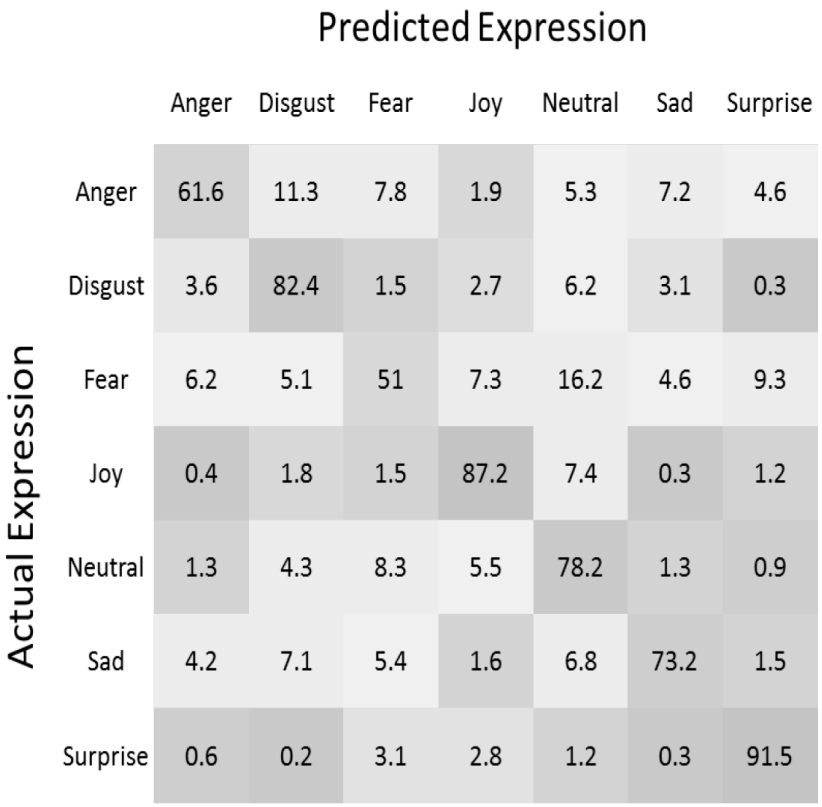
Network Architecture



Network prediction

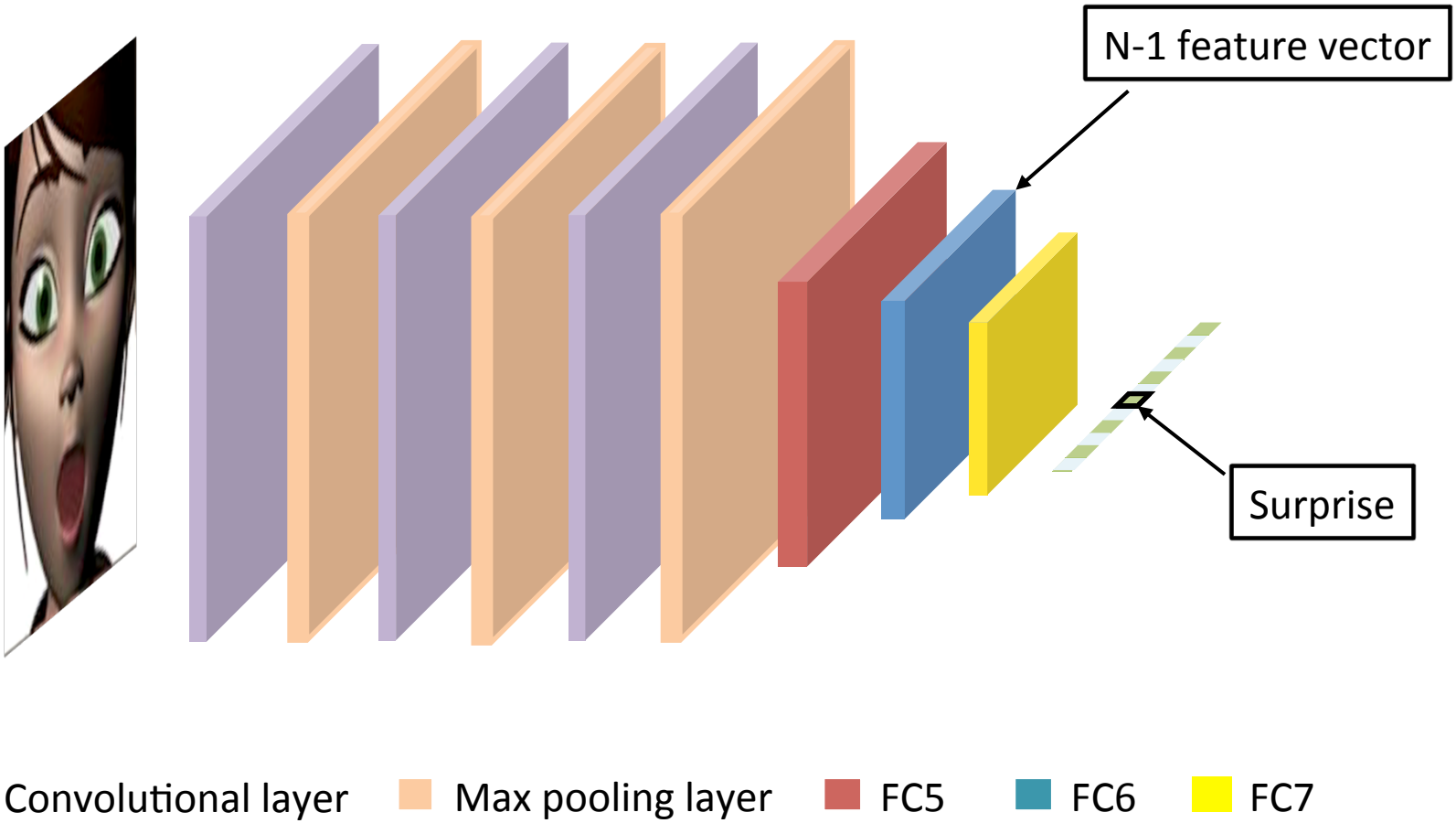


Expression Recognition Accuracy



- Accuracy of Human CNN - 85.27%
- Accuracy of Character CNN - 89.02%

Retrieval


N-1 feature vector
Surprise
Convolutional layer
Max pooling layer
FC5
FC6
FC7

Distance Metrics

- Extracted features from the **last fully connected layer (FC6)** of both the models: HCNN and SCNN and normalized the feature vectors

$$\phi_d = \alpha\,|\text{JS Distance}| + \beta\,|\text{Geometric Distance}|$$

Expression feature vectors
(N-1) Layer features

Geometry feature vectors

Lin, J.: Divergence measures based on the shannon entropy. Information Theory, IEEE Transactions on 37 (1991) 145–151 44.

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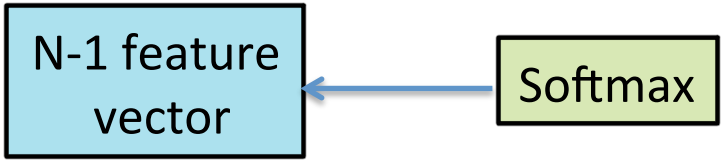

Back propagation

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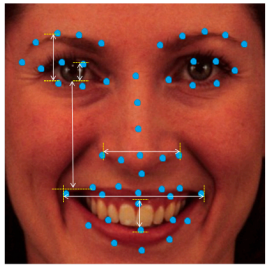
Expression feature vectors
(N-1) Layer features

Geometry feature vectors

N-1 feature vector ← Softmax

Back propagation



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Character Retrieval

Query

Multiple retrieval results for the joy query image

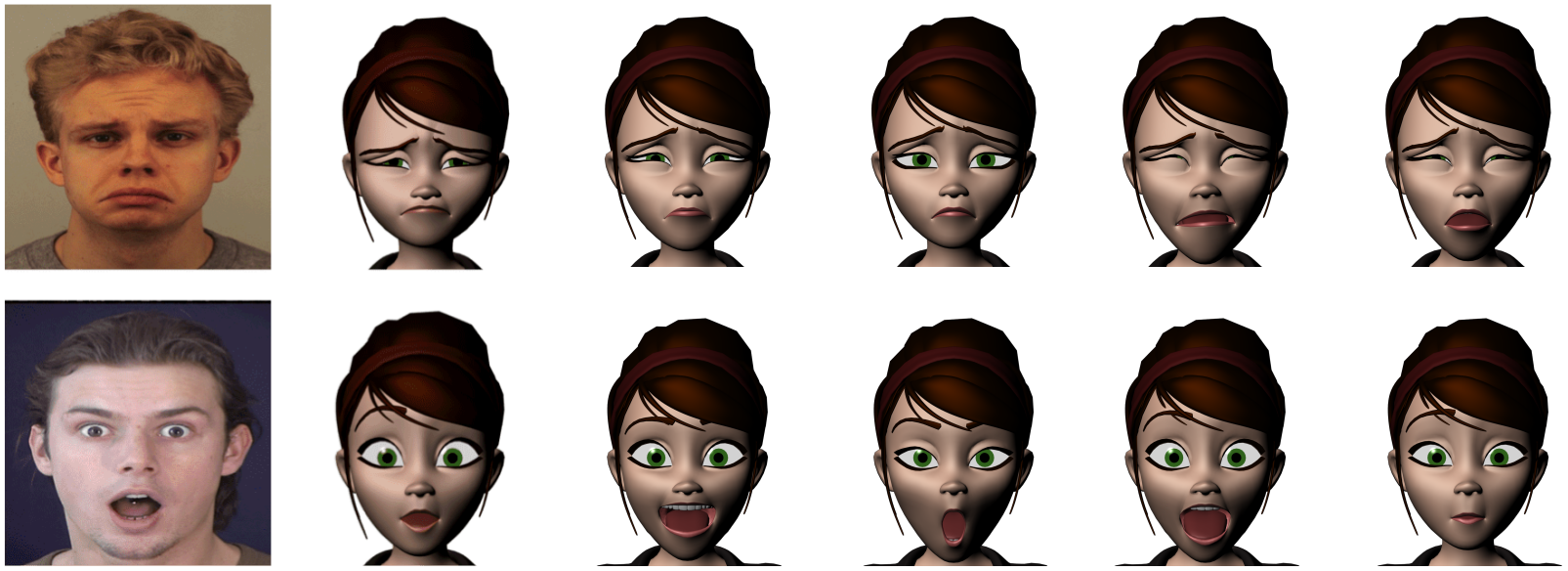
Query

$$\phi_d = \alpha \left| \text{JS Distance} \right|$$

Character Retrieval

Query

Character retrievals sorted by geometry



$$\phi_d = \alpha\,|\text{JS Distance}| + \beta\,|\text{Geometric Distance}|$$

DeepExpr Results

Query

Top matches of Character retrievals

Average Retrieval Score
(for each expression across all characters)

$$score(q) = \frac{1}{1 - N \cdot N_{rel}} \left(\sum_{k=1}^{N_{rel}} R_k - \frac{N_{rel}(N_{rel}+1)}{2} \right)$$

Expression	Geometry	DeepExpr
Anger	0.384	0.213
Disgust	0.386	0.171
Fear	0.419	0.228
Joy	0.276	0.106
Neutral	0.429	0.314
Sad	0.271	0.149
Surprise	0.322	0.125

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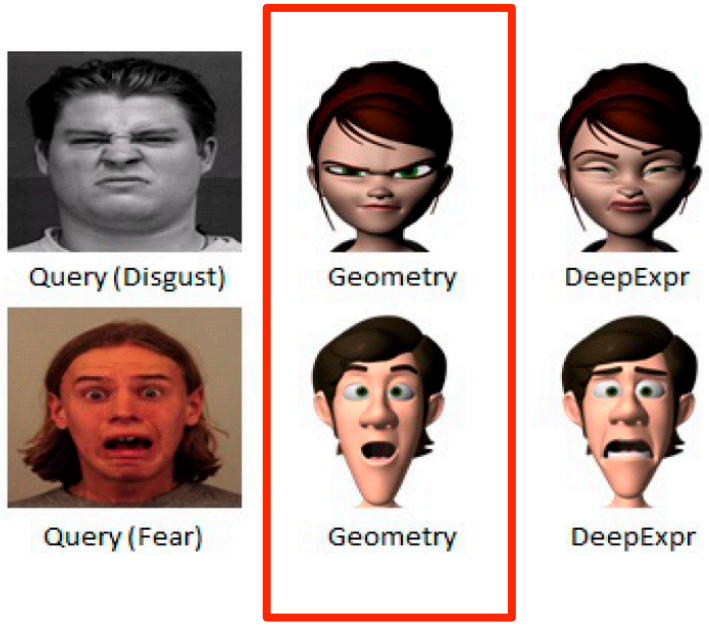
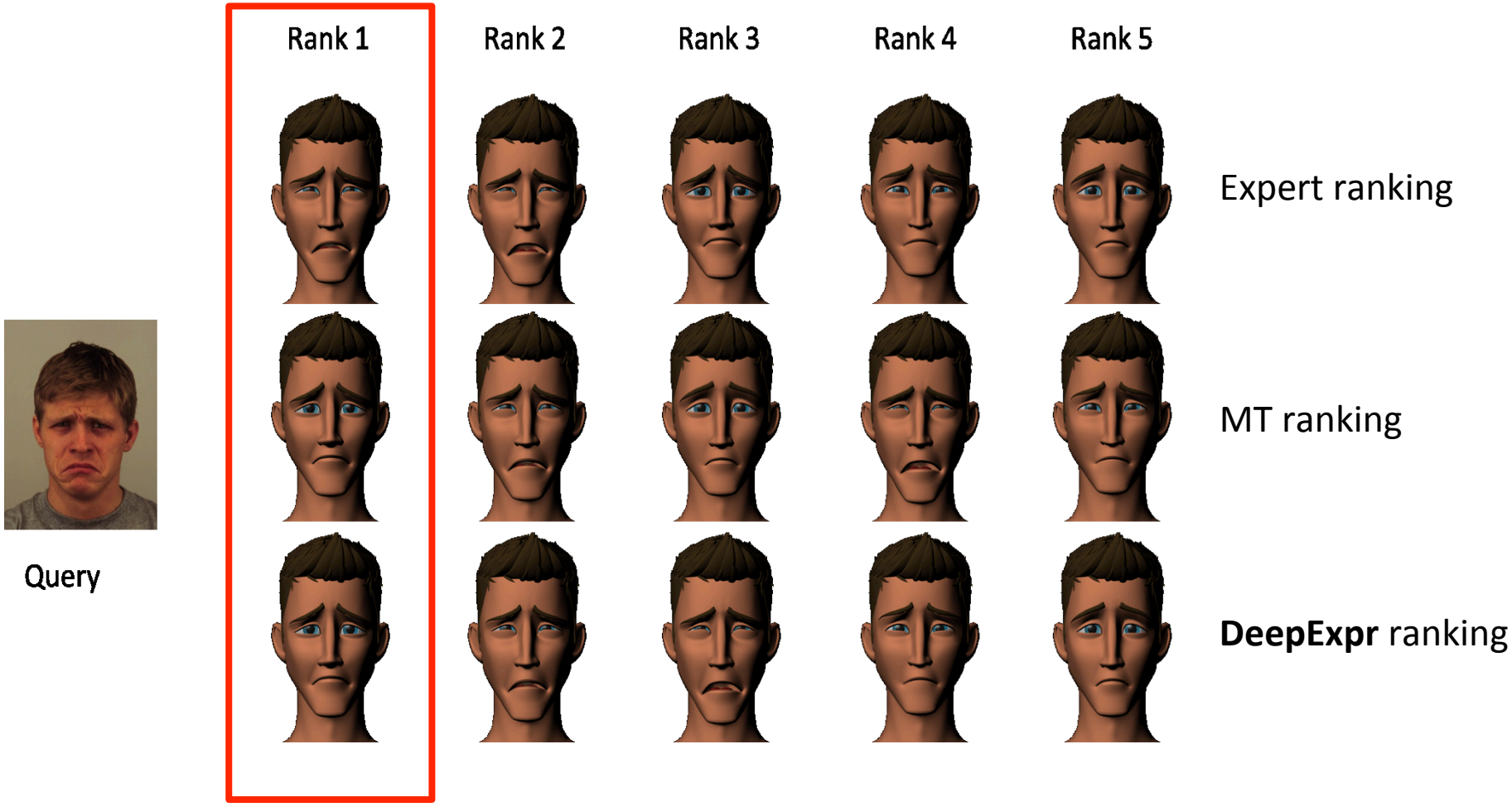
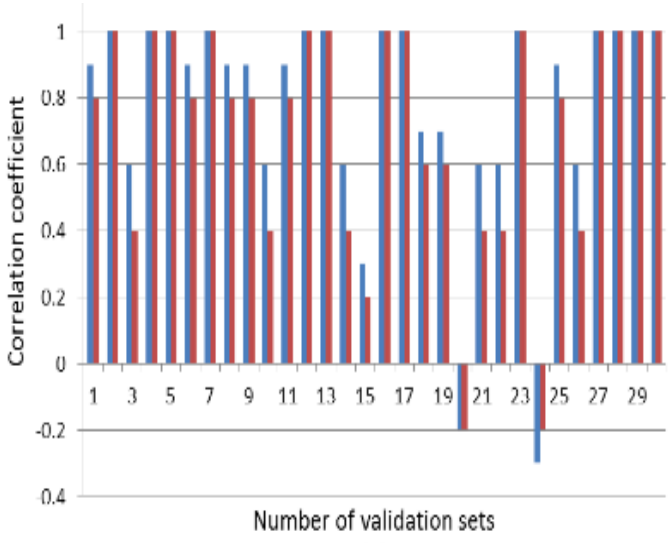


Comparison tests



Correlation

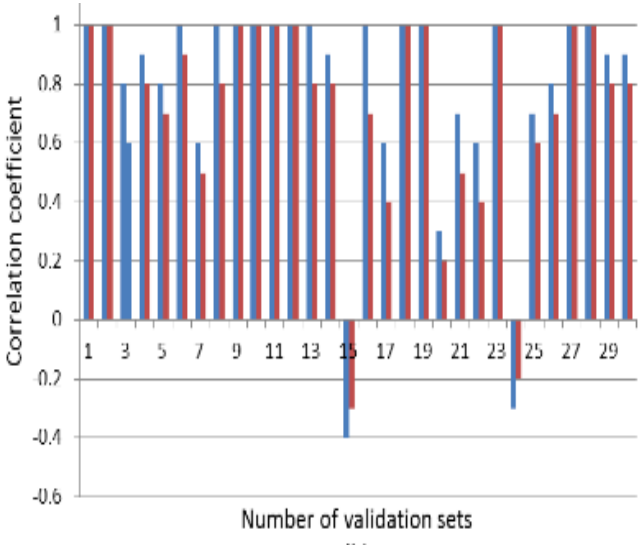
Correlation with Expert



Spearman

Kendall test

Correlation with MT subjects



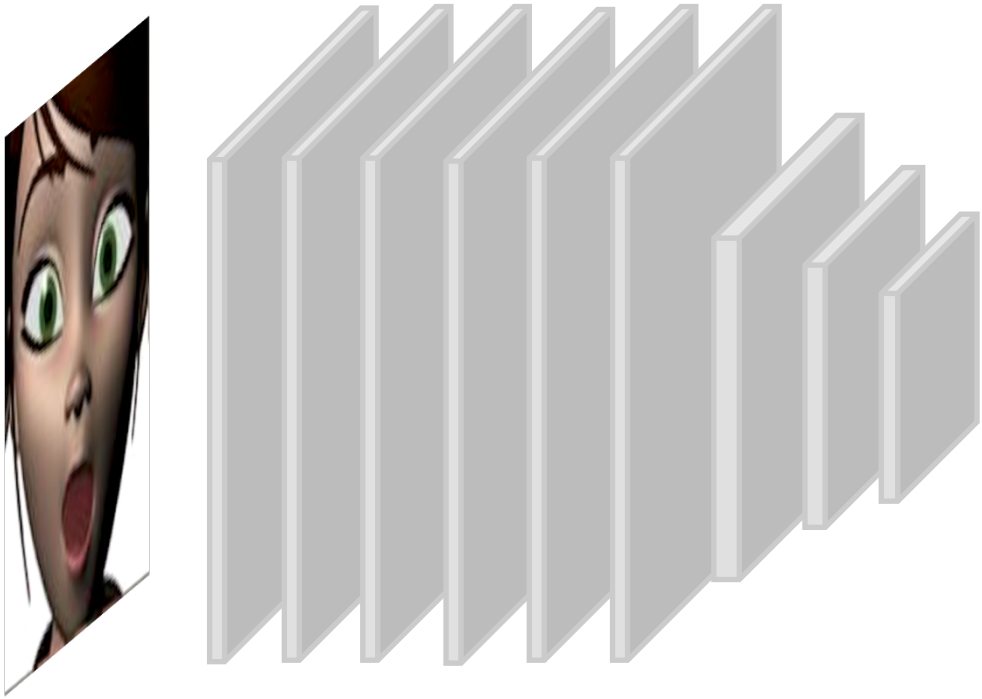
- Spearman correlation with expert best rank is **0.934** and with MT best rank is **0.942**
- Kendall correlation with expert best rank is **0.910** and with MT best rank is **0.927**

Conclusions

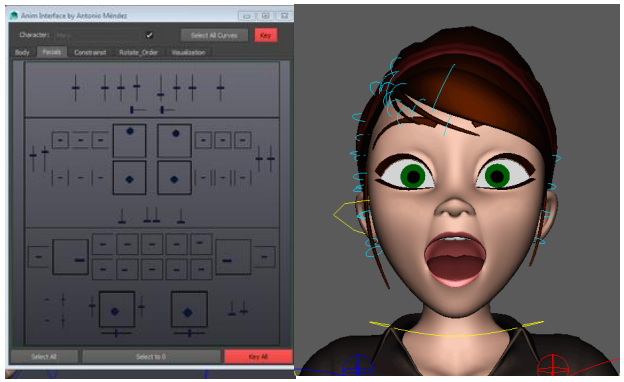
- **Perceptual** model of facial expressions
- **FERG-DB** with cardinal expression annotations
- **Plausible character expression** retrieval

- Improve visual storytelling applications:
  - Animated films
  - Gaming
  - Online marketing
  - VR/AR experiences
  - Robotics

Future work



2D feature vectors



3D Maya parameters

Thank you!

Project webpage
http://grail.cs.washington.edu/projects/deepexpr/

Stylized Character expression Database download
http://grail.cs.washington.edu/projects/deepexpr/ferg-db.html

Acknowledgements – Jamie Austad (animator), Zillow Group, the creators of the rigs we used in our project: Mery (www.meryproject.com), Ray (CGTarian Online School), Malcolm (www.animSchool.com), Aia & Jules (www.animationmentor. com), and Bonnie (Josh Sobel Rigs).