Real-Time Rotation-Invariant Face Detection with Progressive Calibration Networks

CVPR 2018

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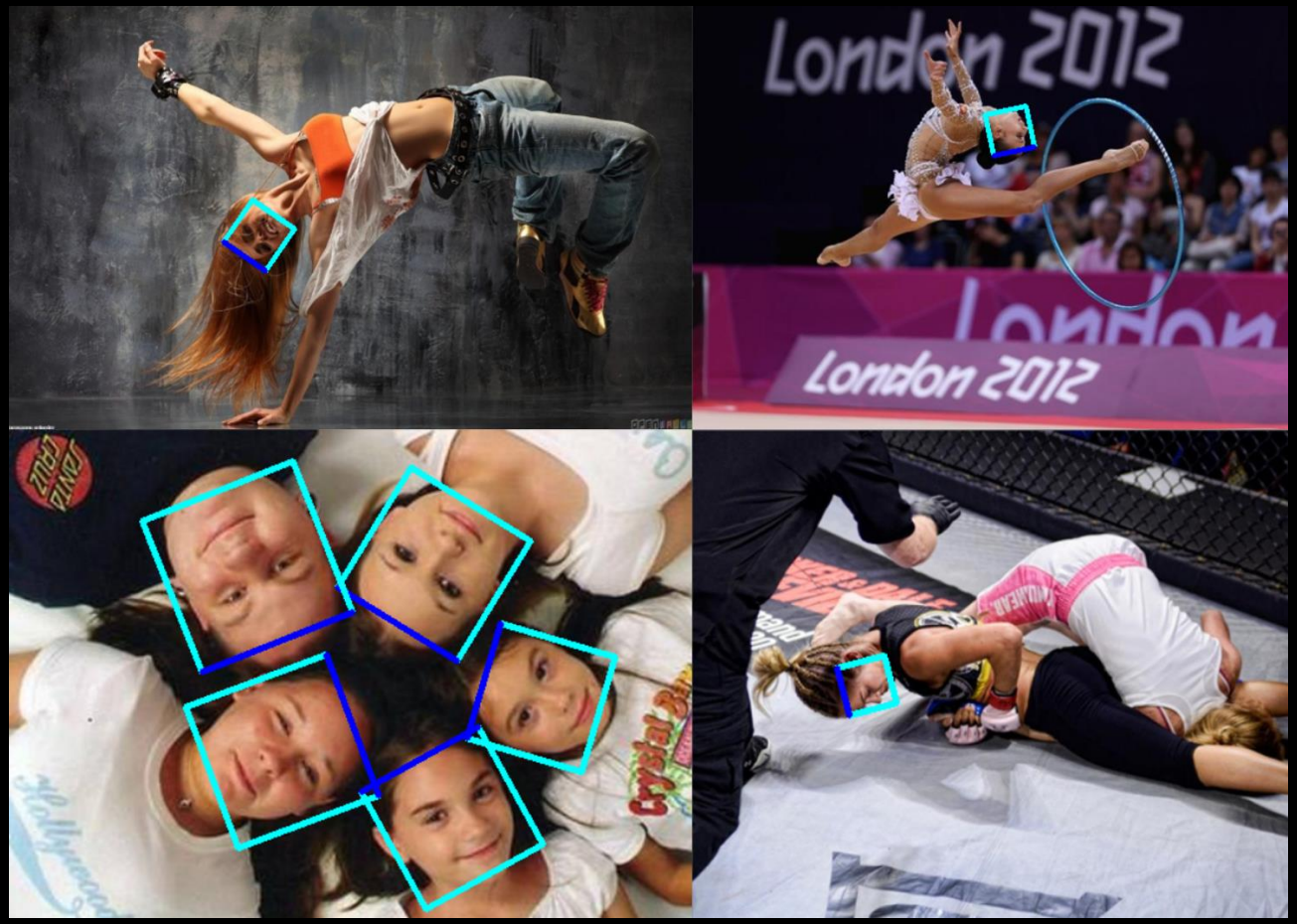
Rotation-Invariant Face Detection

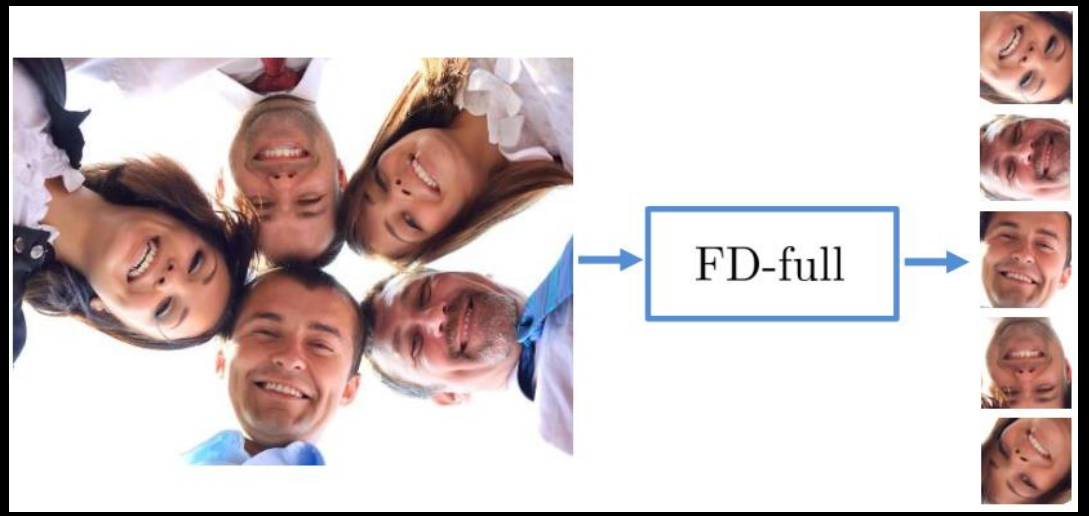
Full rotation-in-plane (RIP) angles

Large appearance variations



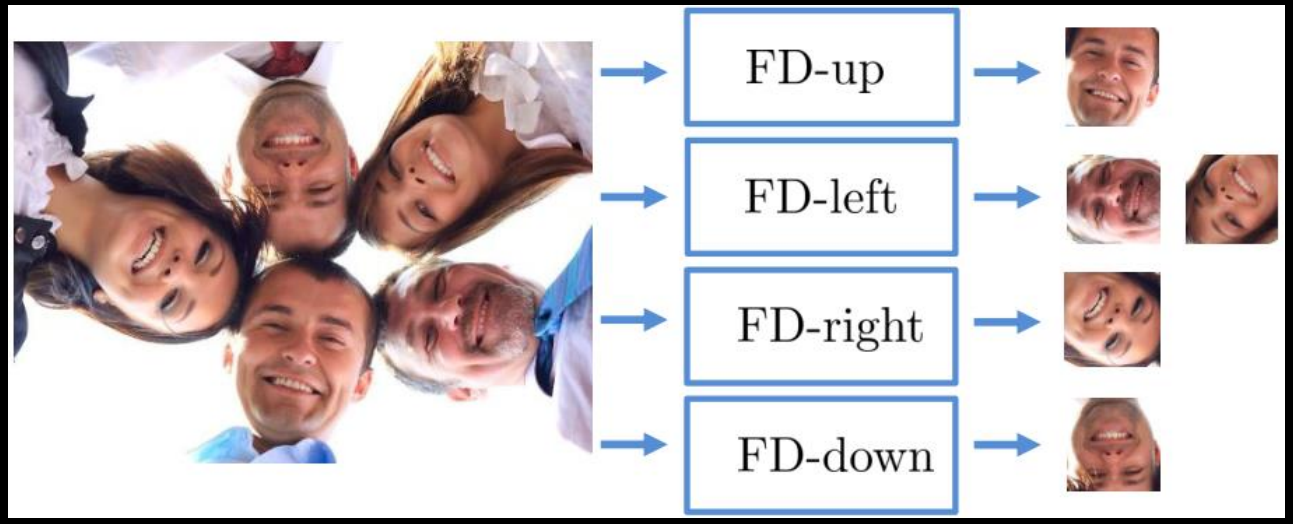
Existing Methods [1/3]

- Data Augmentation
  - To ensure the accuracy, a large neural network is usually required



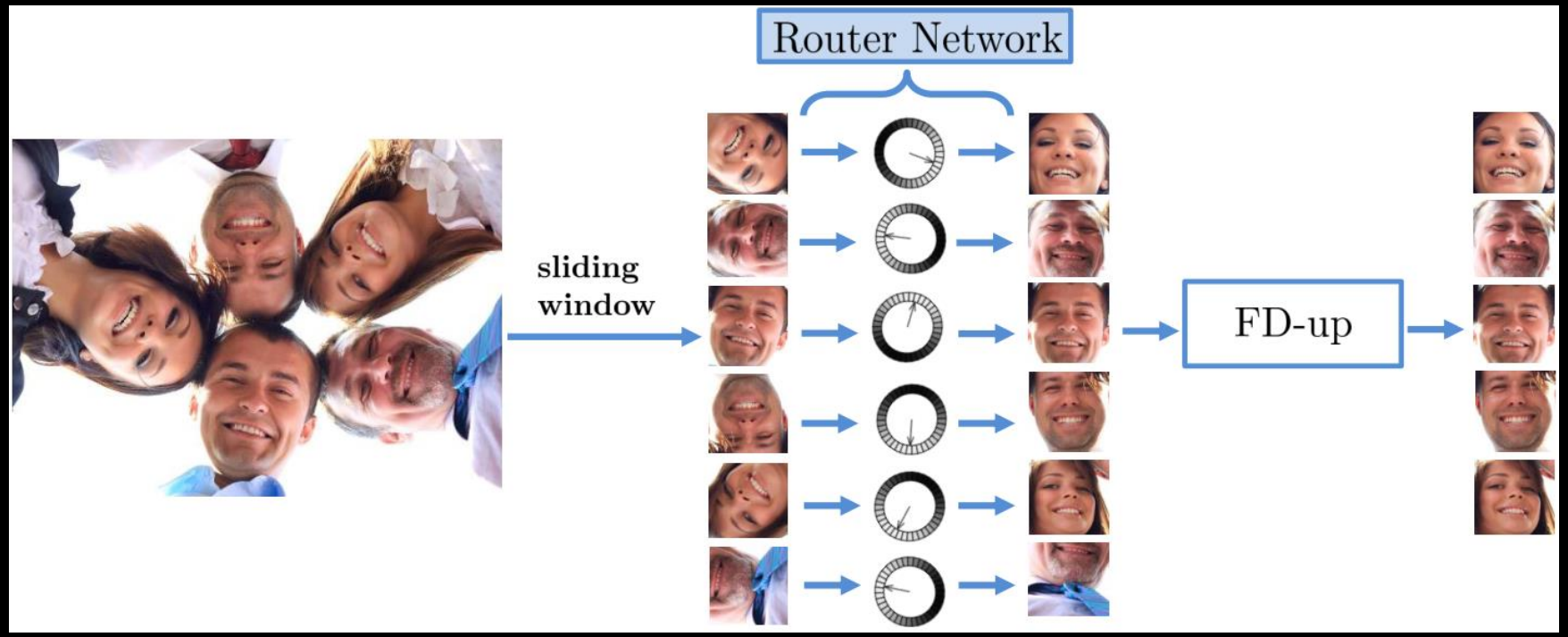
Existing Methods [2/3]

- Divide-and-Conquer [Huang, TPAMI 2007]
  - The overall time-cost largely increases
  - More false alarms are easily introduced



Existing Methods [3/3]

- Rotation Router [Rowley, CVPR 1998]
  - Precisely estimating the RIP angles of faces is quite challenging



Motivation and Goal

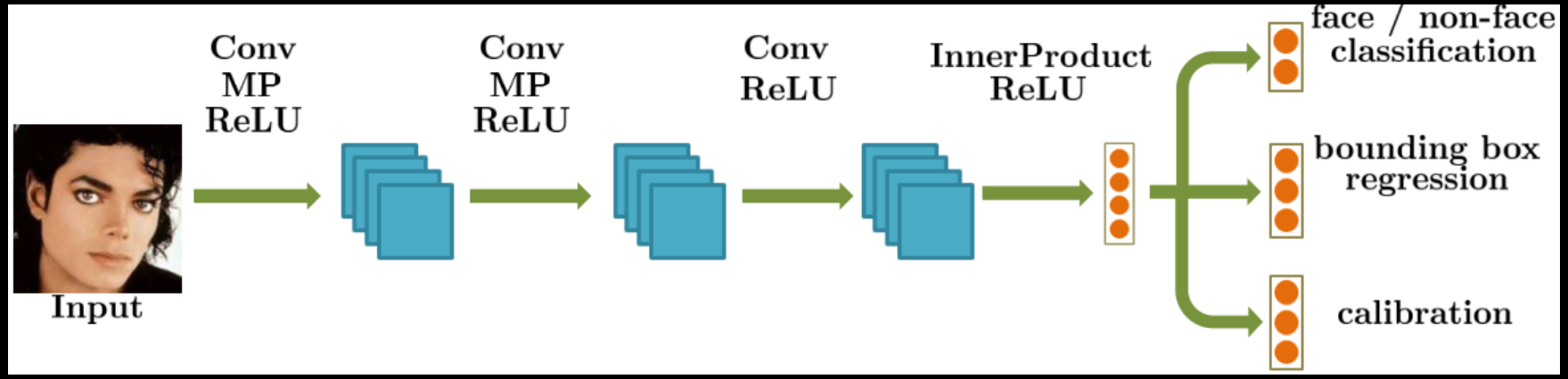
- Most existing methods compromise with speed or accuracy to handle the large RIP variations

- Our PCN aims at accurate rotation-invariant face detection with low time-cost

Progressive Calibration Networks [1/2]

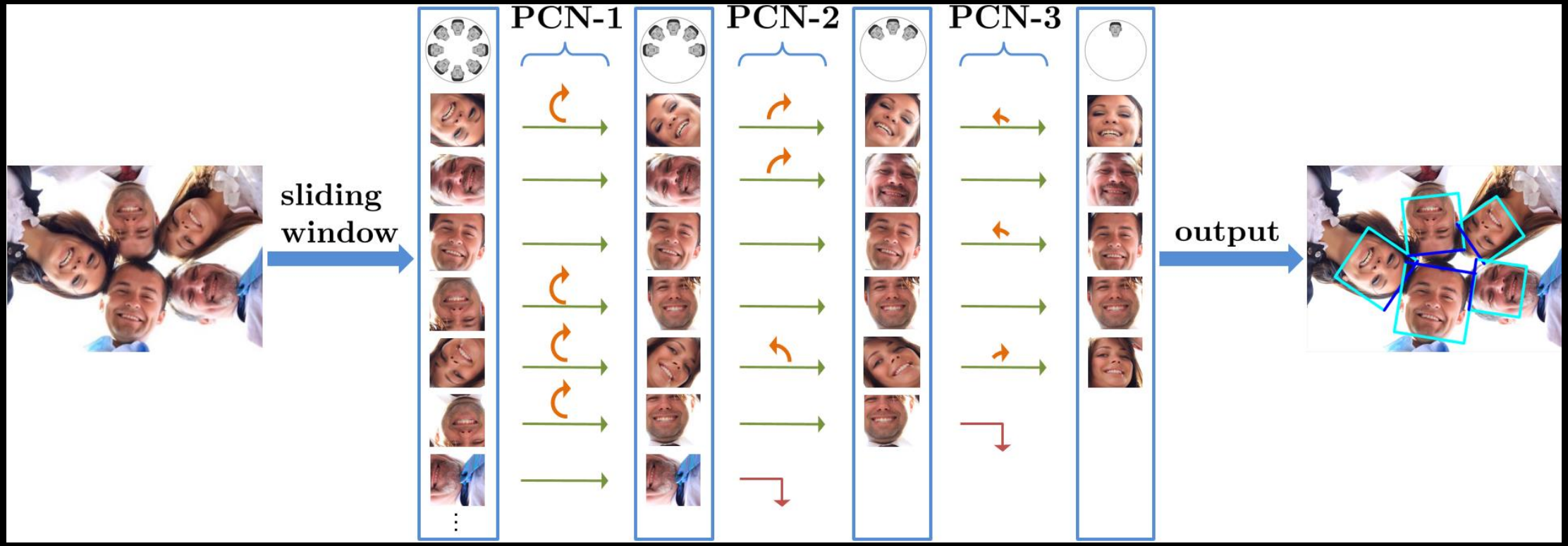
- A sequence of multi-task CNNs
  - Face / non-face classification + bounding box regression + calibration

$$\min_{F} L = L_{classification} + \lambda_{bbox\_reg} \cdot L_{bbox\_reg} + \lambda_{calibration} \cdot L_{calibration}$$



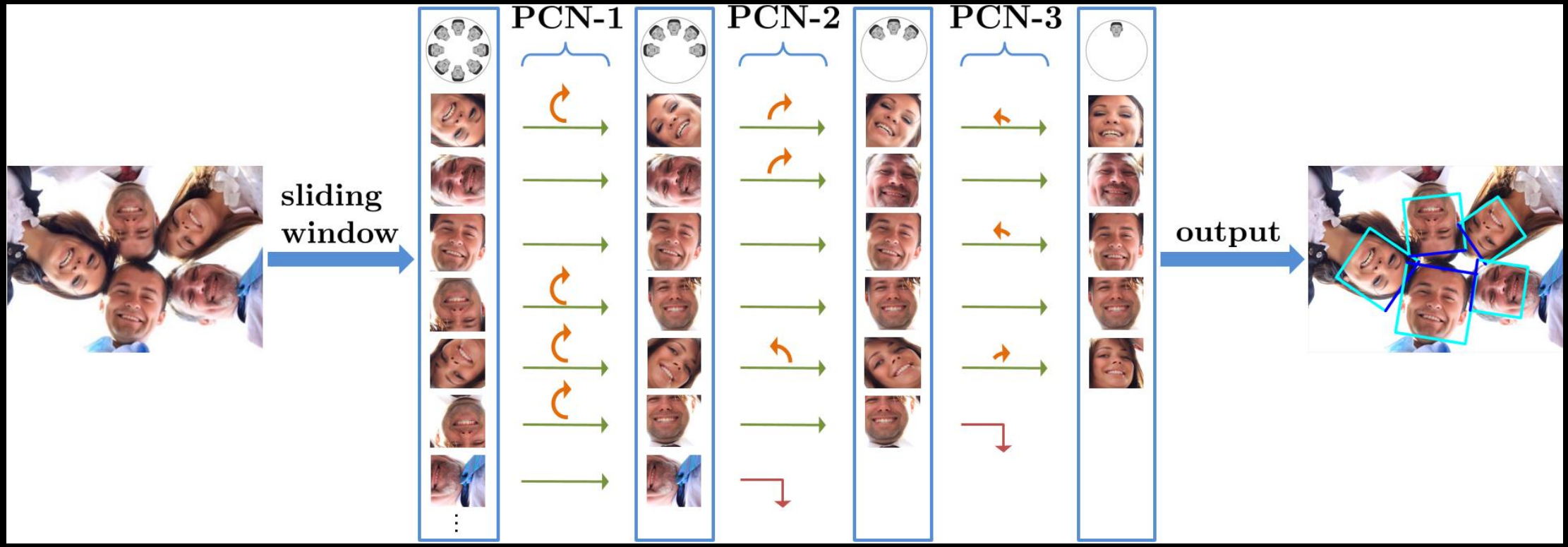
Progressive Calibration Networks [2/2]

- Calibrates the RIP orientation to upright progressively
- Only coarse calibrations are conducted in early stages



Two Cascade Structures in PCN [1/2]

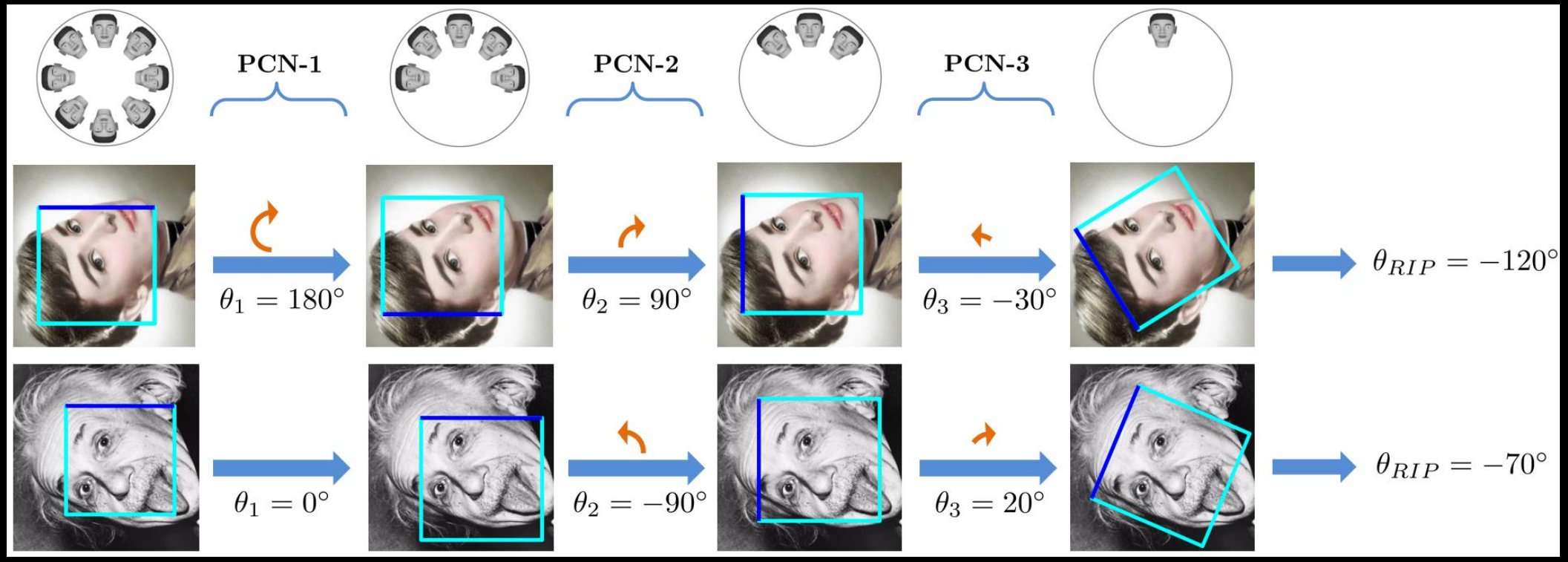
- Cascade classification [Li, CVPR 2015]
  - Significantly improve the speed of detection



Two Cascade Structures in PCN [2/2]

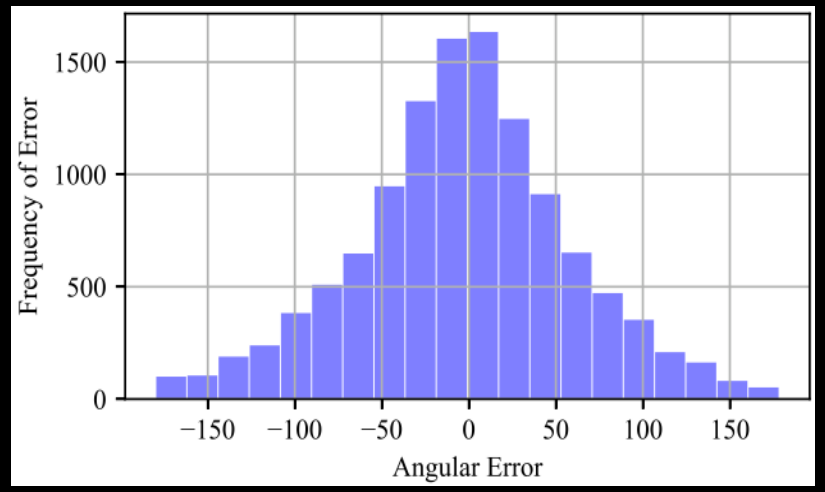
- Cascade calibration
  - Binary classification + ternary classification + regression

$$\theta_{RIP} = \theta_1 + \theta_2 + \theta_3, \theta_1 = 0°/180°, \theta_2 = -90°/0°/90°$$

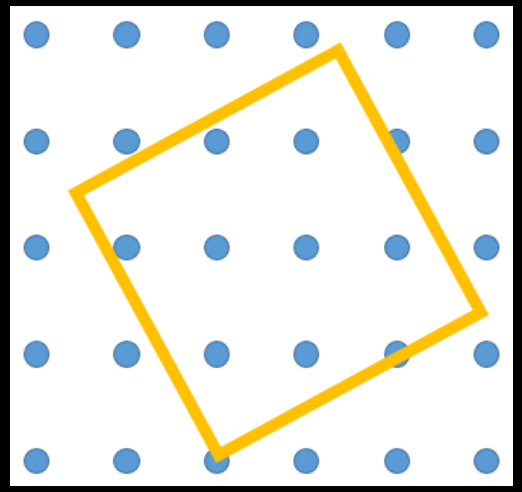


Cascade Calibration [1/2]

- Why cascade?
  - Easier
- Why coarse classification?
  - More accurate

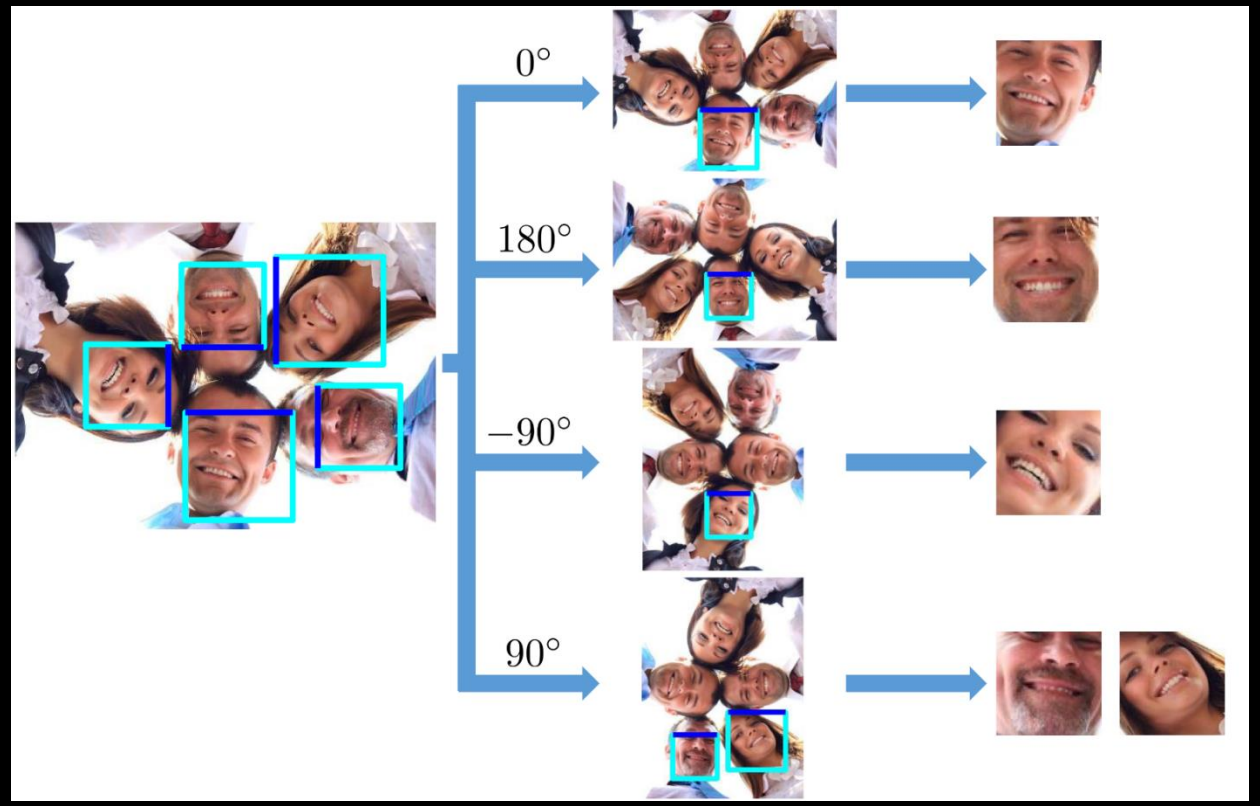


- More efficient
  (Interpolation VS Flipping)



Cascade Calibration [2/2]

- Flip original image three times in advance (1ms - 2ms)
- Reduce the time-cost of calibration dozens of times

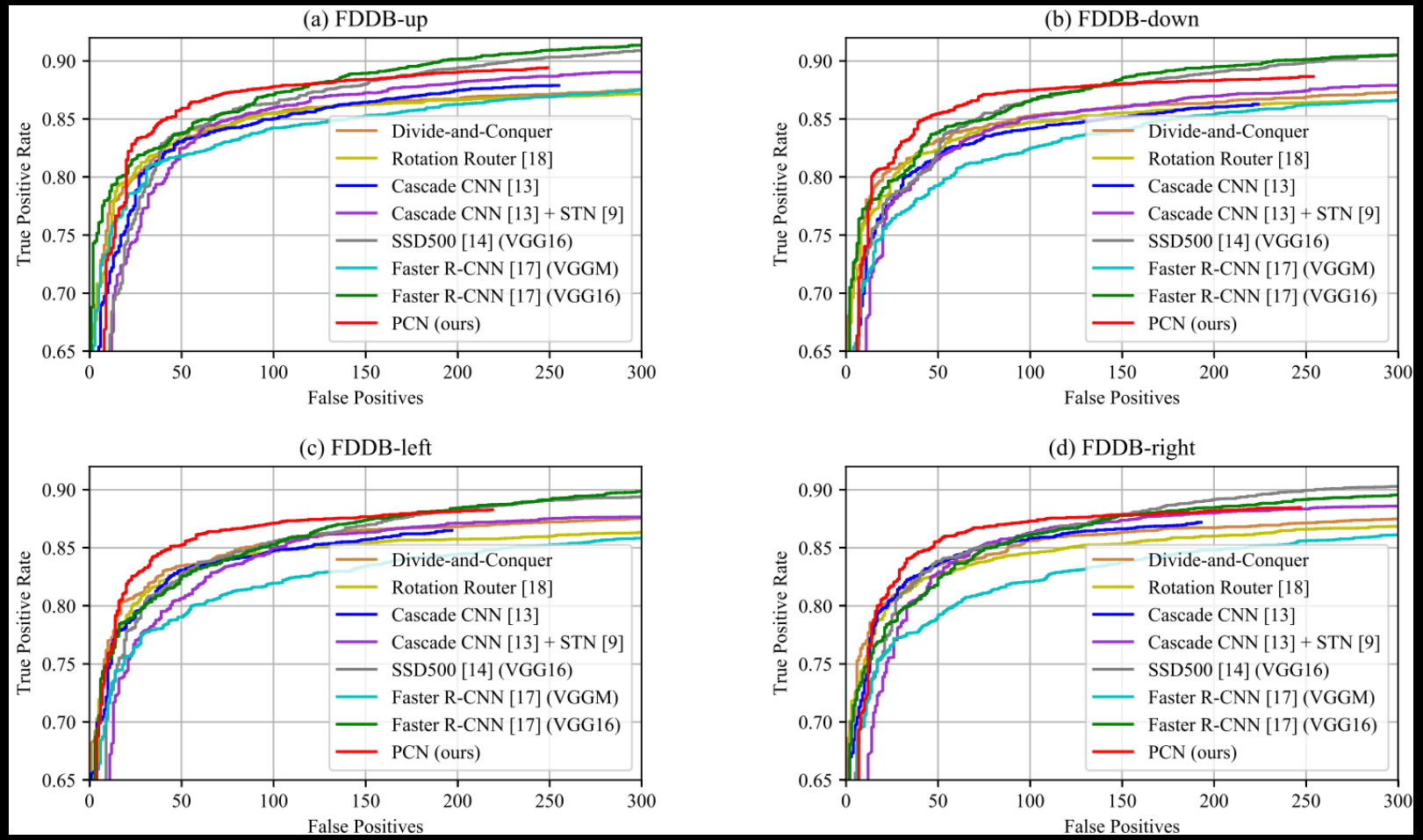


Methods for Comparison

- Data Augmentation
  - Faster RCNN (VGGM, VGG16)
  - SSD500 (VGG16)
  - RFCN (ResNet-50)
  - Cascade CNN
- Divide-and-Conquer
- Rotation Router

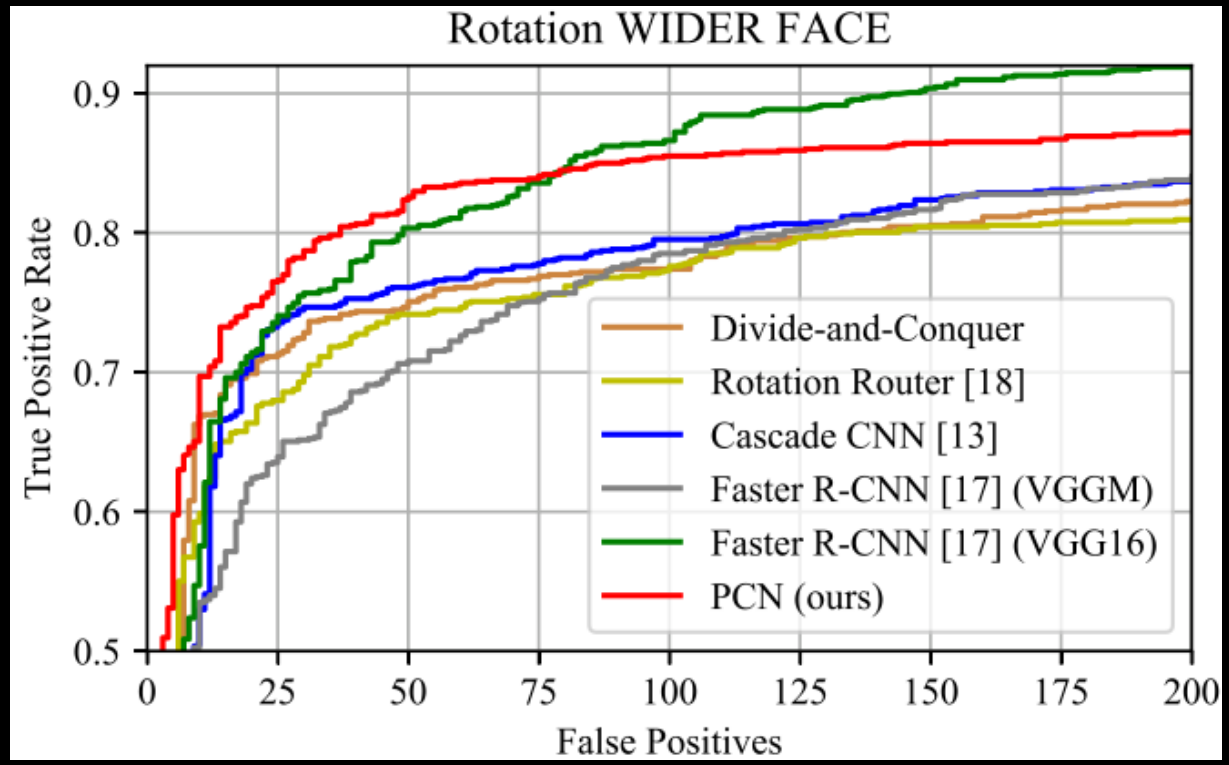
Results [1/3]

- Rotate the FDDB images by -90°, 90°, and 180°respectively



Results [2/3]

- A subset of the WIDER FACE test set containing rotated faces



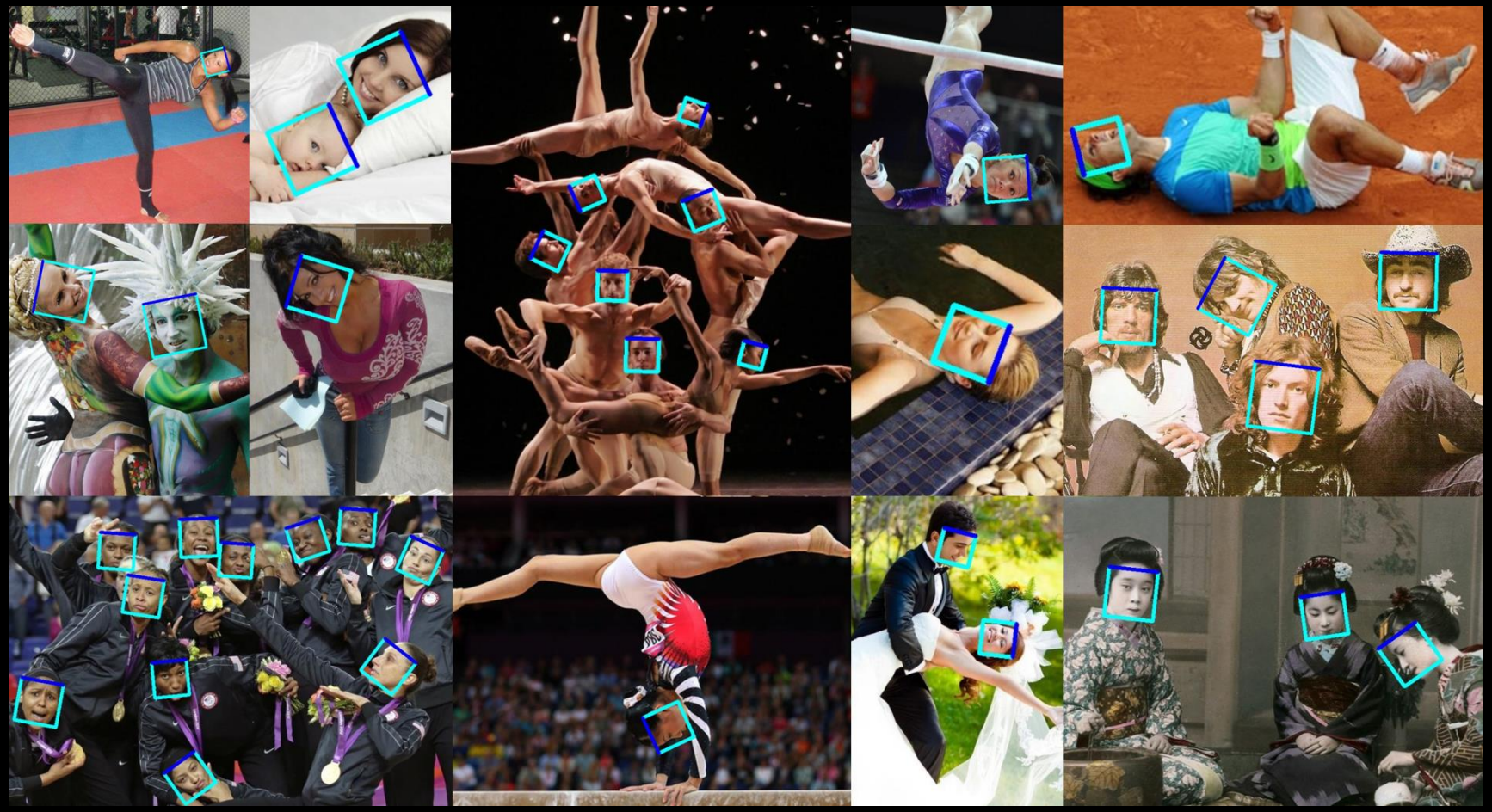
Results [3/3]

- 640×480 VGA images with 40×40 minimum face size
- A desktop computer with 3.4GHz CPU, GTX Titan X
- PCN can run in real-time on both CPU and GPU

Method	Recall rate at 100 FP on FDDB					Speed		Model Size
	Up	Down	Left	Right	Ave	CPU	GPU	
Divide-and-Conquer	85.5	85.2	85.5	85.6	85.5	15FPS	20FPS	**2.2M**
Rotation Router [18]	85.4	84.7	84.6	84.5	84.8	12FPS	15FPS	2.5M
Cascade CNN [13]	85.0	84.2	84.7	85.8	84.9	**31FPS**	**67FPS**	4.2M
Cascade CNN [13] + STN [9]	85.8	85.0	84.9	86.2	85.5	16FPS	30FPS	4.7M
SSD500 [14] (VGG16)	86.3	86.5	85.5	86.1	86.1	1FPS	20FPS	95M
Faster R-CNN [17] (VGGM)	84.2	82.5	81.9	82.1	82.7	1FPS	20FPS	350M
Faster R-CNN [17] (VGG16)	87.0	86.5	85.2	86.1	86.2	0.5FPS	10FPS	547M
R-FCN [2] (ResNet-50)	87.1	86.6	85.9	86.0	86.4	0.8FPS	15FPS	123M
PCN (ours)	**87.8**	**87.5**	**87.1**	**87.3**	**87.4**	29FPS	63FPS	4.2M

Progressive Calibration Networks

- Fast, accurate, robust



Thanks!