Object features and face detection performance: Analyses with 3D-rendered synthetic data

Reporter: Jian Han

Background

Face related research is one of the most studied topics in computer vision.

Real-world scenarios still remain a challenge to face related application.

Variations like lighting condition, exaggerated expression, and extreme pose may degrade performance and hinder many practical applications.

Problem Formulation

Object features:

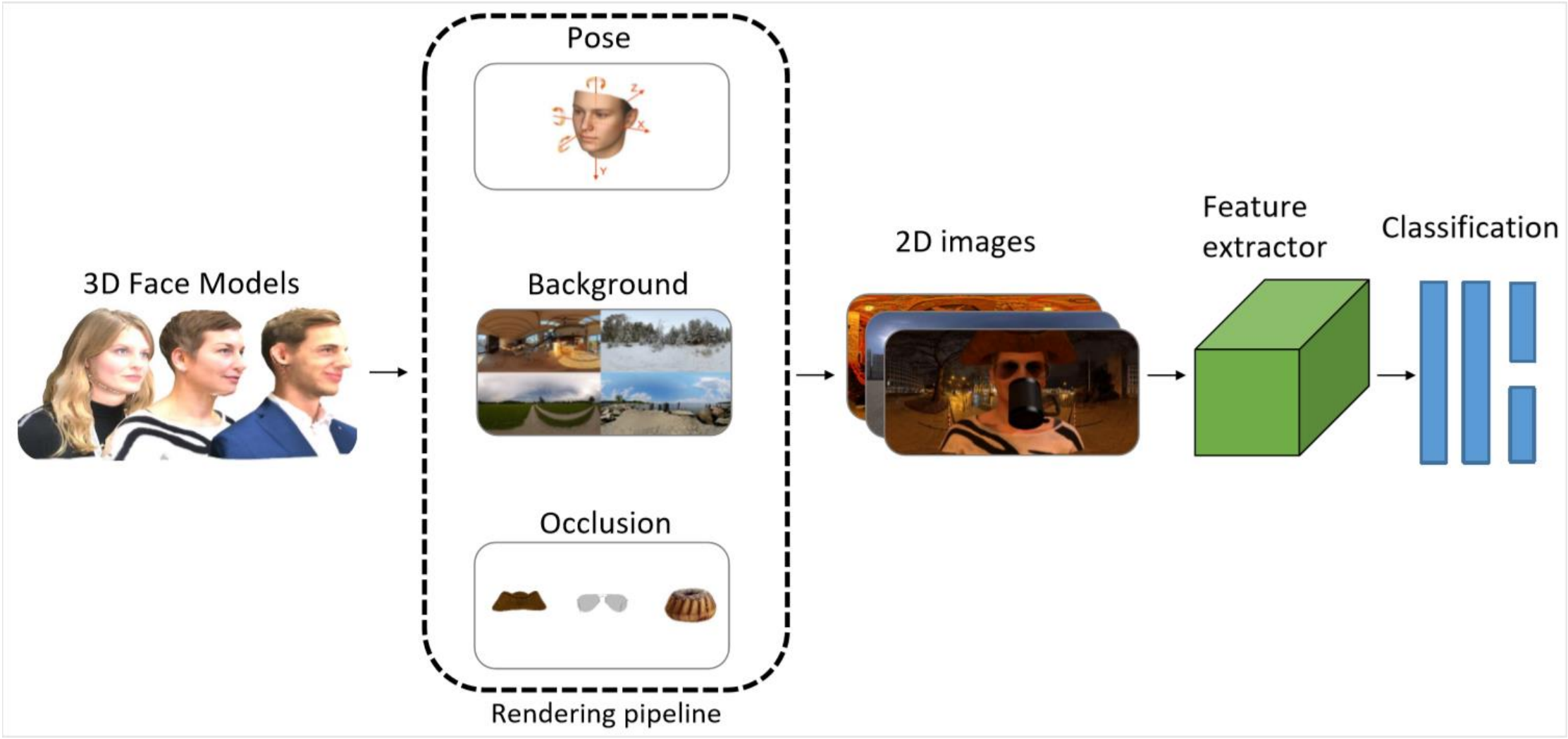
pose, scale, context, facial occlusion, blur, and low resolution

Face detector:

one-step face detector and two-step face detector

Face synthesis

Overview


Pose
3D Face Models
Background
2D images
Feature extractor
Classification
Occlusion
Rendering pipeline

Render pipeline

3D face models

Basic

pose(pitch, yaw, roll), scale, background (ShapeNet, ImageNet)
blending method, number of 2D images
number of 3D models, distribution of face size

Illumination

Energy, direction

Facial occlusion

landmark occlusion, heavy occlusion

Noise

Face Detection Experiment

Face detector: Hybrid Resolutions (HR)[1], Faster RCNN, Single Stage Headless (SSH)[2]

External Experiment

train on synthetic data or combination of synthetic data and real data

test on real data

Dataset: Wider(val), MAFA(test), UFDD(val)

1. Hu, Peiyun, and Deva Ramanan. Finding tiny faces. 2017.
2. Najibi M, Samangouei P, Chellappa R, et al. SSH: Single stage headless face detector. 2017.

Face Detectors vs Features

Feature \ Face Detector	HR	SSH	Faster RCNN
extreme pose	✓	✓	
complex background	✓	✓	✓
blurry	✓	✓	✓
landmark occlusion	✓	✓	✓
heavy occlusion	✓		
extreme illumination			
confounding factors			

Table 2: Difference face detectors vs different features

Hu, Peiyun, and Deva Ramanan. Finding tiny faces. 2017.
Najibi M, Samangouei P, Chellappa R, et al. SSH: Single stage headless face detector. 2017

Face Detection Dataset vs Features

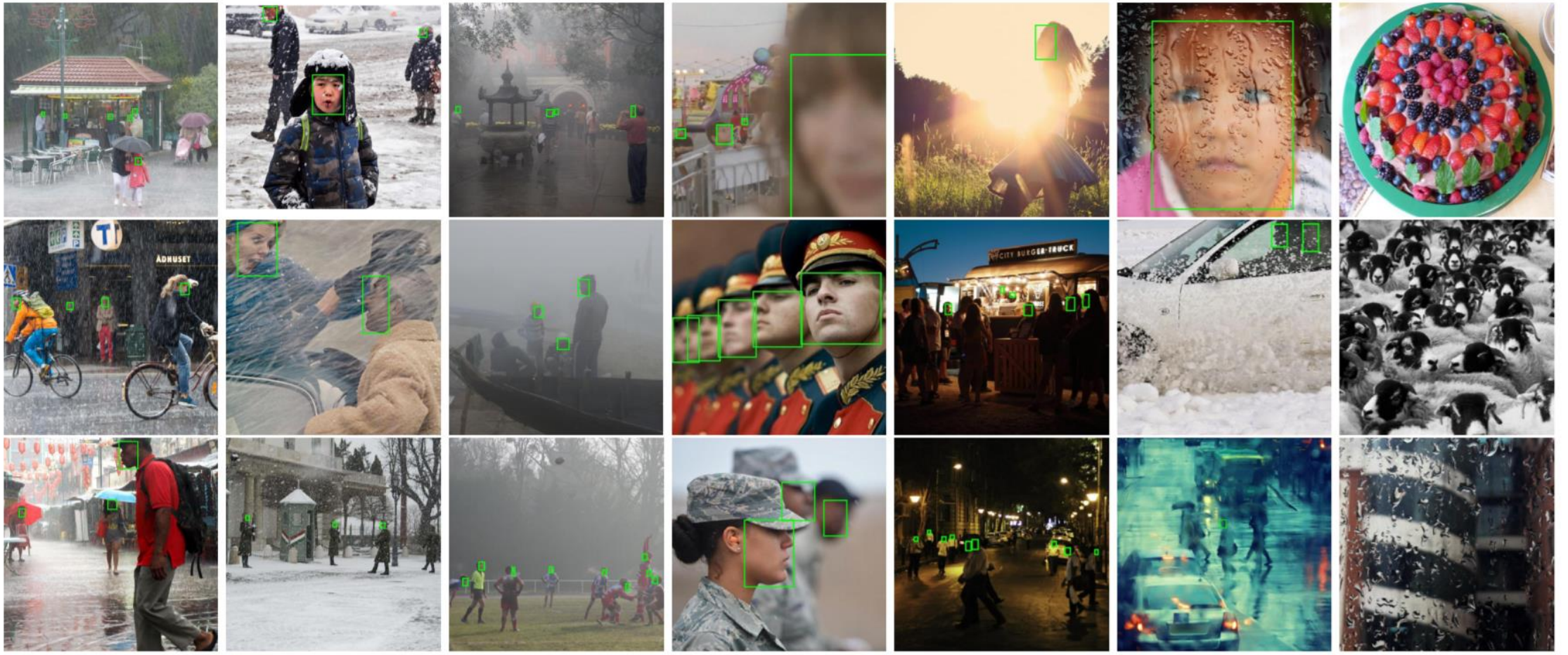
Feature \ Datasets	Wider	MAFA	UFDD
extreme pose	✓		
extreme scale	✓		✓
complex background	✓		
landmark occlusion	✓	✓	✓
heavy occlusion	✓	✓	
imbalanced distribution	✓	✓	
extreme illumination	✓		✓
blurry	✓	✓	✓
low resolution	✓	✓	✓

Table 1. Difference dataset vs different features

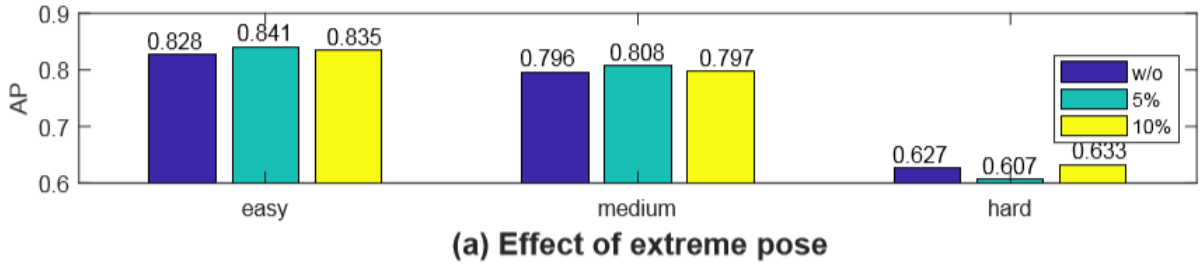
MAFA


Left
Left- frontal
Frontal
Right-frontal
Right
Weak Occlusion (1-2 regions)
Medium Occlusion (3 regions)
Heavy Occlusion (4 regions)

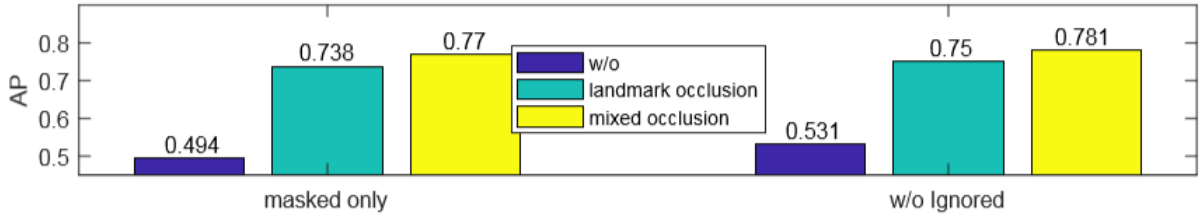
UFDD


Rain
Snow
Haze
Blur
Illumination
Lens impediments
Distractors

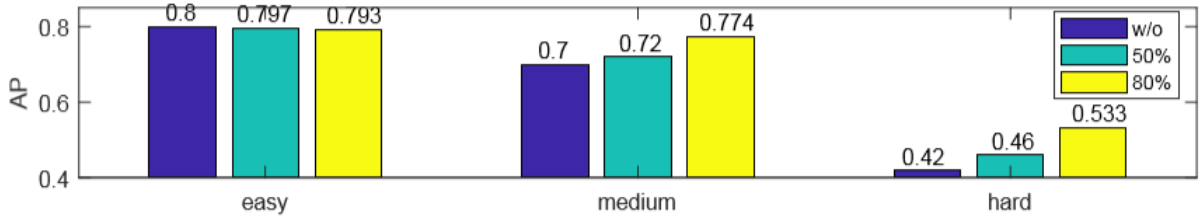
Evaluation on object features



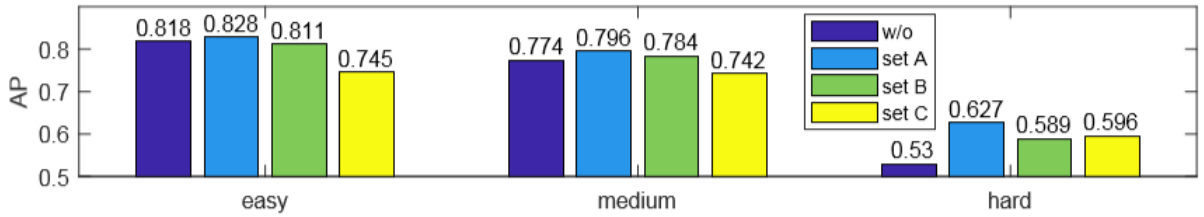
(a) Effect of extreme pose



(b) Effect of occlusion



(c) Effect of occlusion from face



(d) Effect of sampling noise

Evaluation on Wider Face

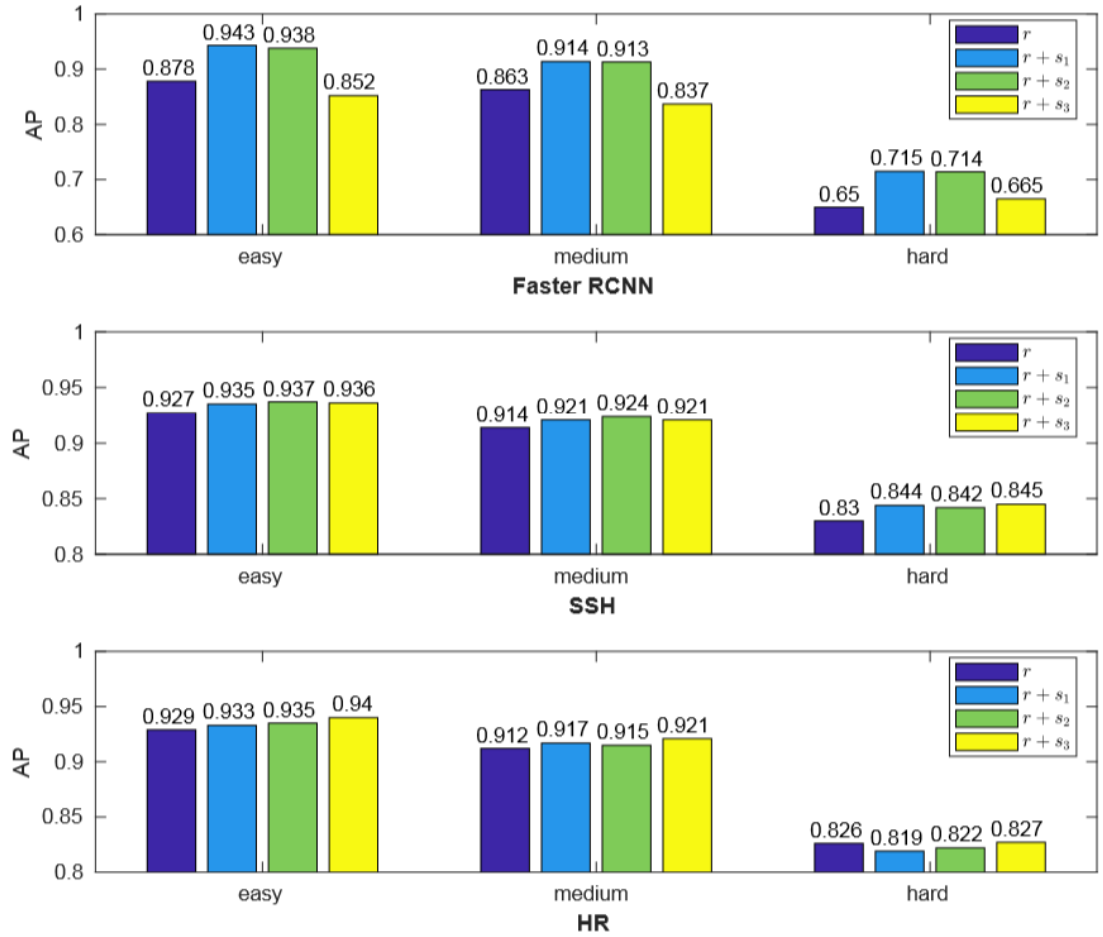
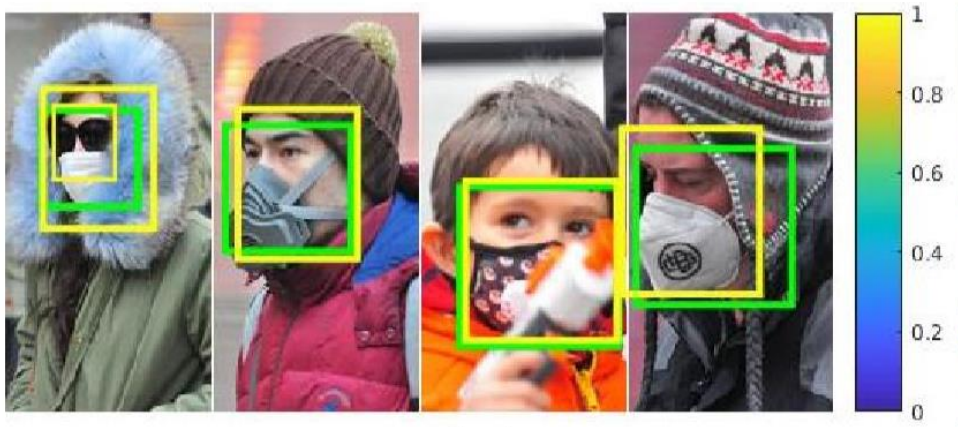


Fig. 5. Performance comparison on different data augmentations on Wider Face validation set with different detectors.

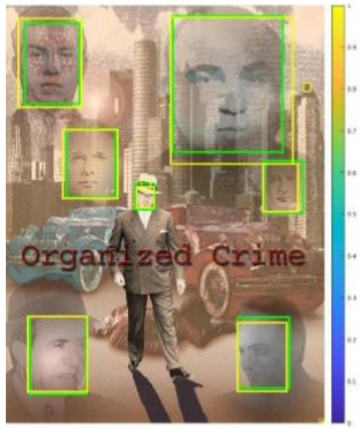
Visualizations on different features



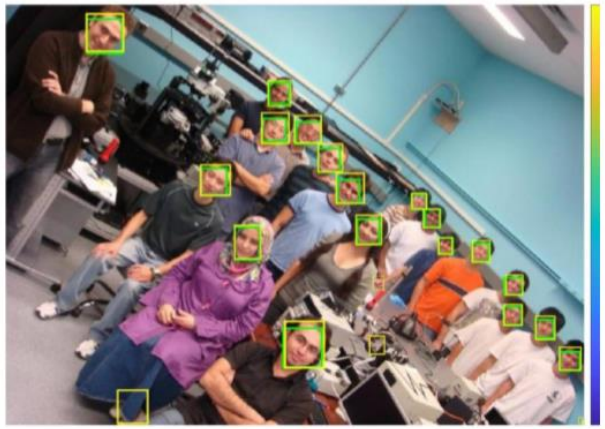
occlusion

illumination

expression



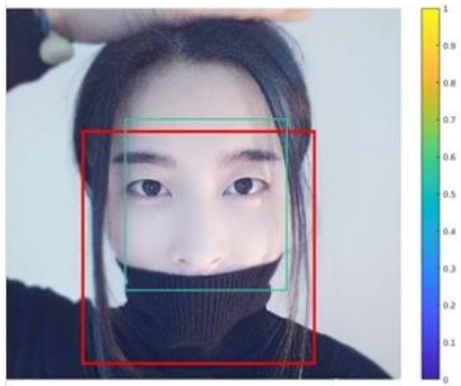
blur



pose

scale

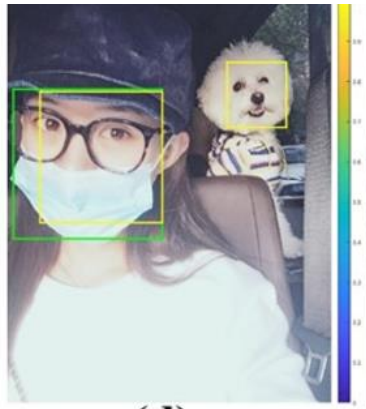
False positive examples



(a)

(b)

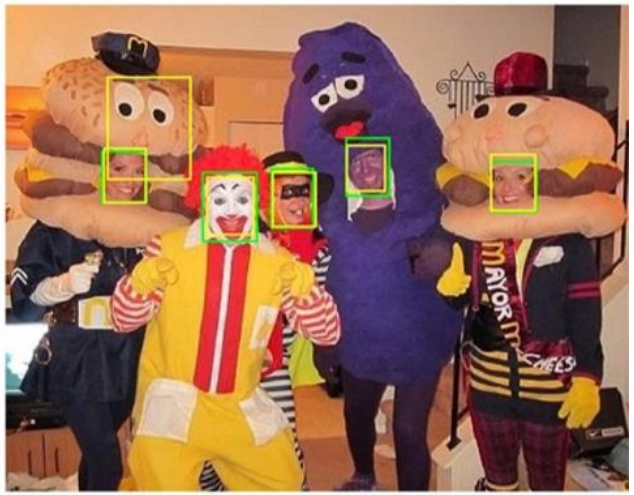
(c)



(d)

(e)

(f)



(g)

Conclusion

We provide a 2D face synthetic data generator with manipulated features (on pose, scale, background, illumination, and occlusion), which enables specified examinations of face detector performances.

We conducted detailed analyses between feature and performance, which can be a guide to compare performances of other face detectors.

Our analyses also reveal some weaknesses of the current face detectors and suggests using synthetic data for future improvement on robustness.

THANKS!