



杭州电子科技大学  
HANGZHOU DIANZI UNIVERSITY

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A CAMALAB  
计算机动画与多媒体分析实验室

# Image Quality Assessment and Its Applications

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Hangzhou Dianzi University

# Contents

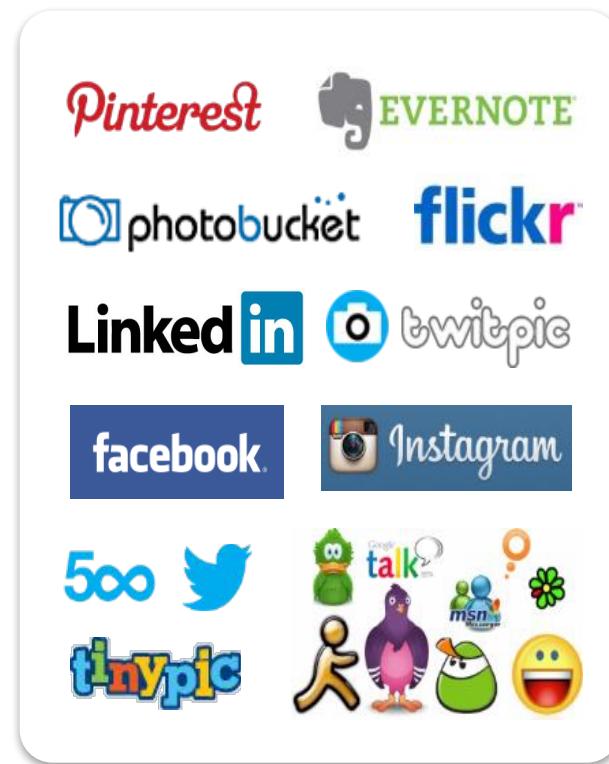
- Background
- Image Quality Assessment (IQA)
- Photo Quality Assessment (PQA)
- Biometric Quality Assessment (BQA)
- Discussions

# Contents

- **Background**
- Image Quality Assessment (IQA)
- Photo Quality Assessment (PQA)
- Biometric Quality Assessment (BQA)
- Discussions

# Background

- Dramatically increasing amount of images
  - **Devices:** computers, mobile phones, cameras, monitors, ...
  - **Applications:** medias, websites, IM clients, ...



# Background

- Extensively existed distortions
  - **Processing:** acquisition, compression, transmission, reconstruction, ...
  - **Distortions:** blurring, JPEG compression, Gaussian noise, ...



# What is Quality?

- **Various aspects**

[Keelan, Handbook of Image Quality, 2002]  
[Janssen and Blommaert, JIST, 1997]  
[Janssen, Proc. IEEE, 2001]  
[Halonen, et al., Proc. SPIE, 2011]

- **Athletics:** perceived beauty or image appeal
- **Fidelity:** deviation from the undistorted version
- **Intelligibility:** discriminability of image content



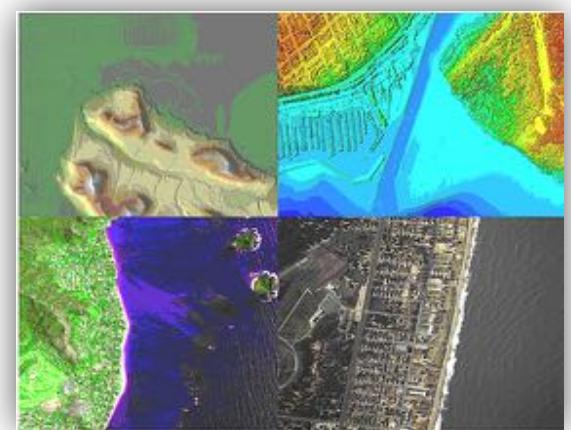
Undistorted

**Athletics**



Distorted

**Fidelity**



**Intelligibility**

# Background

- Demands for IQA metrics

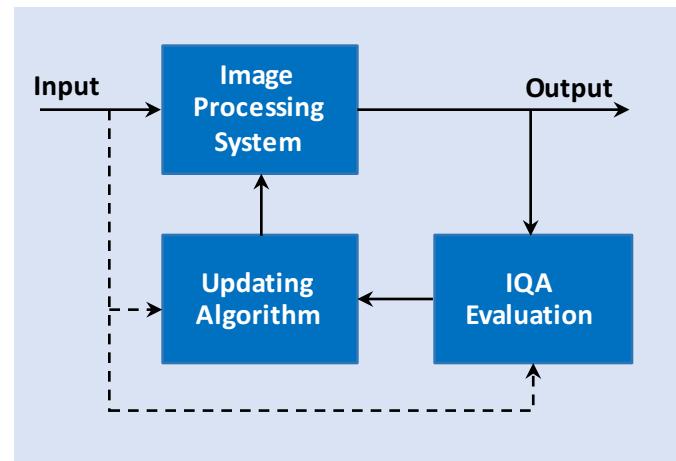


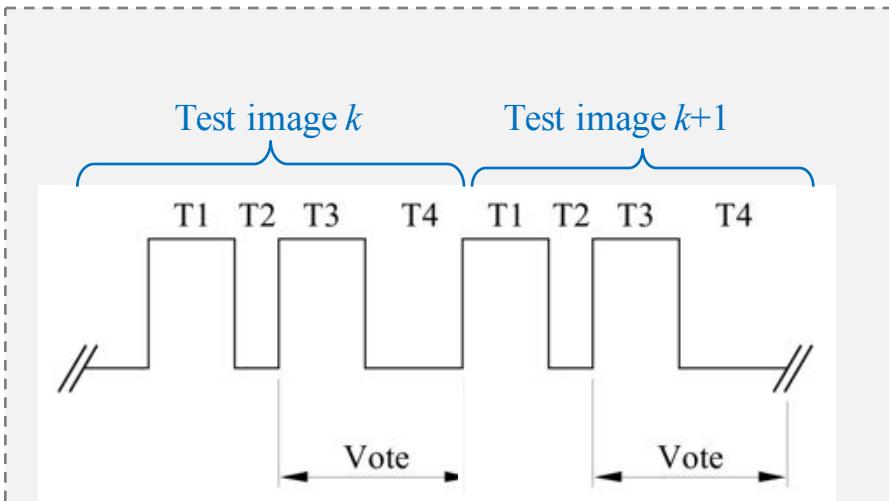
Diagram of IQA-based feedback optimization method. [Z. Wang, IEEE SPM'11]

Evaluation, control, and improve the perceptual quality of multimedia content, quality of service (QoS), image processing systems, ...

# Background

- Common Subjective IQA Method

[ITUR BT.500-13., 2012]



- T1 = 10s      Reference image
- T2 = 3s      Mid-gray image
- T3 = 10s      Test image
- T4 = 10s      Mid-gray image



## Quality Scale/Score

Categorical      Continuous



# Contents

- Background
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# Image Quality Assessment (IQA)

## • Traditional Objective Methods

[Wang & Bovik, IEEE SPM09]

- Mean Squared Error (MSE)

$$MSE = \frac{1}{mn} \sum_{i=1}^m \sum_{j=1}^n |I(i, j) - R(i, j)|^2$$

- Peak Signal-to-Noise Ratio

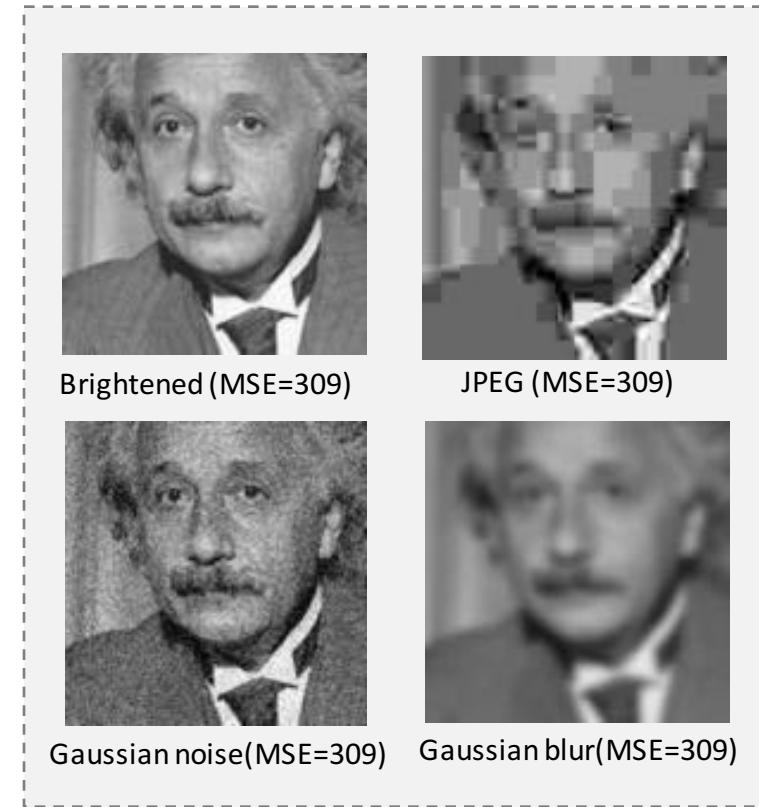
$$PSNR = 10 \cdot \log_{10} \left( \frac{I_{\max}^2}{MSE} \right)$$

- Advantages

- Mathematically conventional
  - Effective for white noise

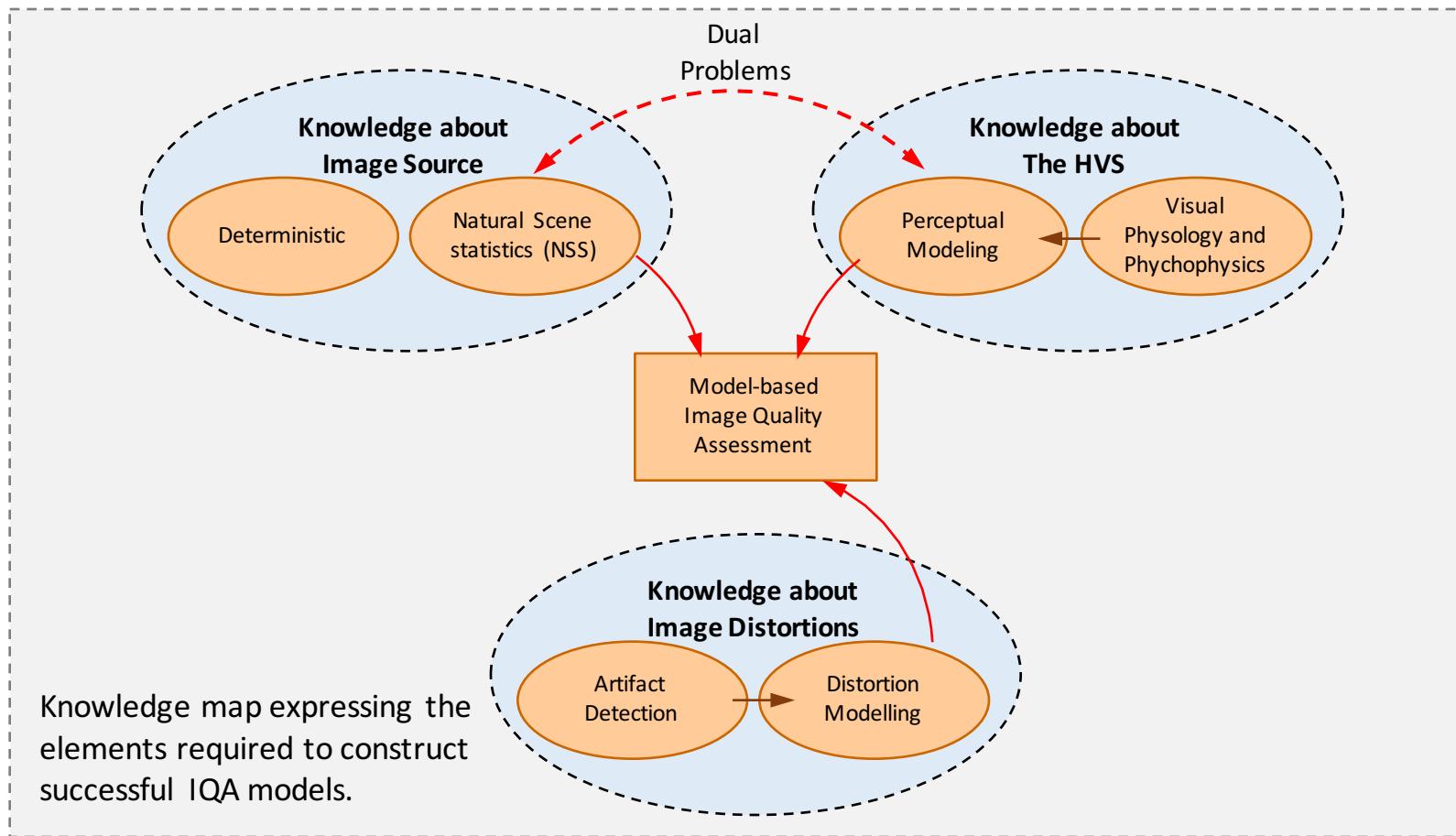
- Disadvantage

- Lack of consideration of human visual property



# Image Quality Assessment (IQA)

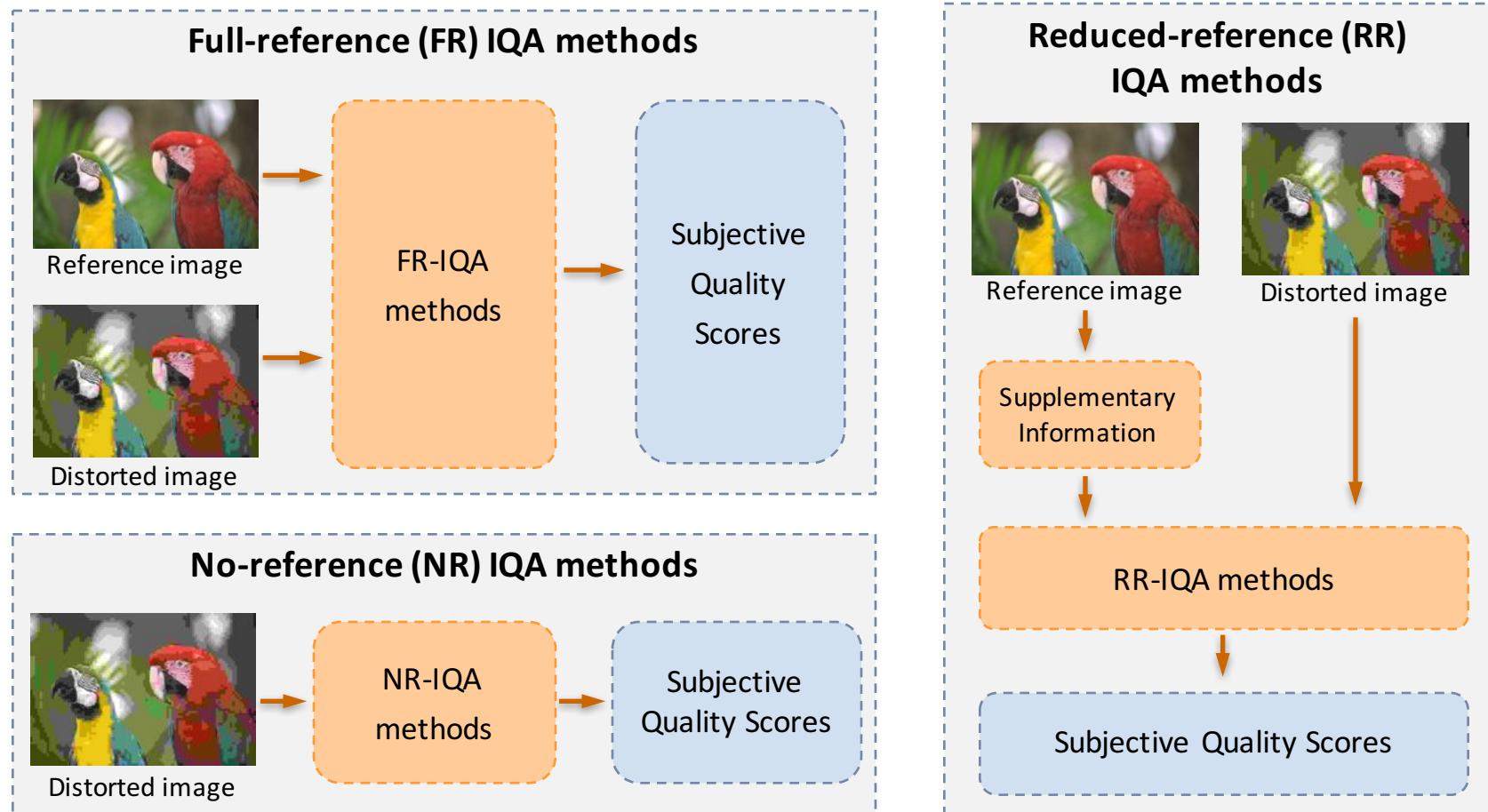
- How to Construct Objective IQA Metrics?



[Wang & Bovik, SPM'11]

# Image Quality Assessment (IQA)

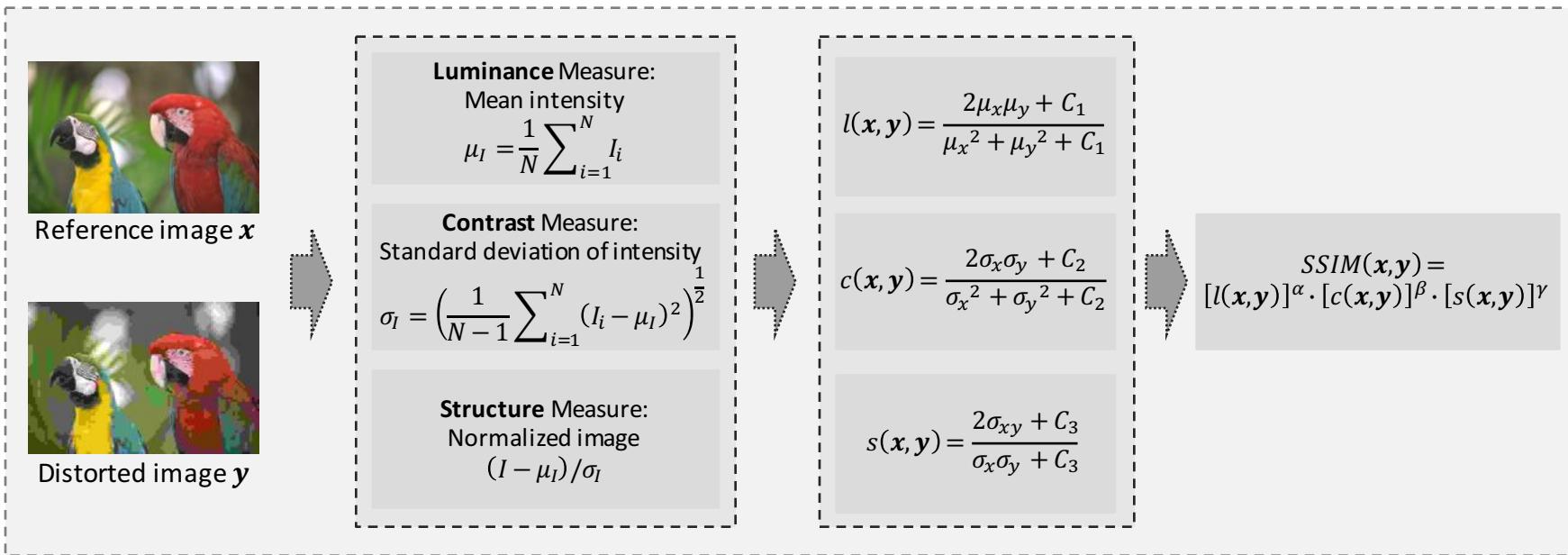
- Classification of Objective IQA



# Image Quality Assessment (IQA)

- **FR-IQA:** Structural Similarity Index (SSIM)

[Z. Wang, et al. TIP'04]

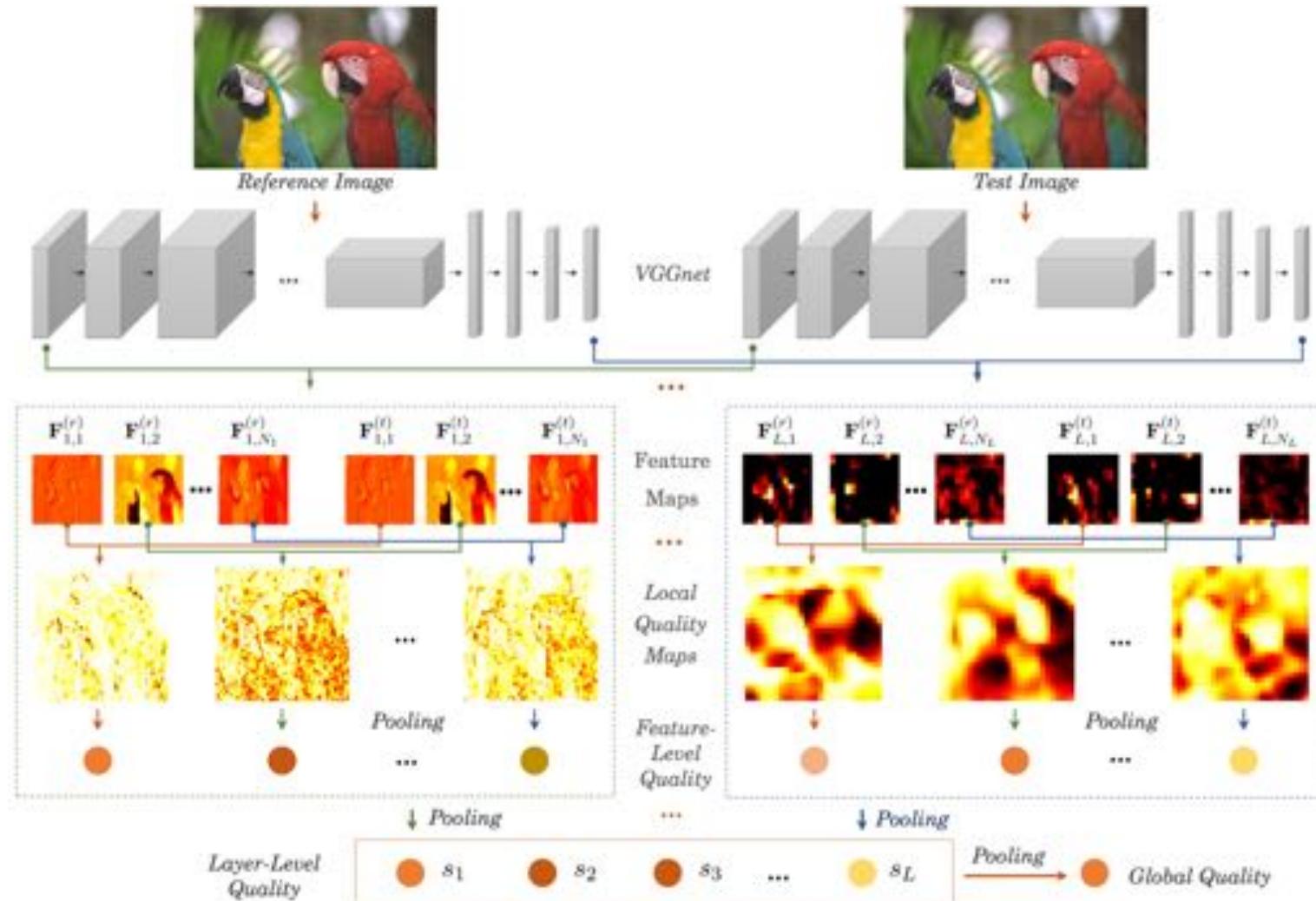


- **Advantages:** efficient and effective
- **Extensions:** CBM [X. Gao et al., LNCS'05], IW-SSIM [W. Zhou and Q. Li, TIP'11], RR-SSIM [A. Rehman and Z. Wang, TIP'12], etc.

# Image Quality Assessment (IQA)

- FR-IQA: Deep Similarity (DeepSim)

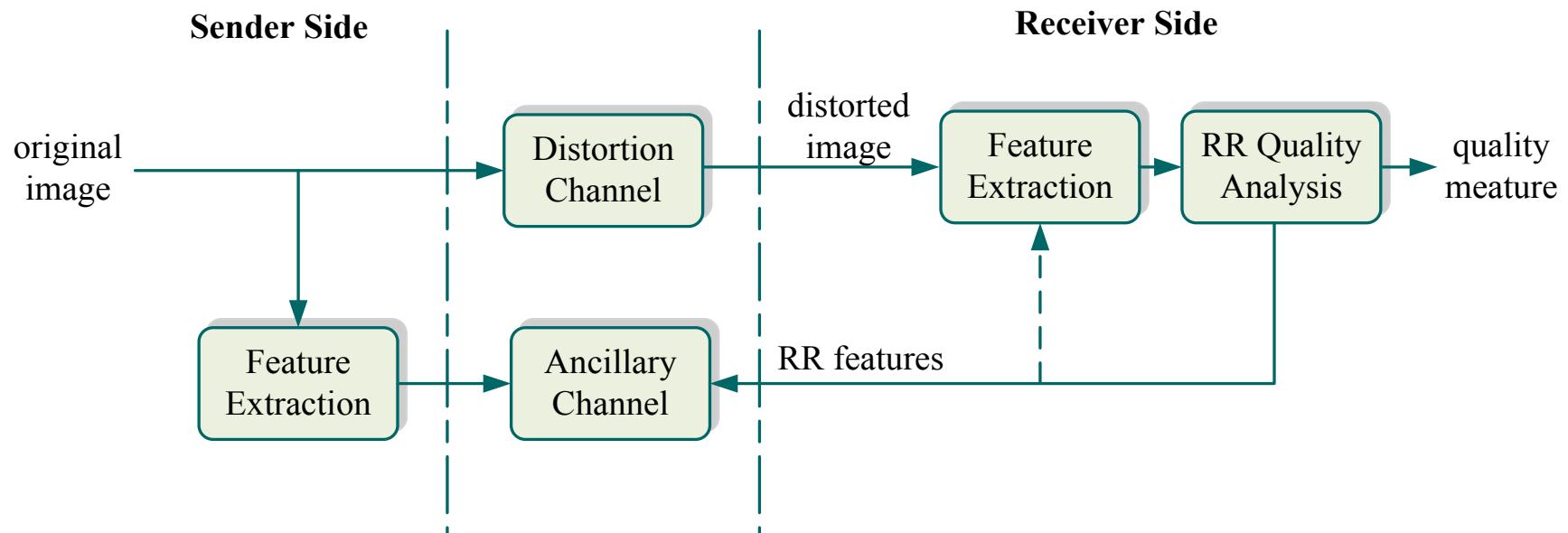
[F. Gao, et al. NEUCOM'17]



# Image Quality Assessment (IQA)

- **RR-IQA**

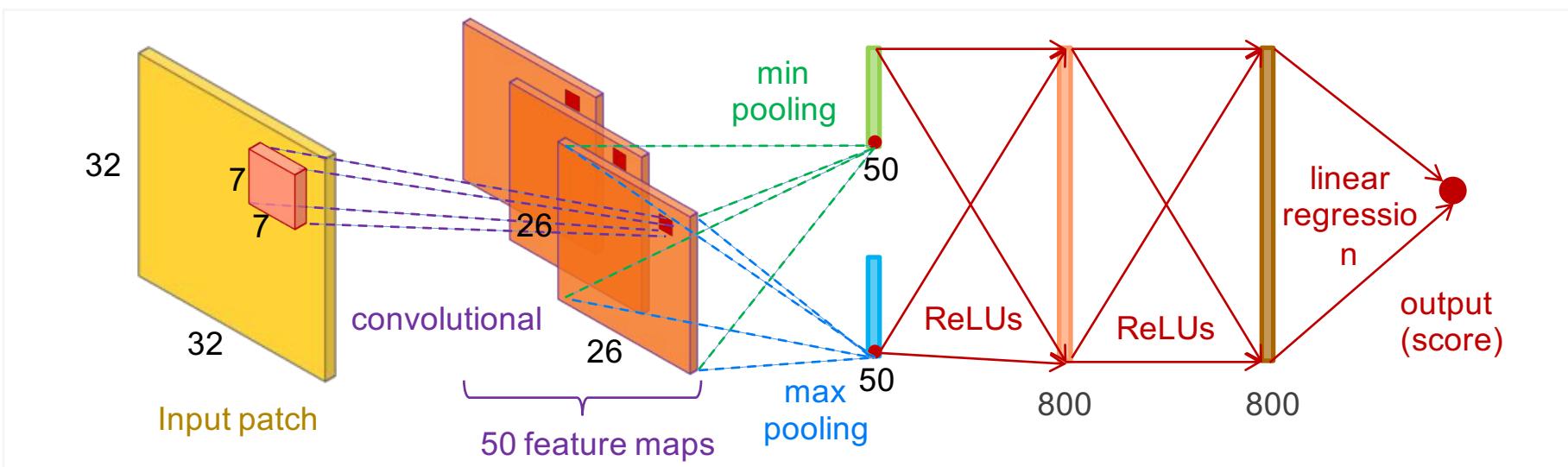
- Application: wireless communication scenario
- Framework of RR-IQA System



# Image Quality Assessment (IQA)

- NR-IQA

- Convolutional Neural Networks for BIQA (Kang et al. CVPR'14)



- a) The input is locally normalized  $32 \times 32$  image patches;
- b) The convolutional layer produces 50 feature maps each of size  $26 \times 26$ , followed by a pooling operation that reduces each feature map to one max and one min;
- c) The last layer is a simple linear regression with a one dimensional output that gives the score.

# Image Quality Assessment (IQA)

- **Performance Evaluation**

[N. Ponomarenko, et al. EUVIP'13]

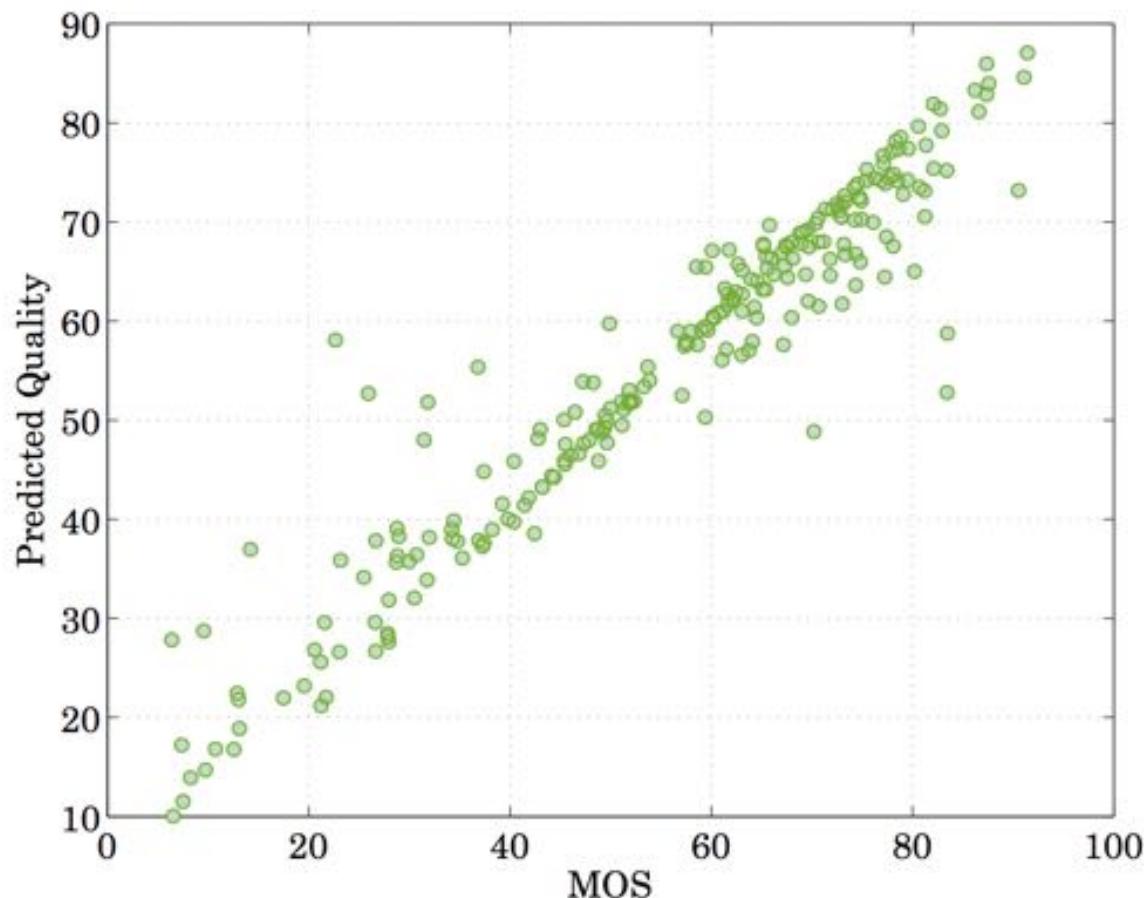
- Color Image Database TID2013

- 25 reference color images (512\*368 pixels);
- 120 distorted versions of each reference image;
- 24 types of distortions, 125 images of each type;
- Totally 3000 images;
- MOS of each image is available.



# Image Quality Assessment (IQA)

- Performance Evaluation
  - Scatter plots



# Image Quality Assessment (IQA)

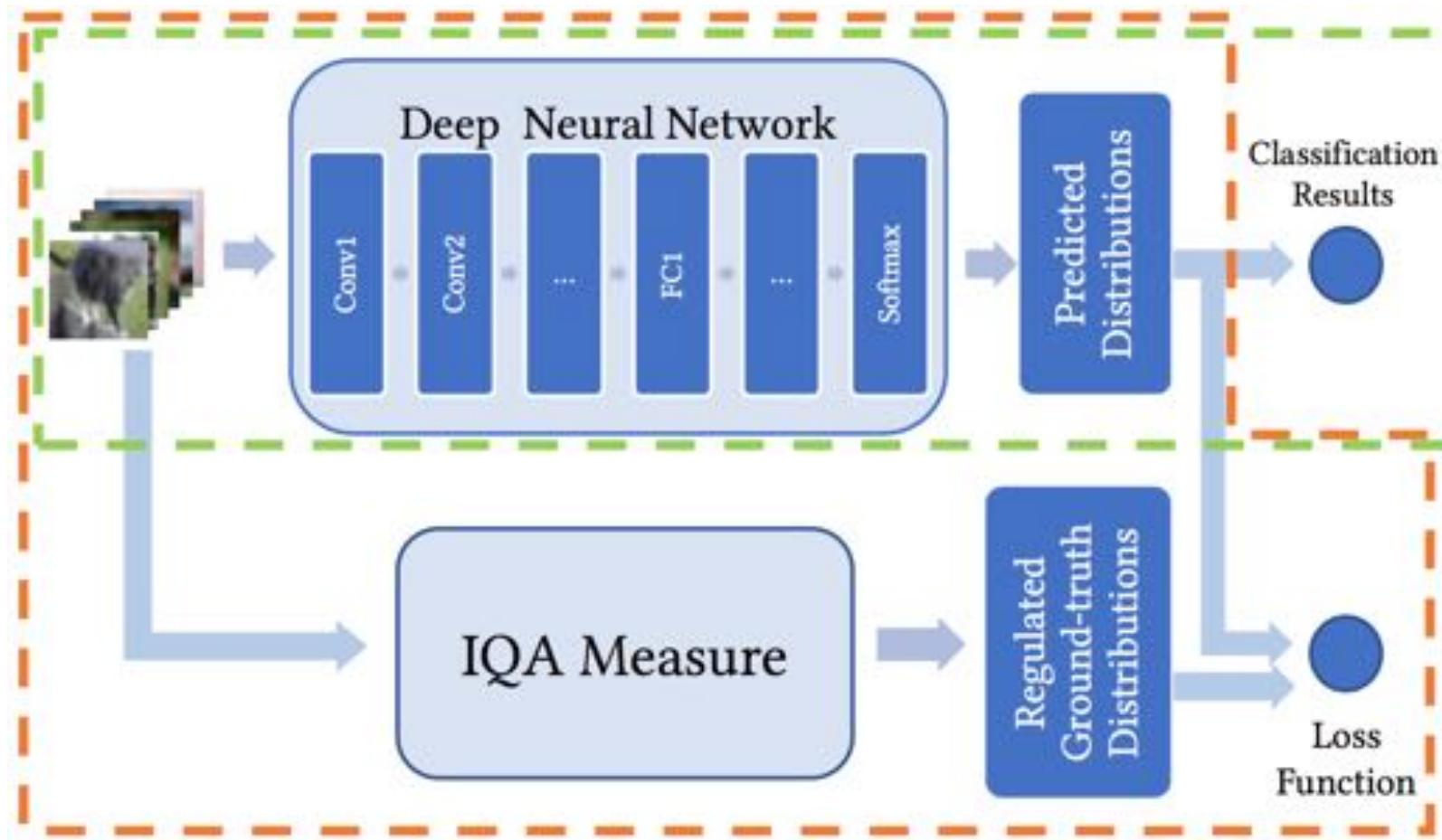
- **Performance Evaluation**

- Pearson linear correlation coefficient (PLCC),
- Spearman's rank- order correlation coefficient (SRCC), and
- Kendall rank-order correlation coefficient (KRCC)

SRCC	RMSE	MSSIM	FSIMc	GMSD	IGM	MAD	BIFS	DeepSim
CSIQ	0.805	0.839	0.917	<b>0.950</b>	0.932	0.937	0.935	0.919
LIVE	0.936	0.954	0.981	0.979	0.978	<b>0.982</b>	0.968	0.974
LIVEMD	0.677	0.646	0.864	0.845	0.856	0.865	0.855	<b>0.877</b>
TID2013	0.674	0.627	0.802	0.804	0.810	0.808	0.832	<b>0.846</b>
Avg.	0.773	0.767	0.891	0.895	0.894	0.898	0.898	<b>0.904</b>
Wgt. avg.	0.744	0.724	0.859	0.864	0.865	0.866	0.876	<b>0.884</b>

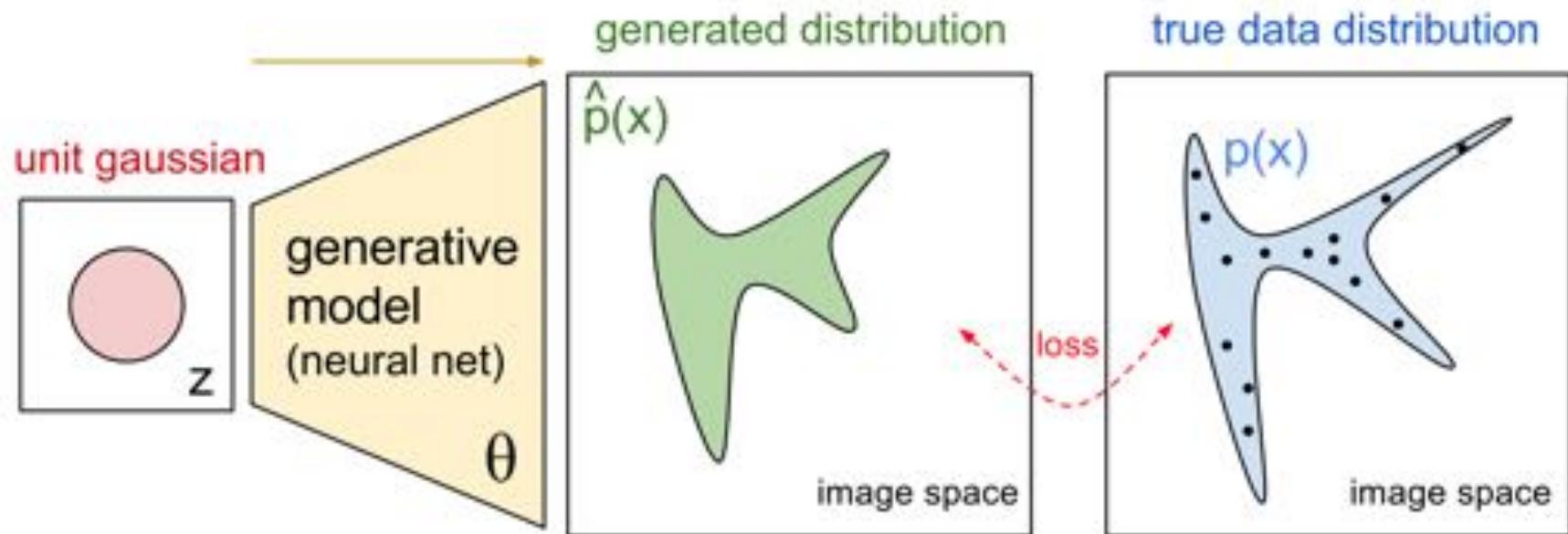
# Image Quality Assessment (IQA)

- Applications: IQA Guided CNNs Training



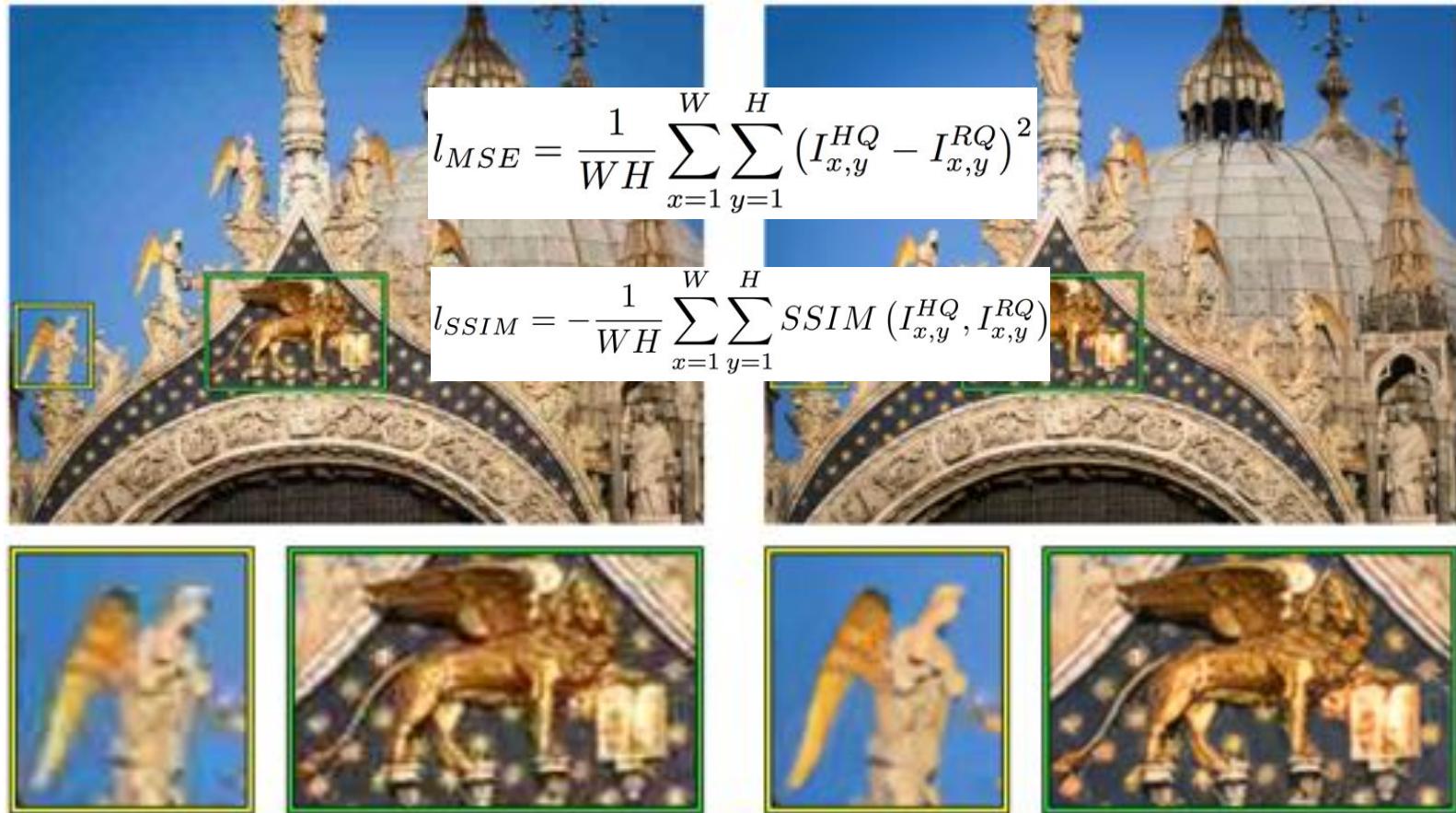
# Image Quality Assessment (IQA)

- Applications: GAN



# Image Quality Assessment (IQA)

- Applications: Compression Artifact Removal



Galteri, Leonardo, et al. "Deep Generative Adversarial Compression Artifact Removal." arXiv preprint arXiv:1704.02518 (2017).

# Contents

- Background
- Visual Quality Assessment (VQA)
- **Photo Quality Assessment (PQA)**
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# Photo Quality Assessment (PQA)

- What is Photo Aesthetic Quality?

[Marchesotti et al. 2015]



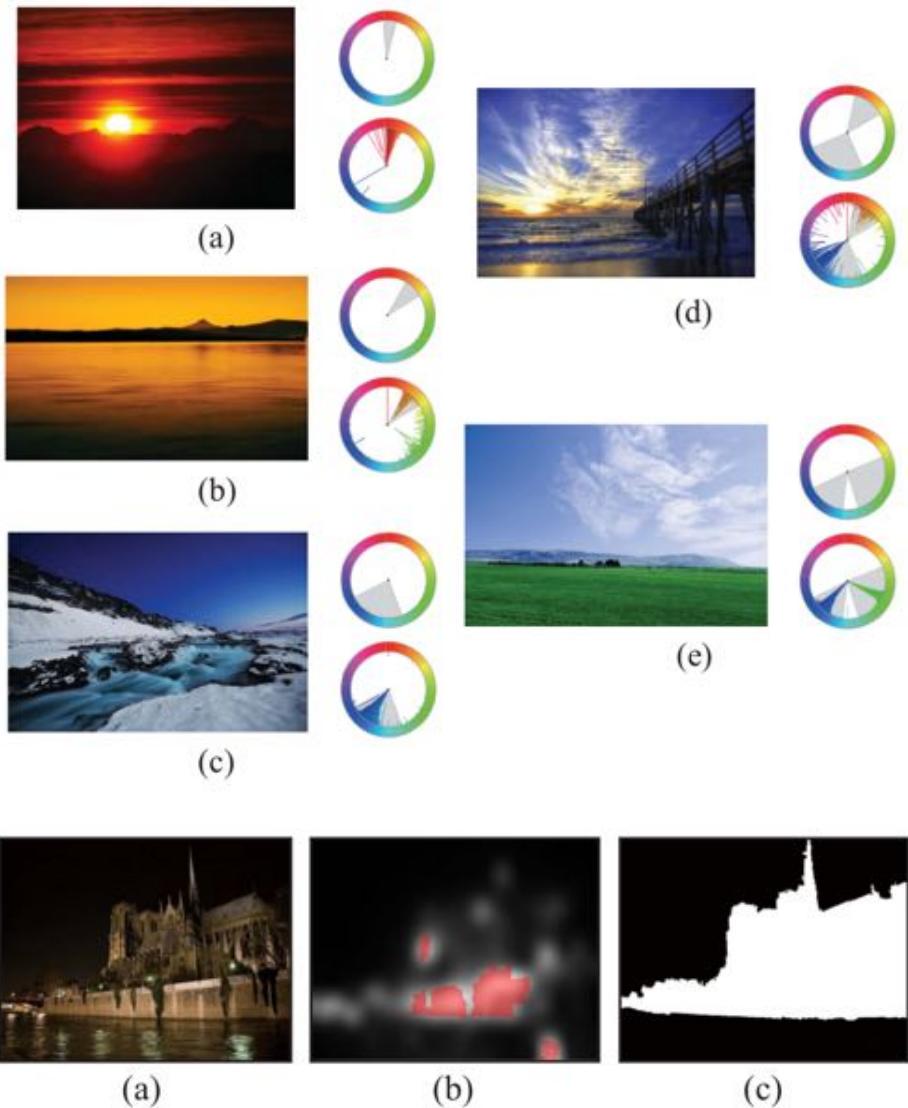
Beautiful / Professional / Good

Ugly / Amateurish / Bad

# Photo Quality Assessment (PQA)

- Challenges

- Aesthetic Principles
- Subjective PQA Mechanism
- Personalized
- Correlated with various image attributes (e.g. emotion, scene, semantic, style)



# Photo Quality Assessment (PQA)

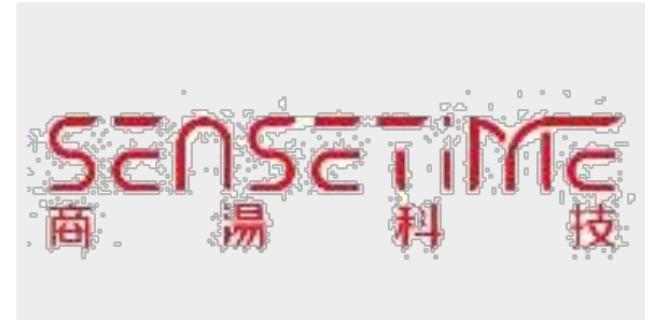
- Research Groups



**Prof. Tang Xiaoou, Sean**

Fellow IEEE

Multimedia Laboratory



**Xin Lu**

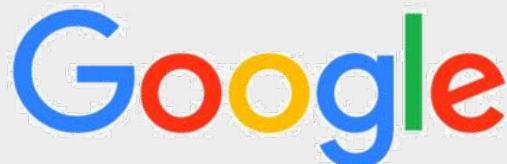


**Xinmei Tian**

Associate Professor



**中国科学技术大学**  
University of Science and Technology of China



# Photo Quality Assessment (PQA)

- AVA database (250k images)
  - Ratings, Average ratings, Semantics, Styles



# Photo Quality Assessment (PQA)

- Crowd Opinion

[Marchesotti et al. 2015]

low variance



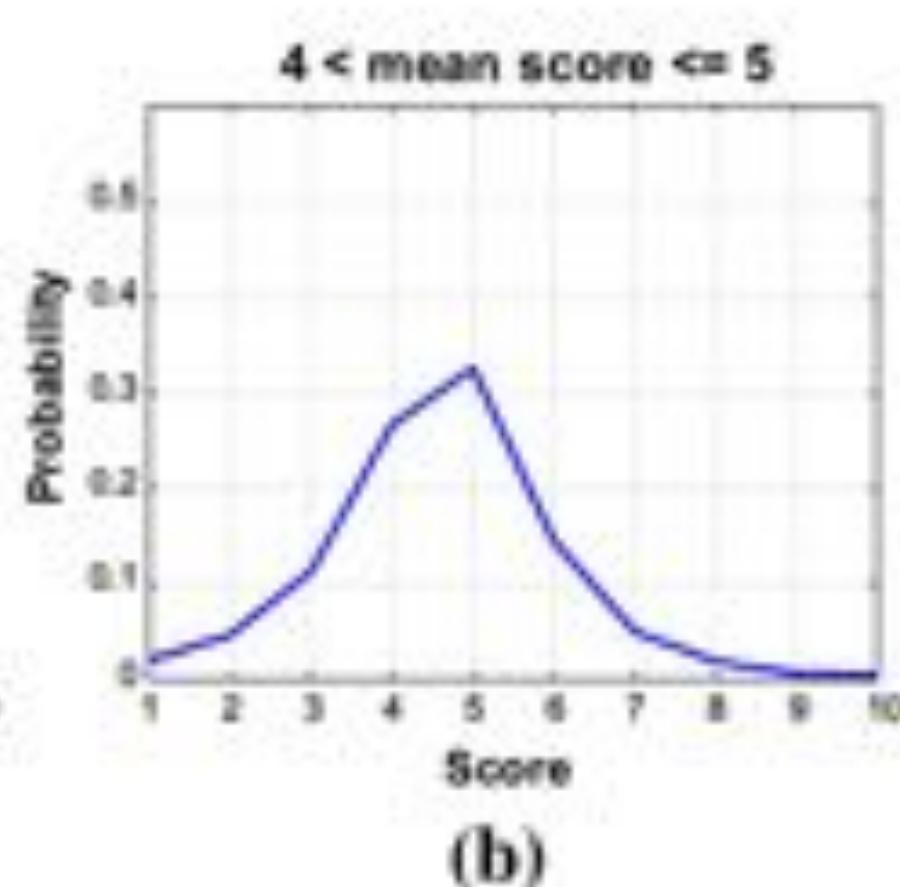
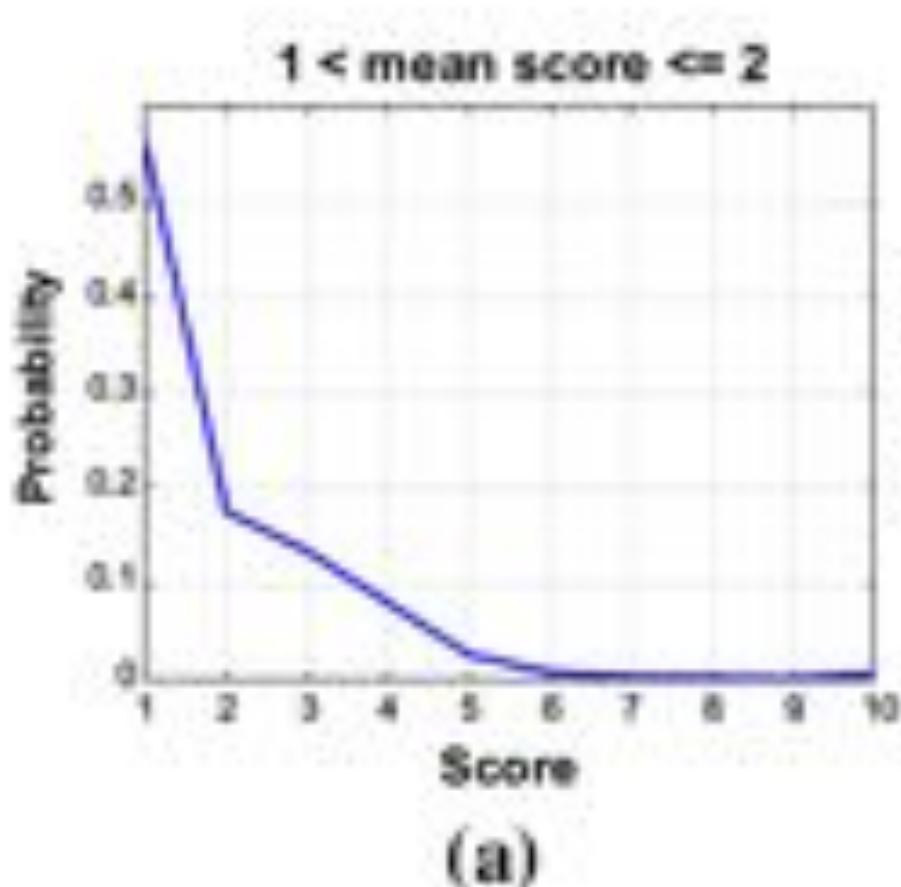
high variance



# Photo Quality Assessment (PQA)

- Crowd Opinion

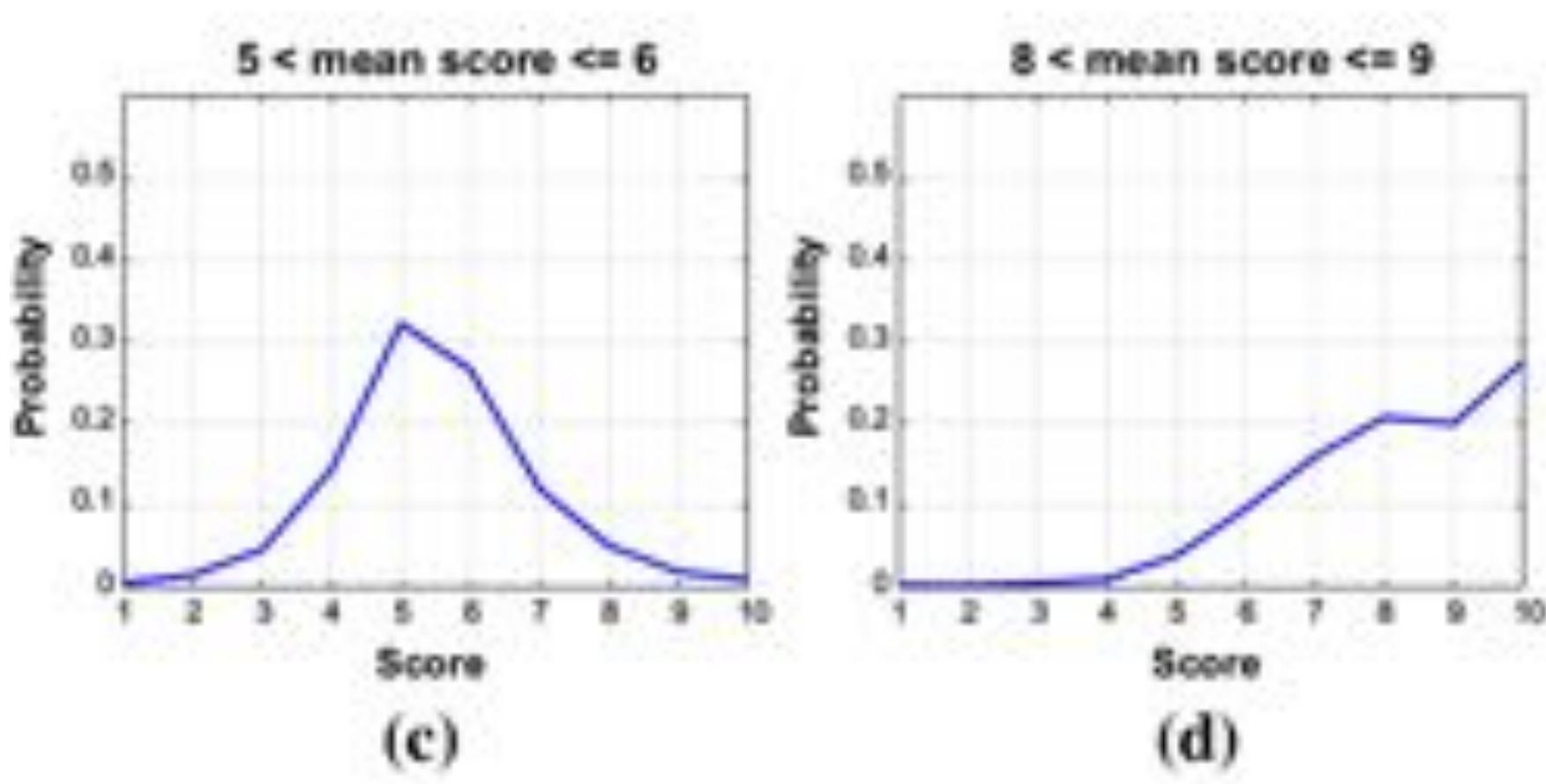
[Marchesotti et al. 2015]



# Photo Quality Assessment (PQA)

- Crowd Opinion

[Marchesotti et al. 2015]



# Photo Quality Assessment (PQA)

- Style

[Marchesotti et al. 2015]



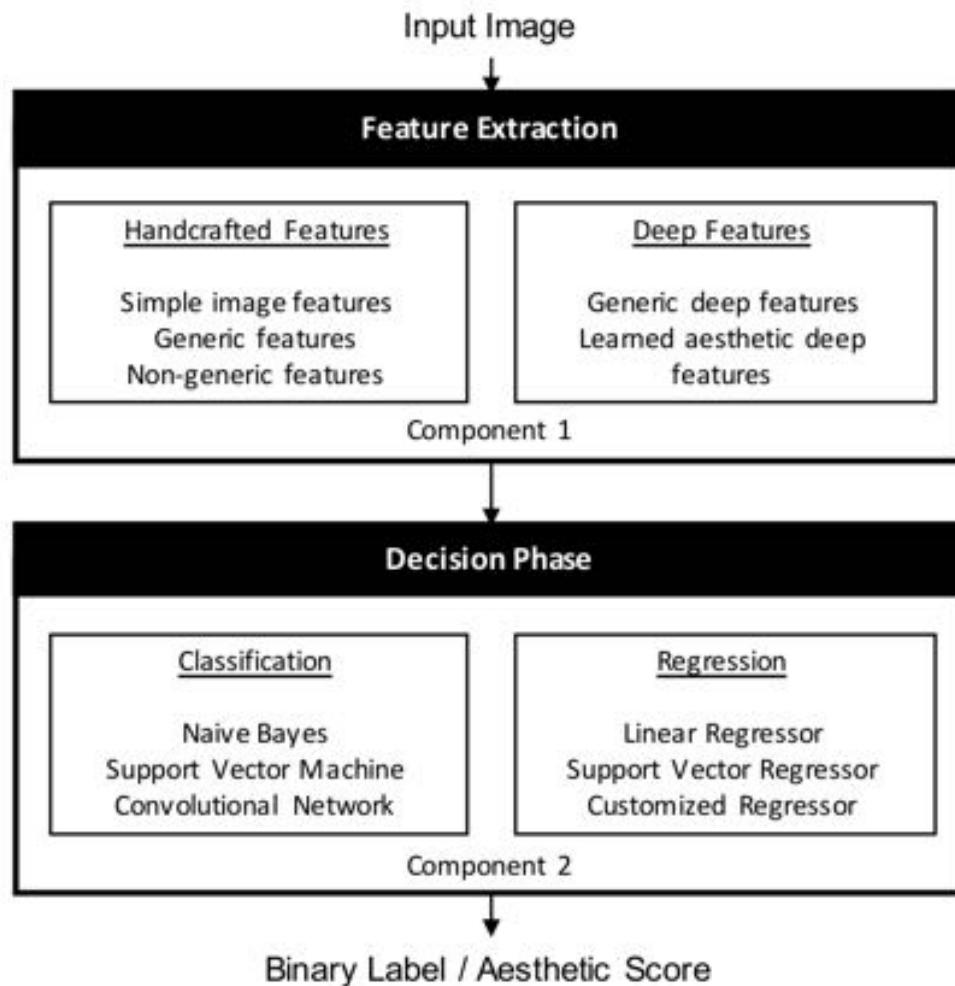
black and white



low depth-of-field, single salient object and rule-of-thirds

# PQA via Deep Learning

## • Methodology



### PQA via CNNs

Single-column CNNs

Multi-column CNNs

Multi-task CNNs

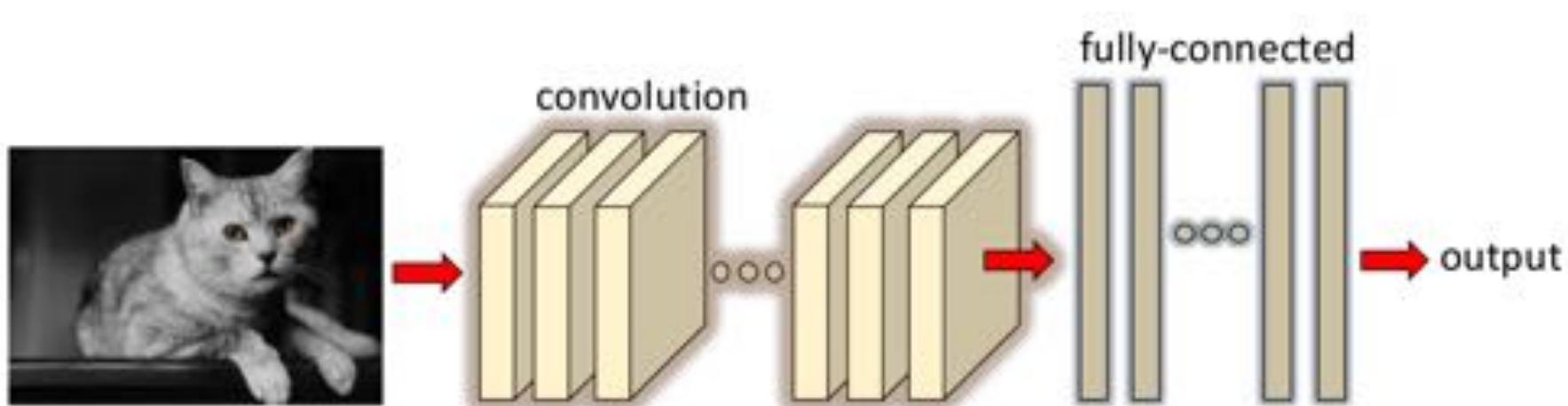
Y. Deng, C.-L. Chen, and X. Tang, "Image aesthetic assessment: An experimental survey," 2016.

# PQA via Deep Learning

- Single-column CNNs

- CNNs trained on ImageNet
- Transferred CNNs
  - Pretrain in the PQA task
  - Fine-tuning in the binary classification task of photo aesthetic (good or bad)

Y. Deng, C.-L. Chen, and X. Tang, "Image aesthetic assessment: An experimental survey," 2016.

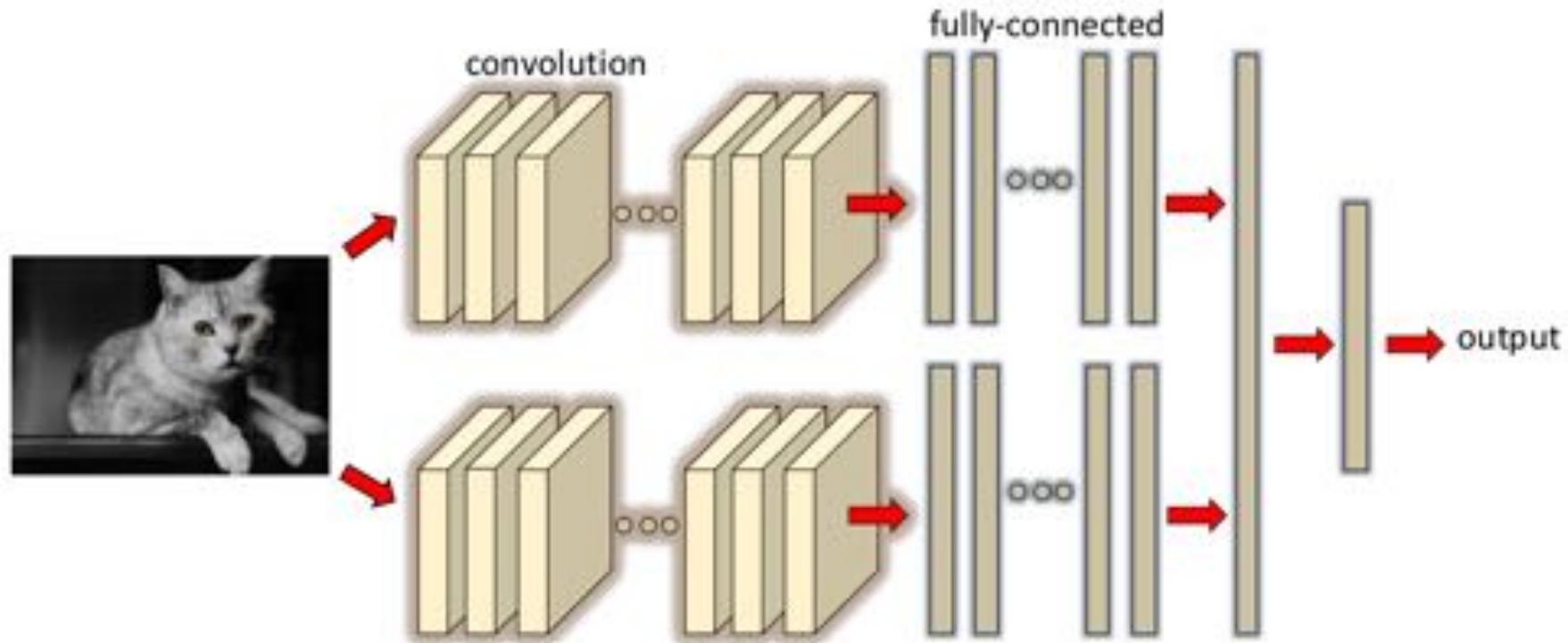


# PQA via Deep Learning

- Multi-column CNNs

- global features + local features
- global features + attribute features

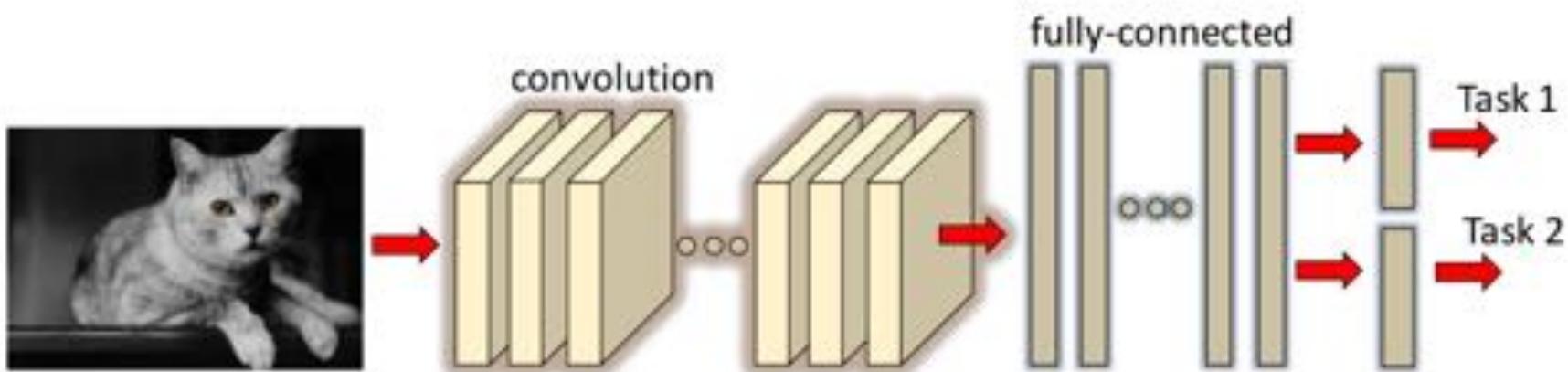
Y. Deng, C.-L. Chen, and X. Tang, "Image aesthetic assessment: An experimental survey," 2016.



# PQA via Deep Learning

- Multi-task CNNs
  - Correlated with various image attributes (e.g. emotion, scene, semantic, style)
    - Task 1: Aesthetic prediction
    - Task 2: Semantic prediction
    - Task  $n$ : ...

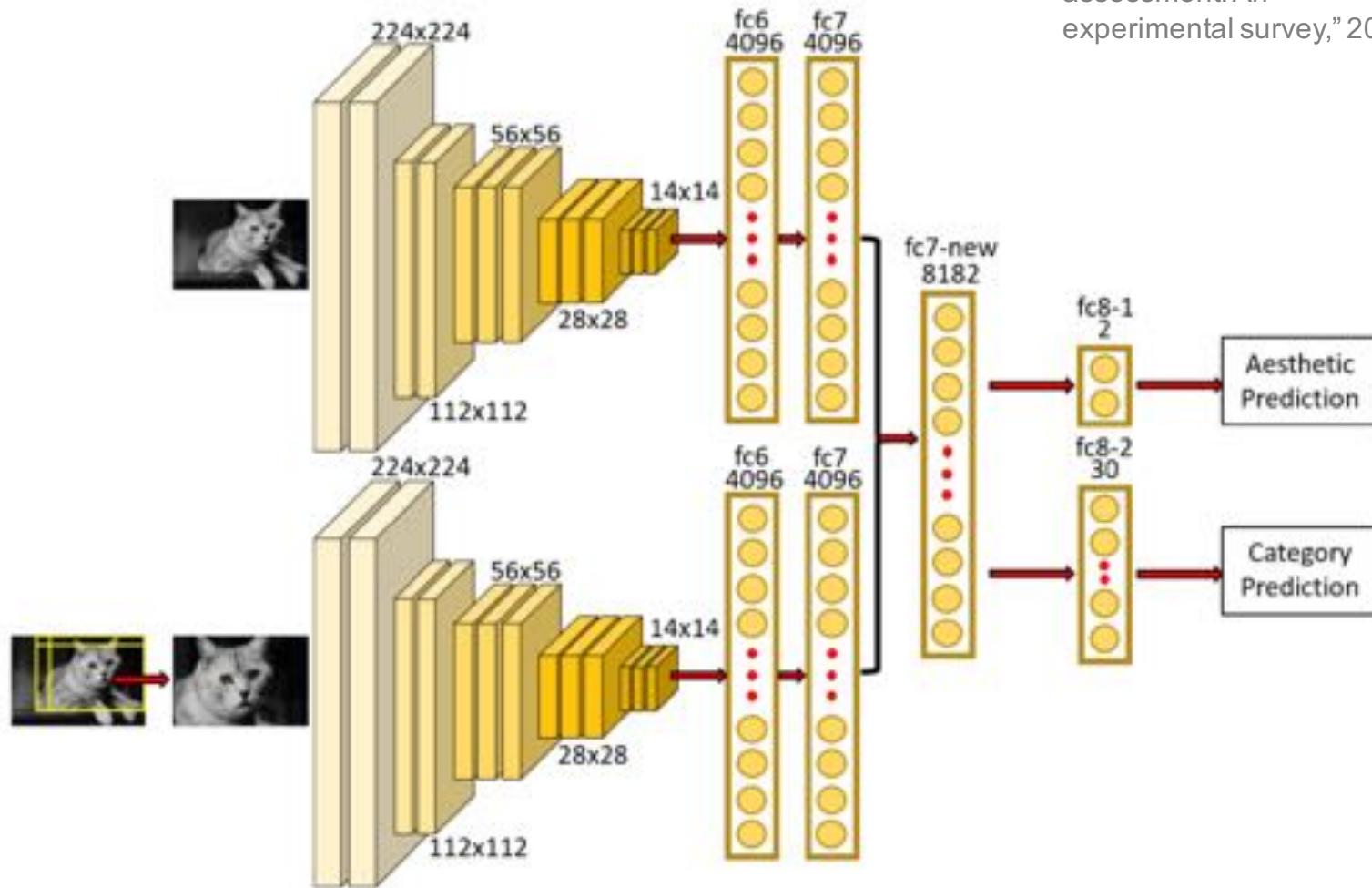
Y. Deng, C.-L. Chen, and X. Tang, “Image aesthetic assessment: An experimental survey,” 2016.



# PQA via Deep Learning

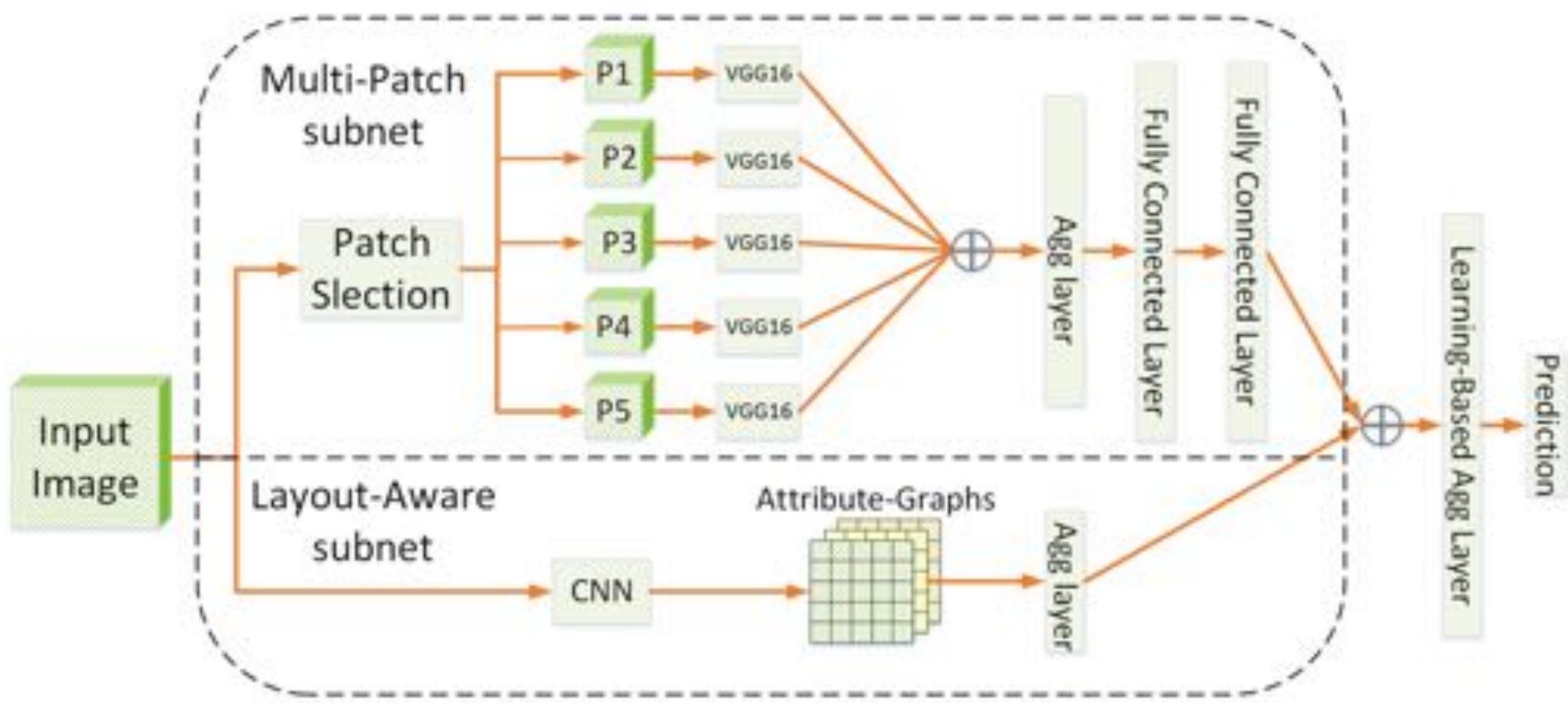
- Multi-task Multi-column CNNs

Y. Deng, C.-L. Chen, and X. Tang, “Image aesthetic assessment: An experimental survey,” 2016.



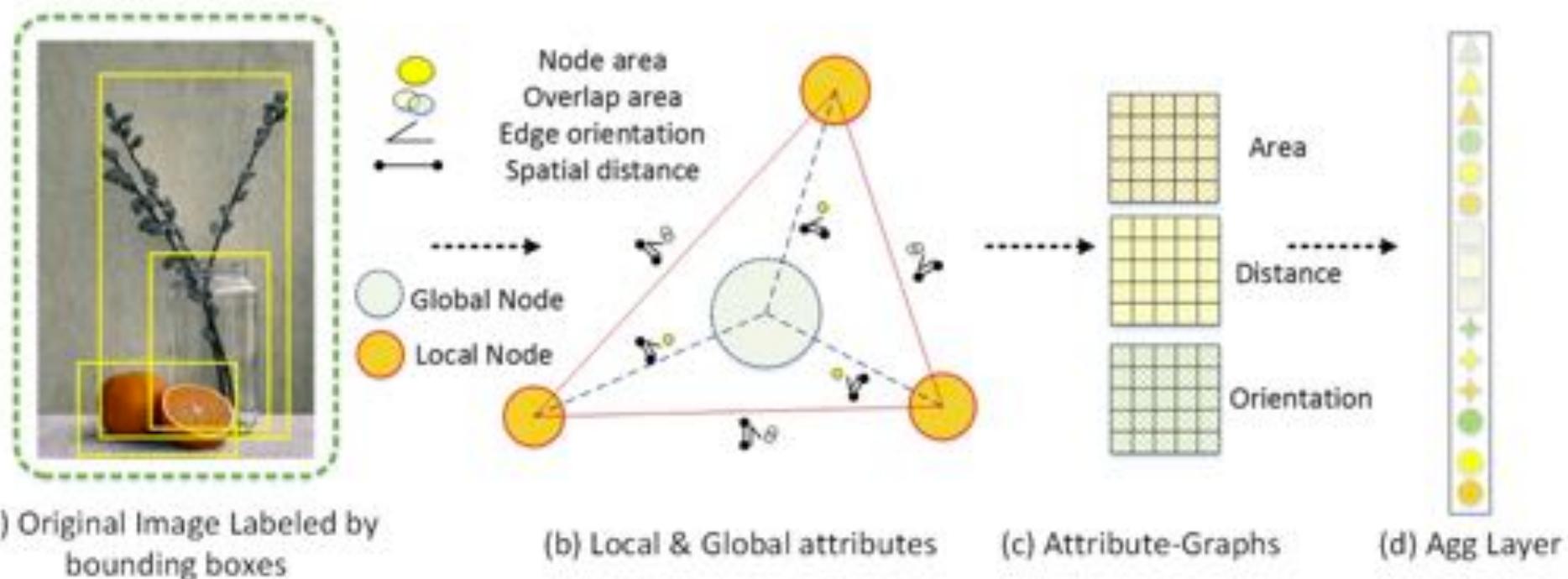
# PQA via Deep Learning

- A-lamp
  - Adaptive Layout-Aware Multi-Patch



# PQA via Deep Learning

- A-lamp



Pipeline of attribute-graphs construction. (a) Salient objects (labeled by yellow bounding boxes) are first detected by a trained CNN, and regarded as local nodes. The dashed green bounding box denote the overall scene, which served as a global node. (b) Local and global attributes are extracted from these nodes to capture the object topology and the image layout. (c) Attribute-graphs are constructed and (d) concatenated into an aggregation layer.

# PQA via Deep Learning

- Performance

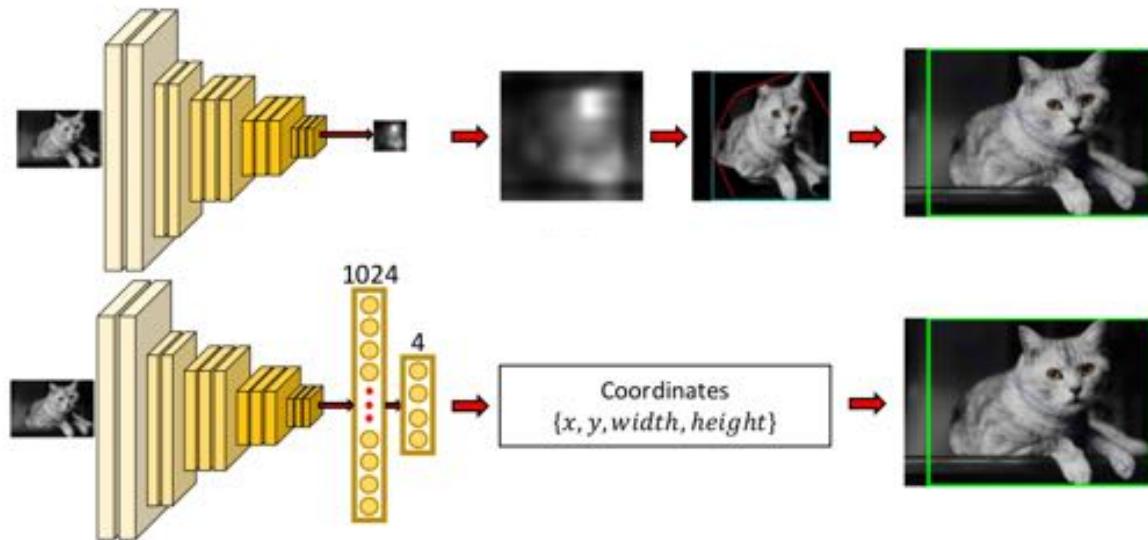
Method	Year	Accuracy
RAPID [10]	2014	75.42
SPP [21]	2015	72.85
DMA net [21]	2015	75.41
Peng et al. [35]	2016	74.50
Kao et al. [19]	2016	74.51
Kao et al. [25]	2016	76.15
Wang et al. [36]	2016	76.94
MNA-CNN [20]	2016	77.10
Kong et al. [9]	2016	77.33
BDN [24]	2016	78.08
Two-column DAN-2 [27]	2016	78.72
MTRLCNN [26]	2017	79.08
Lee et al. [37]	2017	81.02
A-Lamp [22]	2017	82.50
Proposed ( $T_q = 5$ )	2017	78.16
Proposed ( $T_q = 4.8$ )	2017	79.20

Y. Deng, C.-L. Chen, and X. Tang, “Image aesthetic assessment: An experimental survey,” 2016.

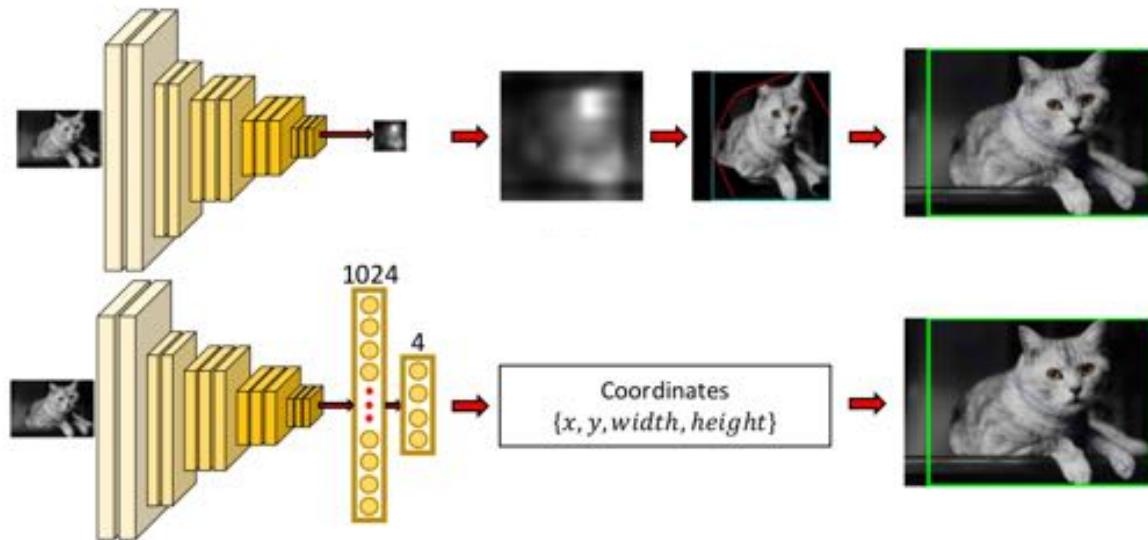
# PQA via Deep Learning

- Applications

- Enhancement



- Retargeting



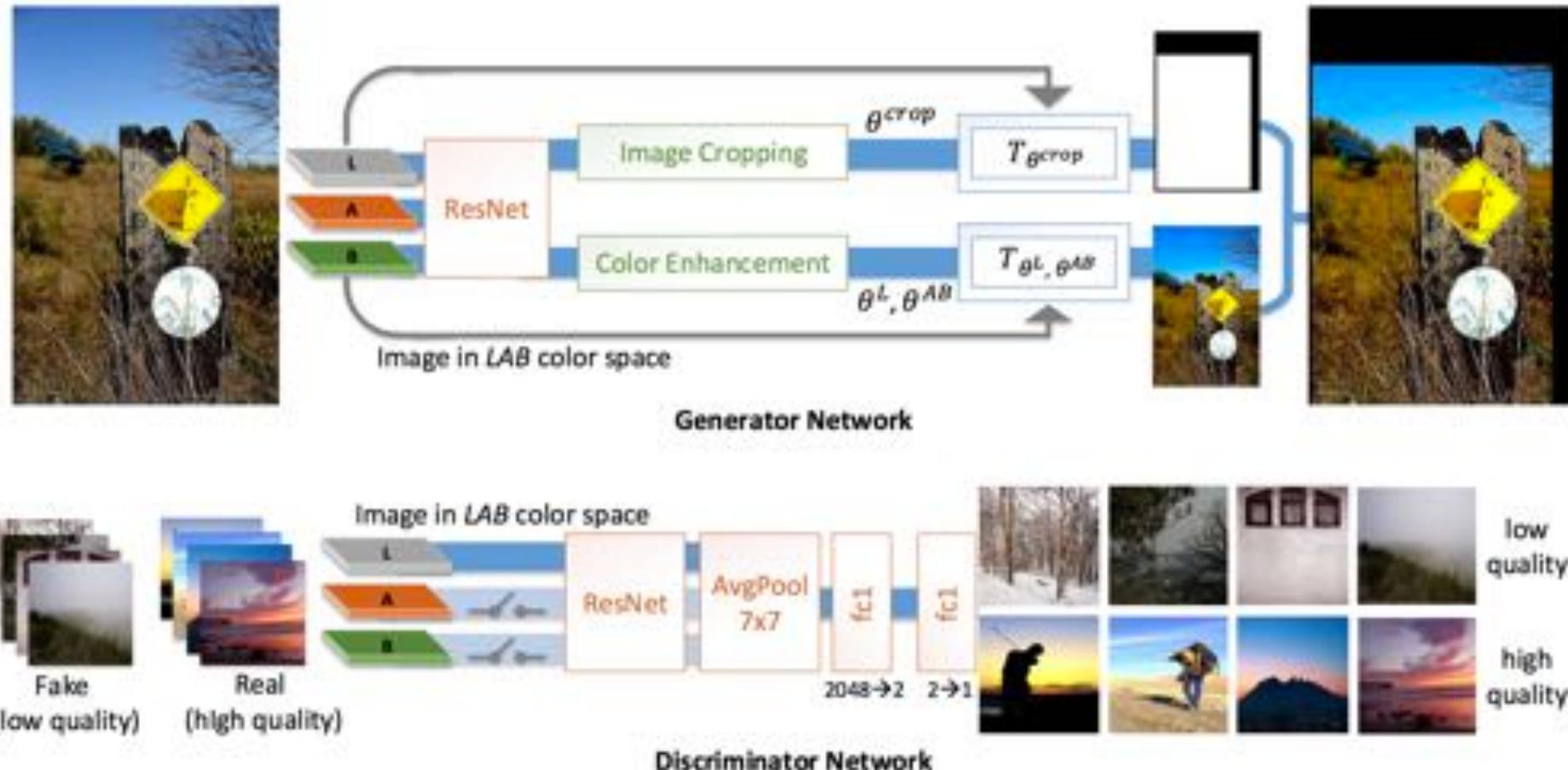
- Retrieval



- Mobile APPs

# Image Enhancement

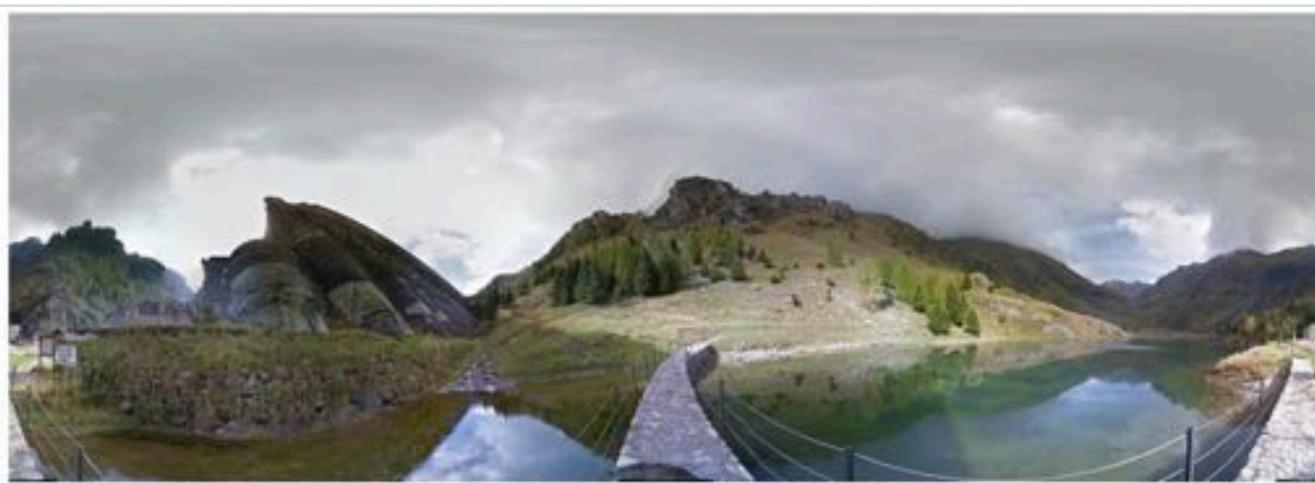
- EnhanceGAN



- Deng, Yubin, Chen Change Loy, and Xiaou Tang. "Aesthetic-Driven Image Enhancement by Adversarial Learning." *arXiv preprint arXiv:1707.05251*(2017).

# Image Enhancement

- Creatism



(a)



(b)



(c)



(d)

A panorama (a) is cropped into (b), with saturation and HDR strength enhanced in (c), and with dramatic mask applied in (d).

- Fang, Hui, and Meng Zhang. "Creatism: A deep-learning photographer capable of creating professional work." *arXiv preprint arXiv:1707.03491*(2017).

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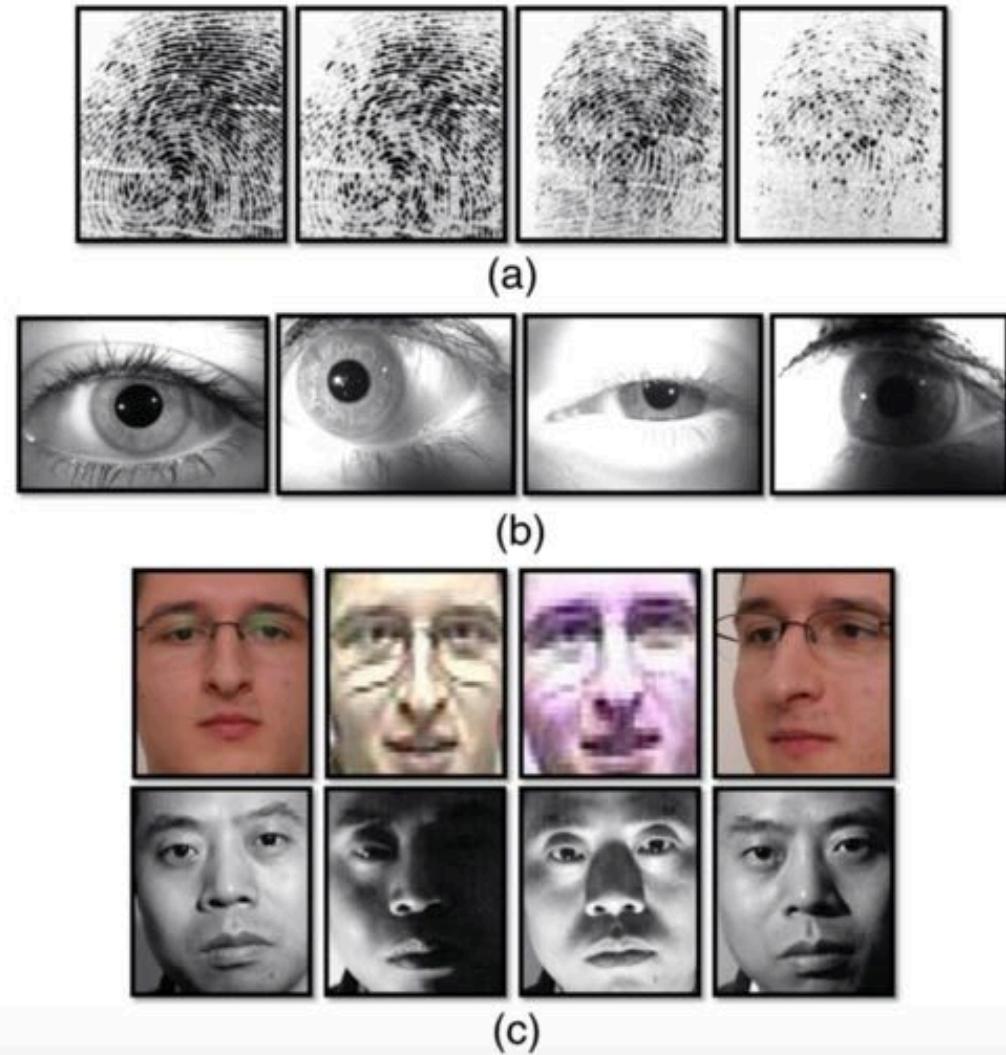
# Biometric Quality Assessment (BQA)

- **Definition**

- *Quality of a biometric sample is a measure of its efficiency in aiding recognition of an individual, ideally, irrespective of the recognition system in use.*

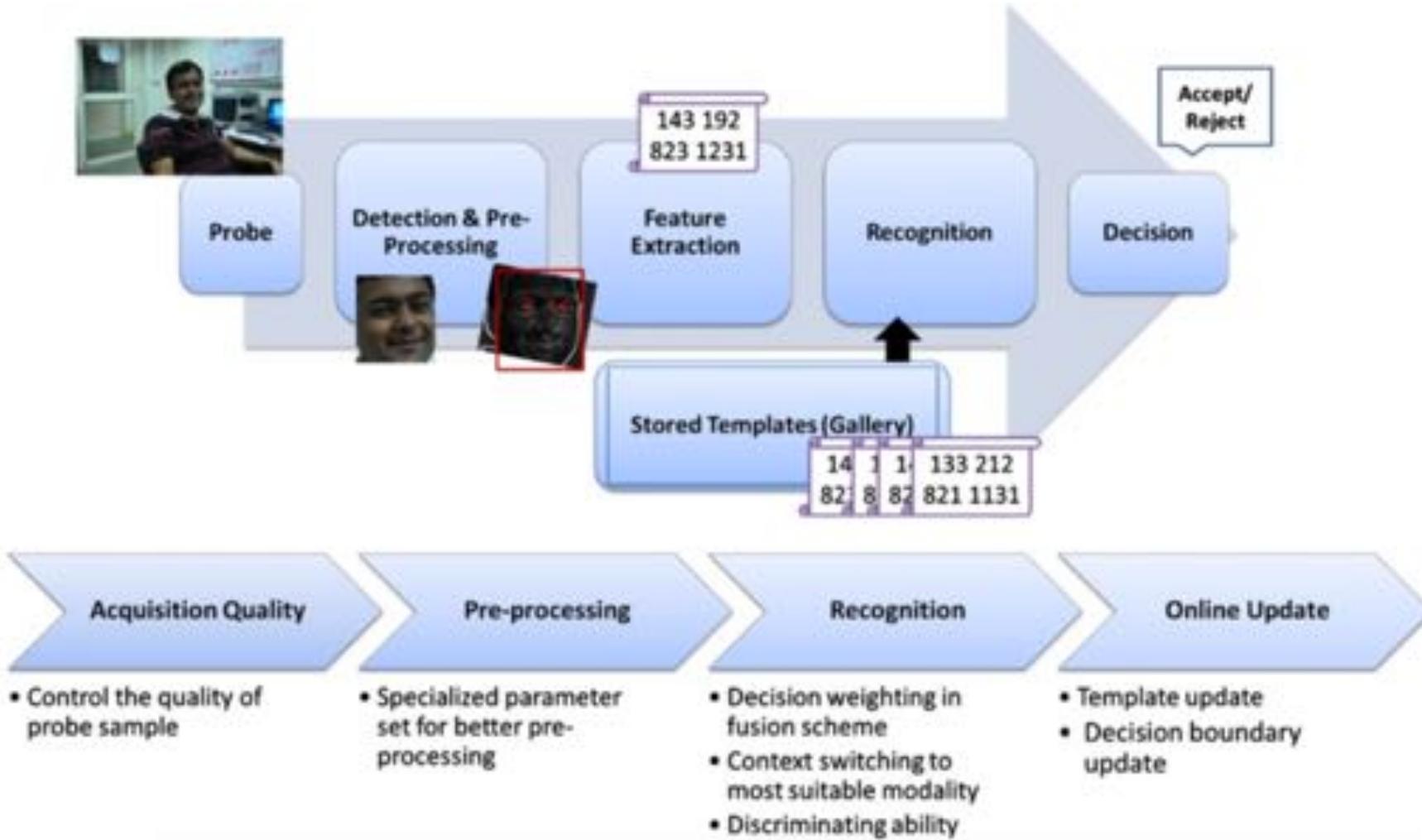
**Sample images of varying quality.**

(a) Fingerprint, (b) iris (from WVU multimodal database), and (c) face (from SCface and CAS-PEAL face databases)



# Biometric Quality Assessment (BQA)

- Pipeline of a typical biometric system.



# Biometric Quality Assessment (BQA)

- Face



a) Blur



b) Contrast



c) Color Balance



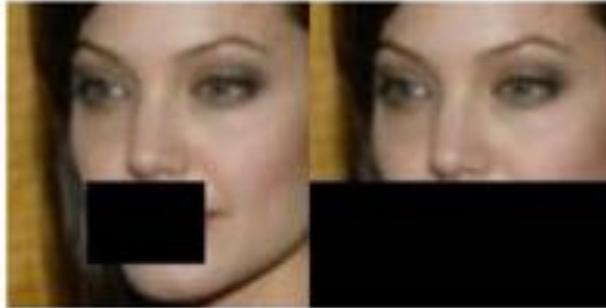
d) Noise



e) Channel



f) Eye Area Occlusion



g) Mouth Occlusion



h) Nose Occlusion

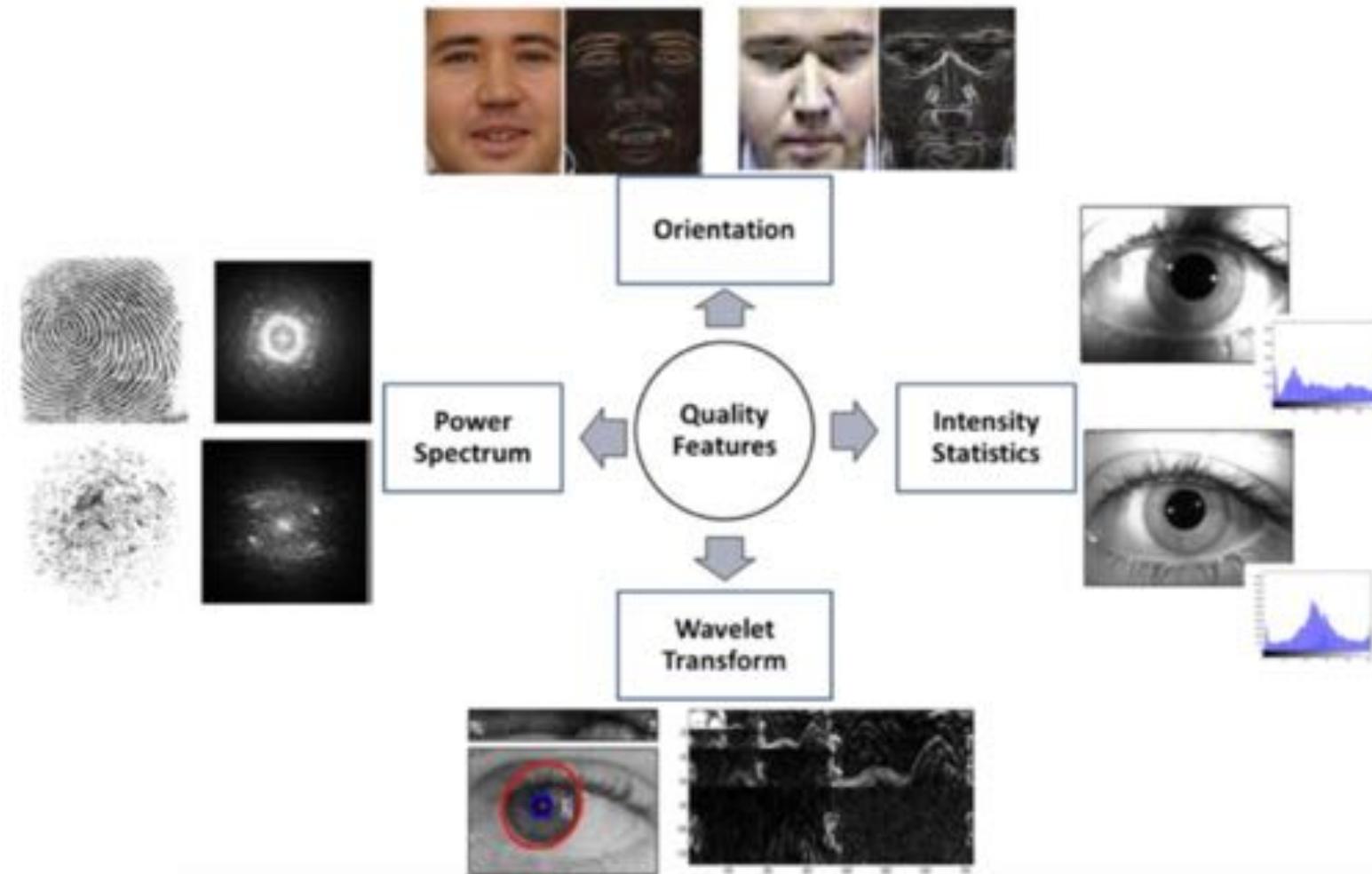
# Biometric Quality Assessment (BQA)

- Face: ID

Metric Quality	Compression Artifacts	Contrast	Focus	Facial Shadows
Good				
Poor				

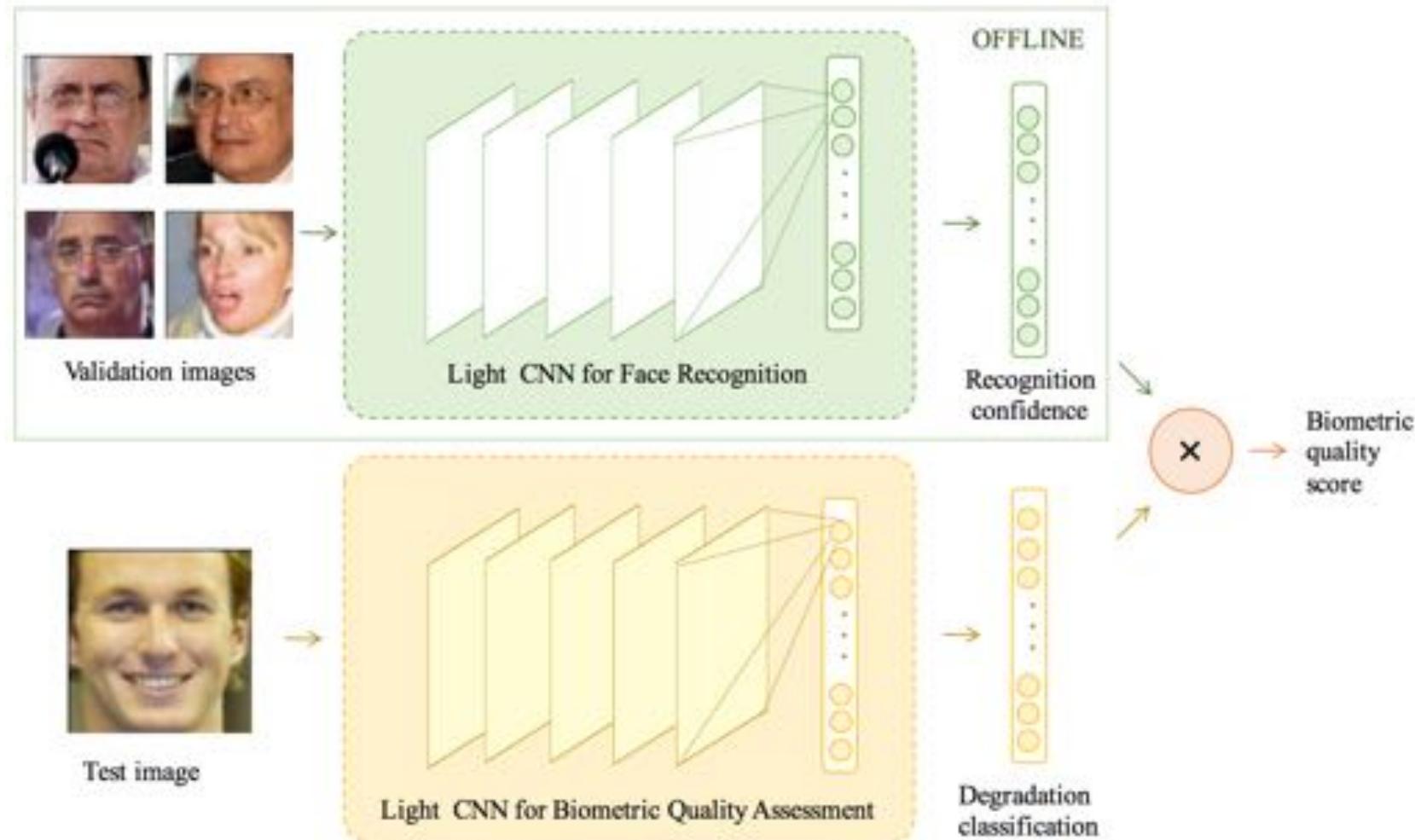
# Biometric Quality Assessment (BQA)

- Four primary image features for BQA



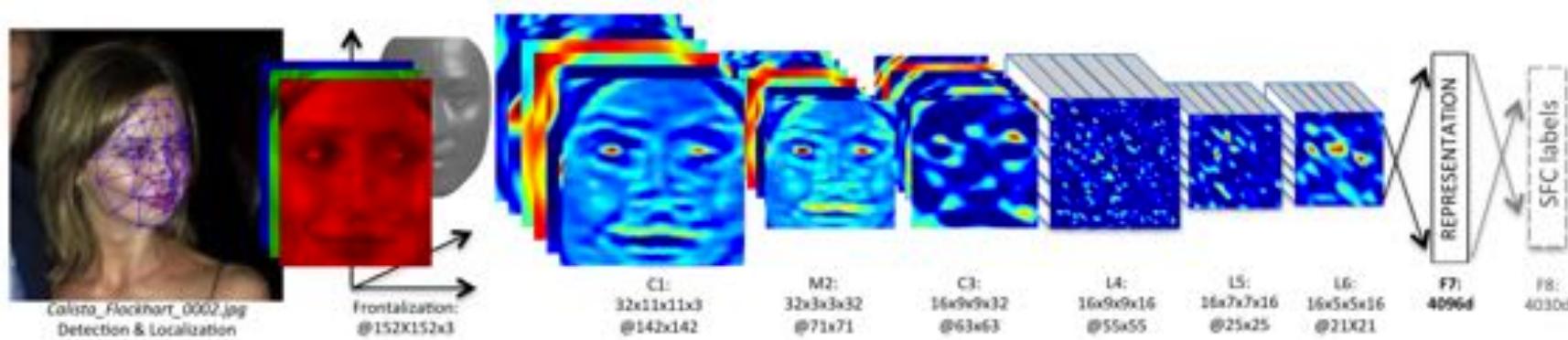
# Biometric Quality Assessment (BQA)

- BQA via LightCNN



# Biometric Quality Assessment (BQA)

- Face recognition/identification/verification

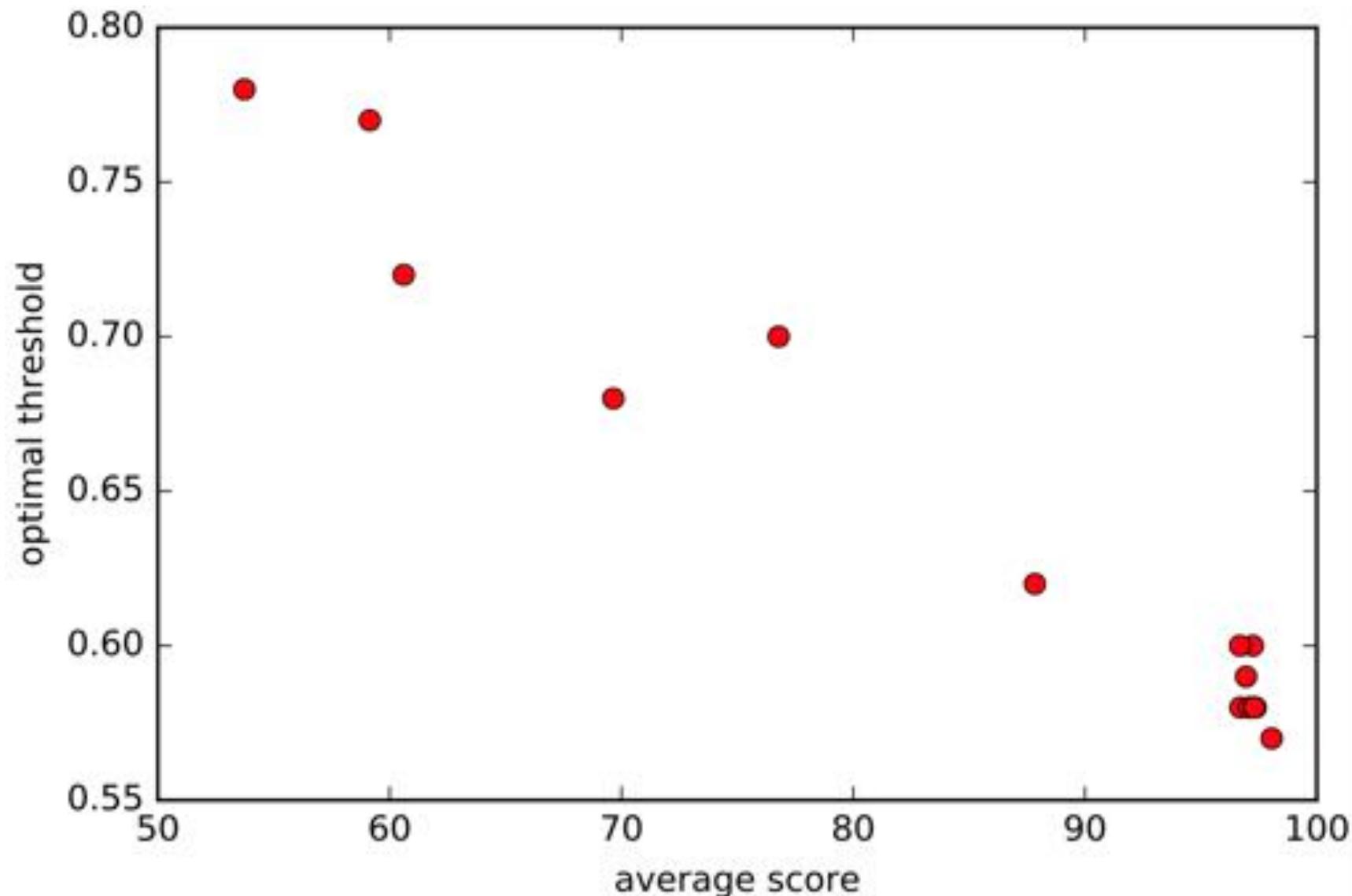


Outline of the *DeepFace* architecture.



Sigma	0	10	20	30	40	50
VGG-Face	0.79	0.74	0.62	0.43	0.28	0.22
AlexNet	0.61	0.54	0.33	0.22	0.16	0.13
GoogLeNet	0.78	0.77	0.57	0.42	0.28	0.18

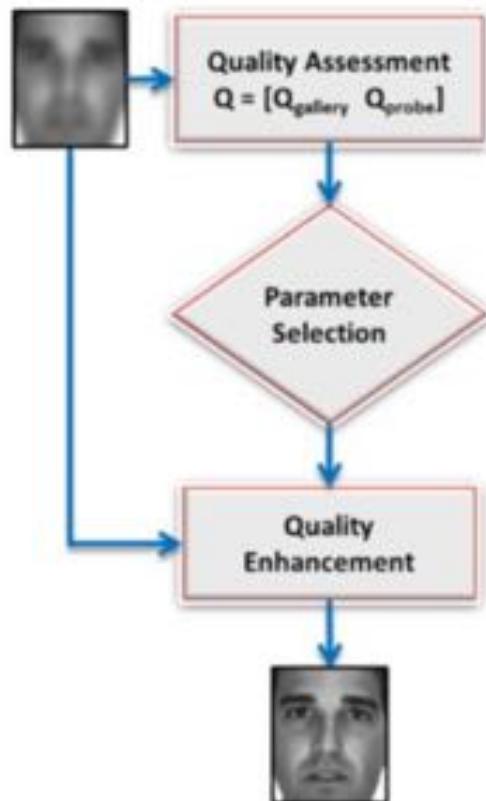
# Biometric Quality Assessment (BQA)



# Biometric Quality Assessment (BQA)

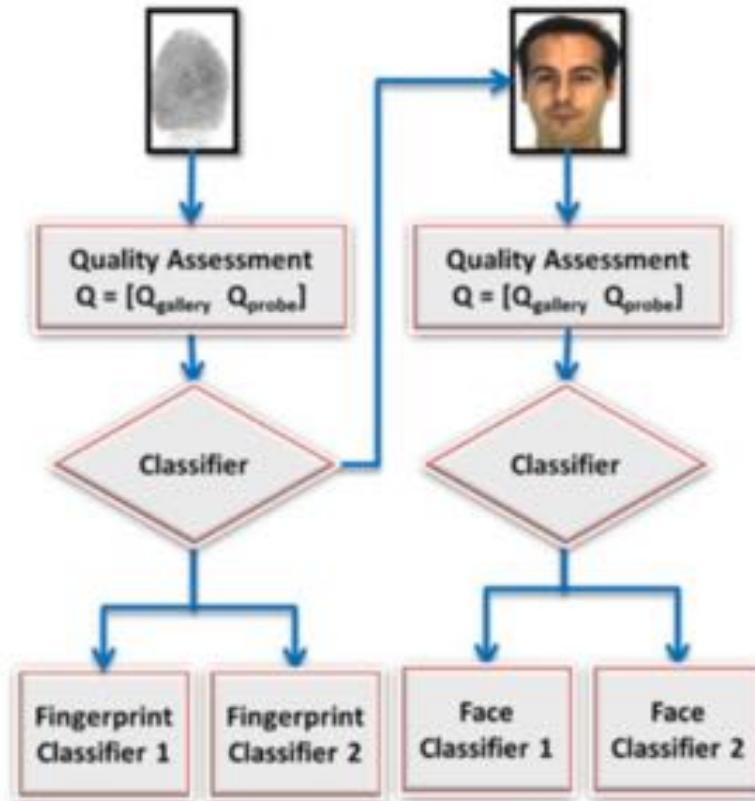
- Applications: Utilizing BQA for context switching

Quality Assessment based Enhancement



(a)

Quality based Multimodal Context Switching



(b)

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*Q & A*

*Thank You !*