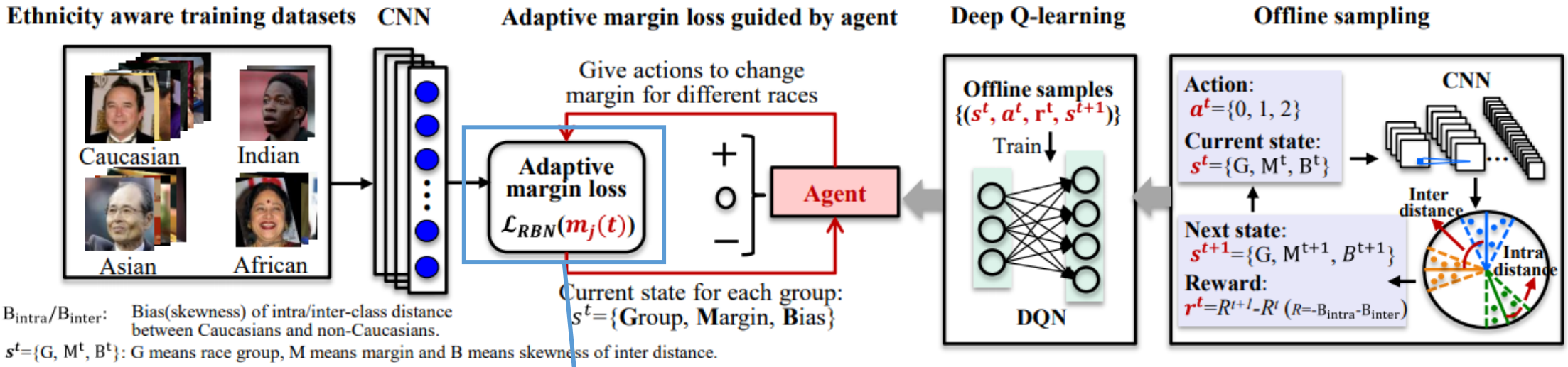
Fairness

: 얼굴 인식의 공정성에 대한 연구 조사

염지현

[18] Mitigating bias in face recognition using skewness-aware



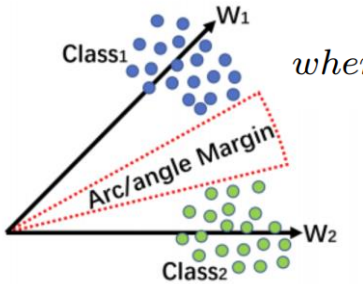
Positive pair: $y^{(j)}$ label(ID)과 $y^{(j)}$에 속하는 deep feature j 간 cosine 유사도

$$L_{RBN} = -\frac{1}{N}\sum_{j=1}^{N} log \frac{e^{s_c\left(cos\left(\theta_{y^{(j)}\,j}+\alpha_j(t)\right)\right)}}{e^{s_c\left(cos\left(\theta_{y^{(j)}\,j}+\alpha_j(t)\right)\right)} + \sum_{i=1,i\neq y^{(j)}}^{n} e^{s_c cos\theta_{ij}}}$$

Negative pair

$$where, \alpha_j(t) = \begin{cases} m, & if\ j \in Caucasian \\ m_j(t), & otherwise \end{cases}$$

학습하고자 하는 것!



(a) ArcFace

Mei Wang and Weihong Deng. Mitigating bias in face recognition using skewness-aware reinforcement learning. In IEEE Conf. Comput. Vis. Pattern Recog., pages 9322–9331, 2020.

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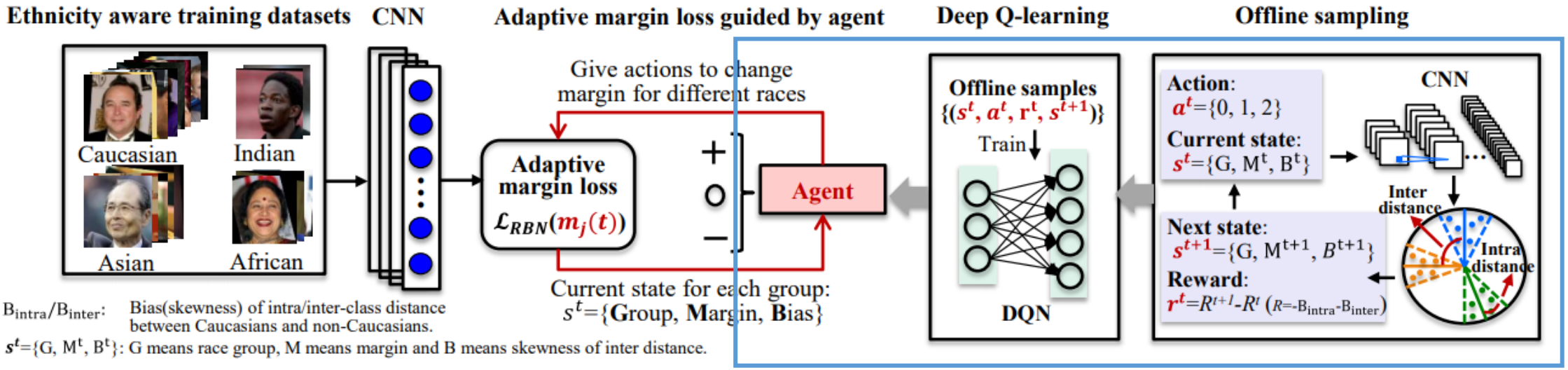

Margin을 결정하는 reinforcement learning

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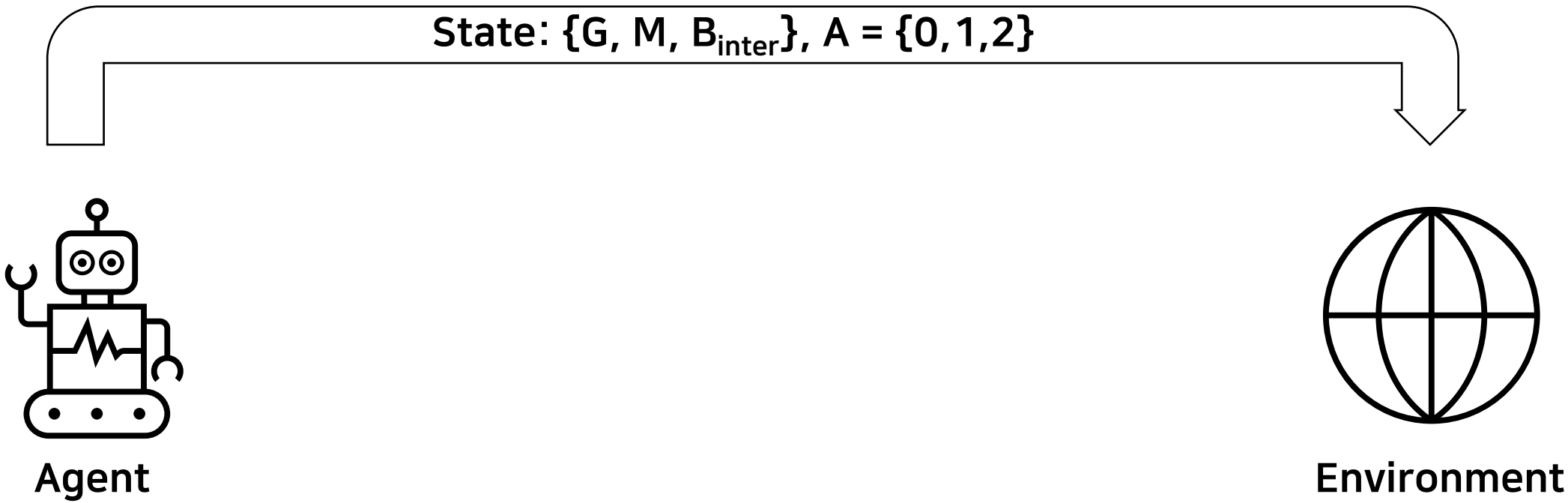

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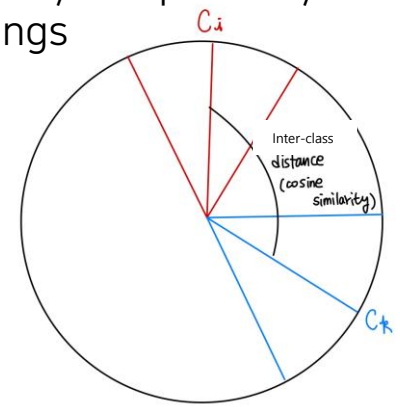
State: {G, M, B_{inter}}, A = {0,1,2}

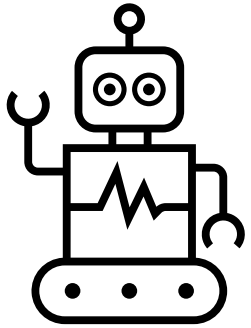
G: race
M: margin
B_{inter}: g-th group와 백인 사이 inter-class distance bias

$$B_{inter} = \left| d^{g}_{inter} - d^{Cau}_{inter} \right|$$

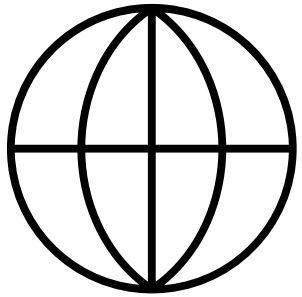
$$where,\ d^{g}_{inter} = \frac{1}{N_g} \sum_{i=1}^{N_g} \max_{k=1:N_g, k \neq i} cos(c_k, c_i)$$

c_i: feature centre of i-th identity computed by the mean vector of embeddings





Agent



Environment

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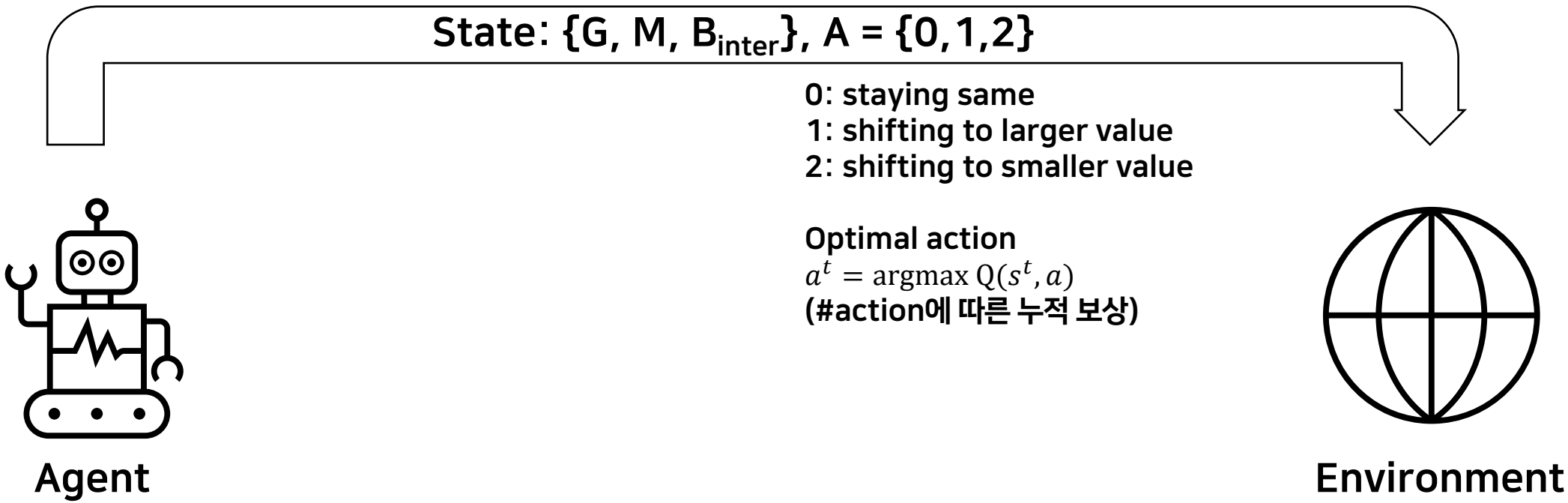

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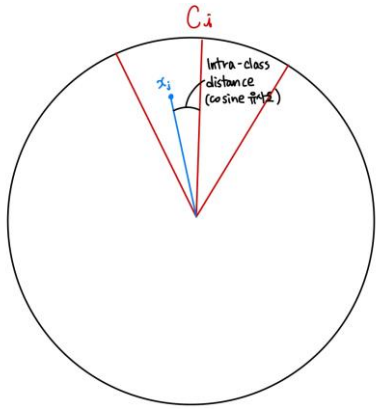
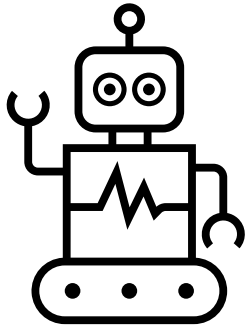




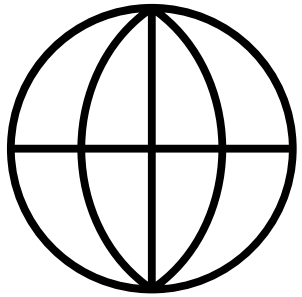
Agent

$$B_{intra} = \left| d^{g}_{intra} - d^{Cau}_{intra} \right|$$

$$where,\ d^{g}_{intra} = \frac{1}{N_g} \sum_{i=1}^{N_g} \frac{1}{|\mathcal{I}_i|} \sum_{x_j \in \mathcal{I}_i} cos(x_j, c_i)$$

$$r(s^t, a^t) = R^{t+1} - R^t$$

$$where,\ R = -\left(B_{inter} + B_{intra}\right)$$



Environment

B_{inter}, B_{intra} 값이 감소할수록 보상 증가

Reward: $r(s^t, a^t) = R^{t+1} - R^t$, Next state: s^{t+1}

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Test→ Train↓	Method↓	Caucasian	Indian	Asian	African	Avg	Fairness STD	Fairness SER
$4:2:2:2$	N-Softmax [46]	89.67	87.97	84.68	84.17	86.62	**2.64**	**1.53**
	RL-RBN(soft)	91.35	90.77	89.87	90.13	90.53	**0.66**	**1.17**
$5:\frac{5}{3}:\frac{5}{3}:\frac{5}{3}$	N-Softmax [46]	89.88	88.52	85.13	83.42	86.74	**2.98**	**1.64**
	RL-RBN(soft)	90.33	90.23	88.97	89.37	89.73	**0.67**	**1.22**
$6:\frac{4}{3}:\frac{4}{3}:\frac{4}{3}$	N-Softmax [46]	90.43	88.32	84.75	83.32	86.70	**3.26**	**1.74**
	RL-RBN(soft)	90.17	90.02	87.67	88.27	89.03	**1.25**	**1.25**
$7:1:1:1$	N-Softmax [46]	90.67	87.77	84.37	82.97	86.44	**3.46**	**1.83**
	RL-RBN(soft)	90.63	90.73	87.72	87.53	89.15	**1.77**	**1.35**

Table 2. Verification accuracy (%) on RFW [49] trained with varying racial distribution. We boldface STD (lower is better) and skewed error ratio (SER) (1 is the best) since this is the important fairness criterion.

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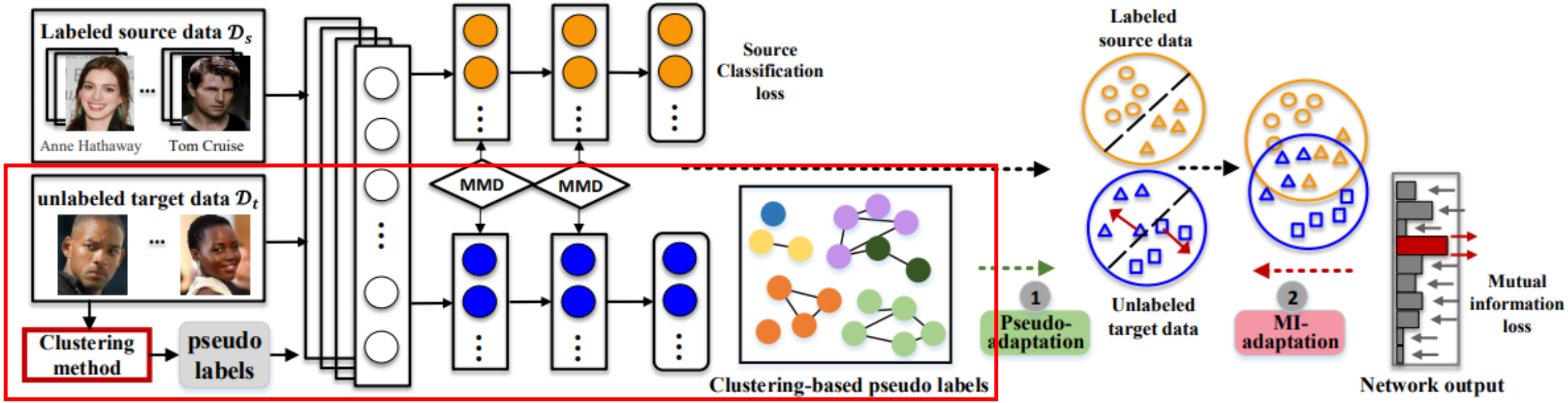
[19] Racial faces in the wild: Reducing racial bias by information maximization adaptation network



Label이 없는 유색인종 이미지(target data)로부터 feature map 추출 후,
이미지별 cosine 유사도를 비교하여,

$$e(n_i, n_j) = \begin{cases} 1, & if\ s(i,j) > \lambda \\ 0, & otherwise \end{cases}$$

다음 식을 바탕으로 그래프 생성 ➔ 하나의 ID 생성 및 부여

Mei Wang, Weihong Deng, Jiani Hu, Xunqiang Tao, and Yaohai Huang. Racial faces in the wild: Reducing racial bias by information maximization adaptation network. In IEEE Conf. Comput. Vis. Pattern Recog., pages 692–702, 2019.

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- UDA(Unsupervised Domain Adaptation)

- UDA 알고리즘 착안한 이유(추측)
  - ID가 없는 FACE도 인식할 수 있도록 하기 위해
  - 백인 얼굴 인식 시, Convolution layer마다 얼굴 인식에서 불변하는 특징을 잡아내는 것이 핵심
    → Source domain, target domain 가중치를 공유함으로써 백인 얼굴 인식에서 불변하는 특징을 잘 잡아내는 가중치를 다른 인종에서도 동일하게 사용하여 인종 편향 감소

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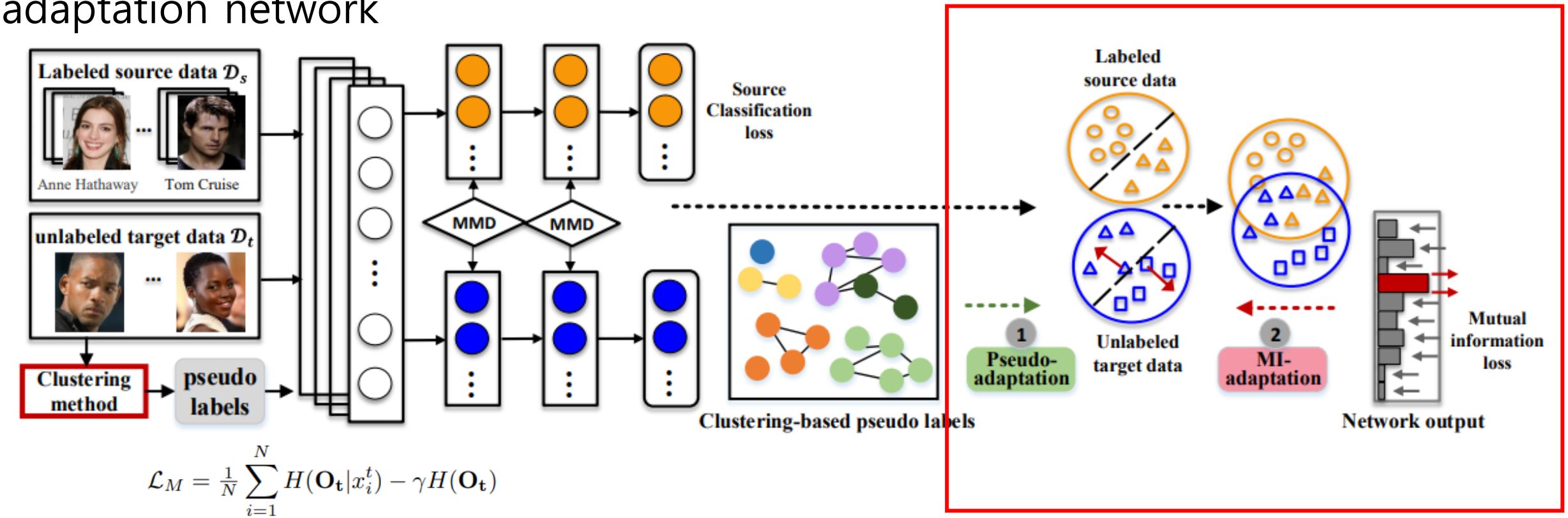

$$\mathcal{L}_M = \frac{1}{N}\sum_{i=1}^{N} H(\mathbf{O_t}|x_i^t) - \gamma H(\mathbf{O_t})$$

$$= \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{N_C} p(o_j^t|x_i^t) log p(o_j^t|x_i^t) - \gamma \sum_{j=1}^{N_C} p(o_j^t) log p(o_j^t)$$

$$= \sum_{i=1}^{N}\sum_{j=1}^{N_C} p(x_i^t) p(o_j^t|x_i^t) log p(o_j^t|x_i^t) - \gamma \sum_{j=1}^{N_C} p(o_j^t) log p(o_j^t)$$

$$= H\left[\mathbf{O_t}|\mathbf{X_t}\right] - \gamma H\left[\mathbf{O_t}\right] \approx -I(\mathbf{X_t};\mathbf{O_t})$$

Target image 예측 시,
이상적인 조건부 분포: $p(O_t|x_i^t) = [0, 0, \ldots, 1, 0, 0]$와 같이 한 클래스의 출력을 확대하는 것이 목표
→ 모든 target image에 대해 비슷한 확률 분포가 나오길 바람
→ 엔트로피 관점에서 봤을 때 사건마다 확률 분포가 같을 때 가장 큰 엔트로피 출력

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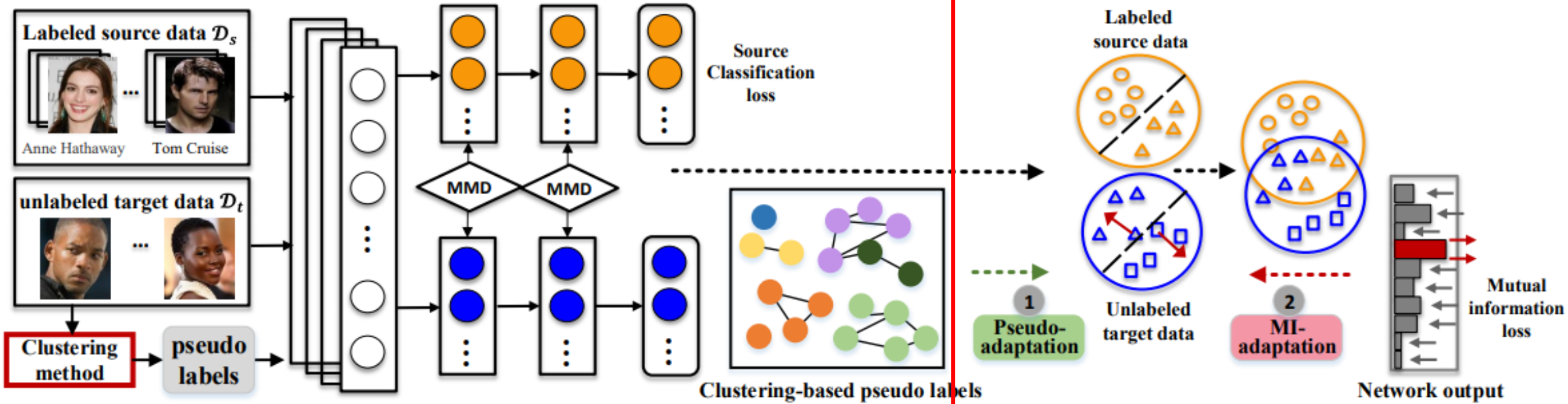

$$\mathcal{L}_M = \frac{1}{N}\sum_{i=1}^{N} H(\mathbf{O_t}|x_i^t)$$ - 한 클래스 출력 확대, 나머지 클래스 출력 축소

$$= \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{N_C} p(o_j^t|x_i^t) log p(o_j^t|x_i^t) - \gamma \sum_{j=1}^{N_C} p(o_j^t) log p(o_j^t)$$

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→ 모든 target image에 대해 비슷한 확률 분포가 나오길 바람
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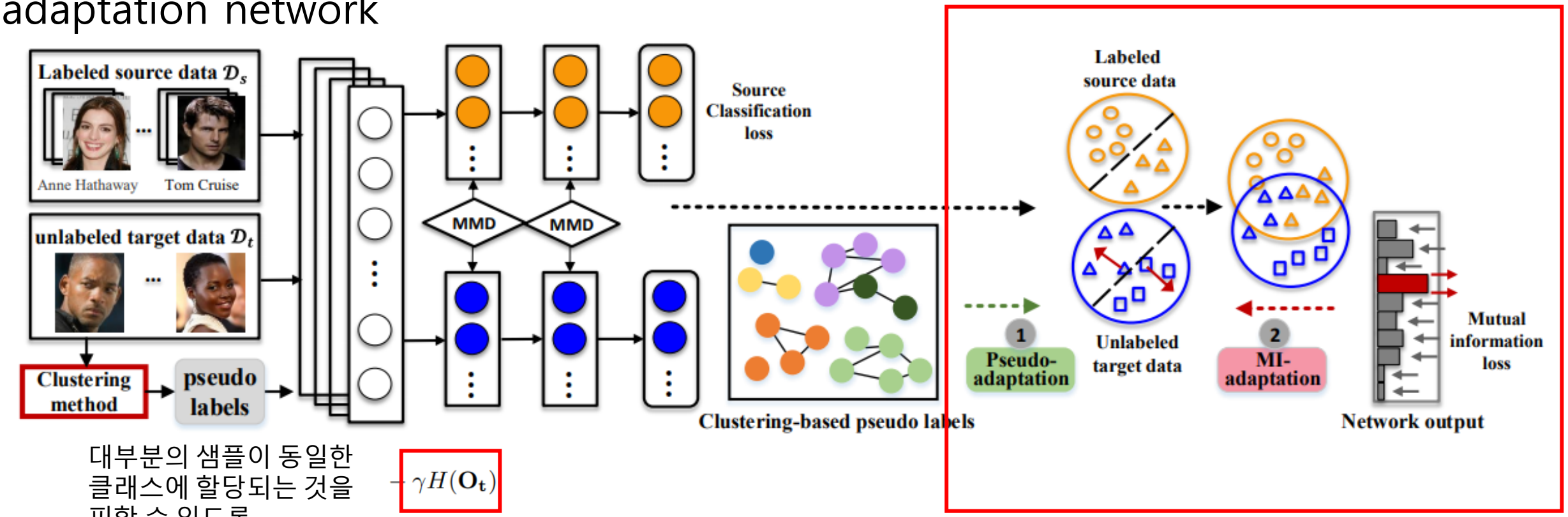

대부분의 샘플이 동일한 클래스에 할당되는 것을 피할 수 있도록 $-\gamma H(\mathbf{O_t})$

$$= \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{N_C} p(o_j^t|x_i^t) log p(o_j^t|x_i^t) - \gamma \sum_{j=1}^{N_C} p(o_j^t) log p(o_j^t)$$

$$= \sum_{i=1}^{N}\sum_{j=1}^{N_C} p(x_i^t) p(o_j^t|x_i^t) log p(o_j^t|x_i^t) - \gamma \sum_{j=1}^{N_C} p(o_j^t) log p(o_j^t)$$

$$= H\left[\mathbf{O_t}|\mathbf{X_t}\right] - \gamma H\left[\mathbf{O_t}\right] \approx -I(\mathbf{X_t};\mathbf{O_t})$$

Target image 예측 시,
이상적인 조건부 분포: $p(O_t|x_i^t) = [0, 0, \ldots, 1, 0, 0]$와 같이 한 클래스의 출력을 확대하는 것이 목표
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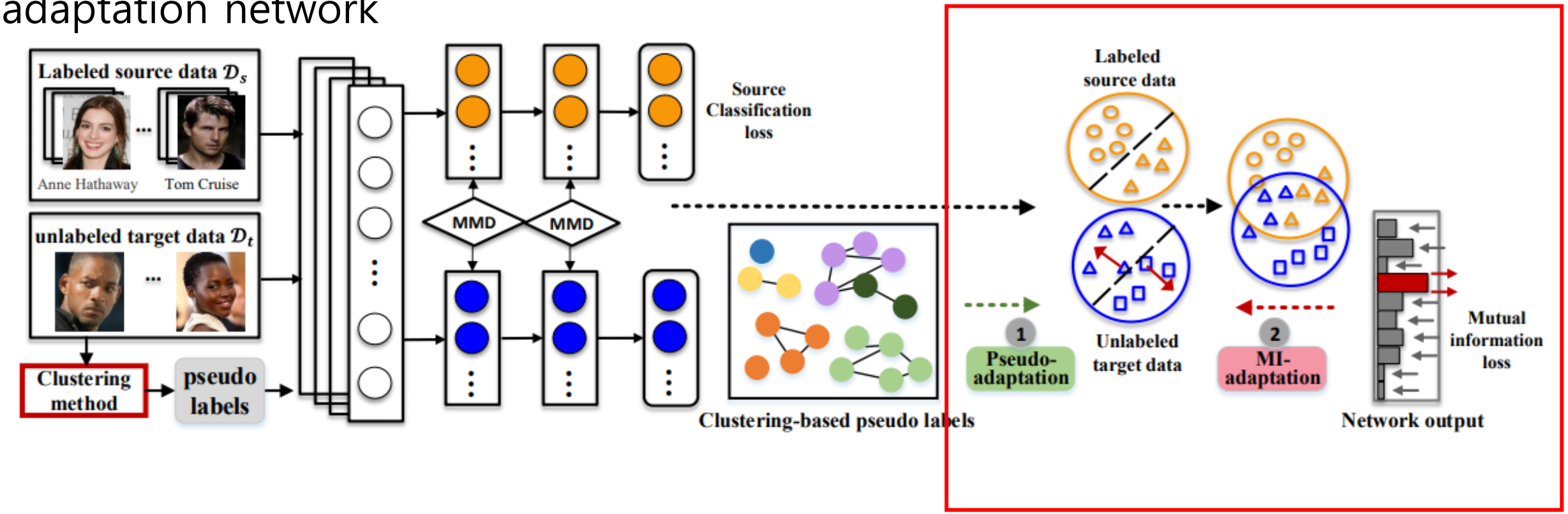

Target domain label이 존재하지 않기 때문에
이 단계에서 pseudo-label을 사용하여 예측 값을 비교!

Target image 예측 시,
이상적인 조건부 분포: $p(O_t|x_i^t) = [0, 0, \dots, 1, 0, 0]$와 같이 한 클래스의 출력을 확대하는 것이 목표
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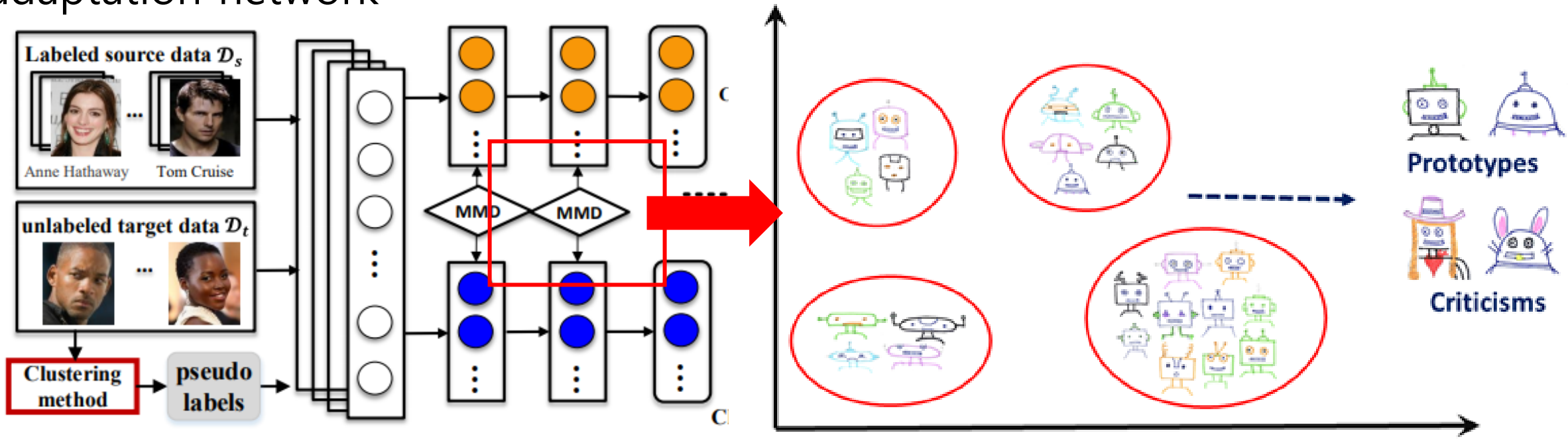

MMD(Maximum Mean Discrepancy)

- Class를 대표하는 prototypes과 class에서 예외적인 criticisms를 찾아 데이터를 직관적으로 확인 가능
- Source domain과 target domain 간의 MMD를 통해 두 분포 간의 불일치를 측정하는 도구(두 분포 간의 차이를 측정)

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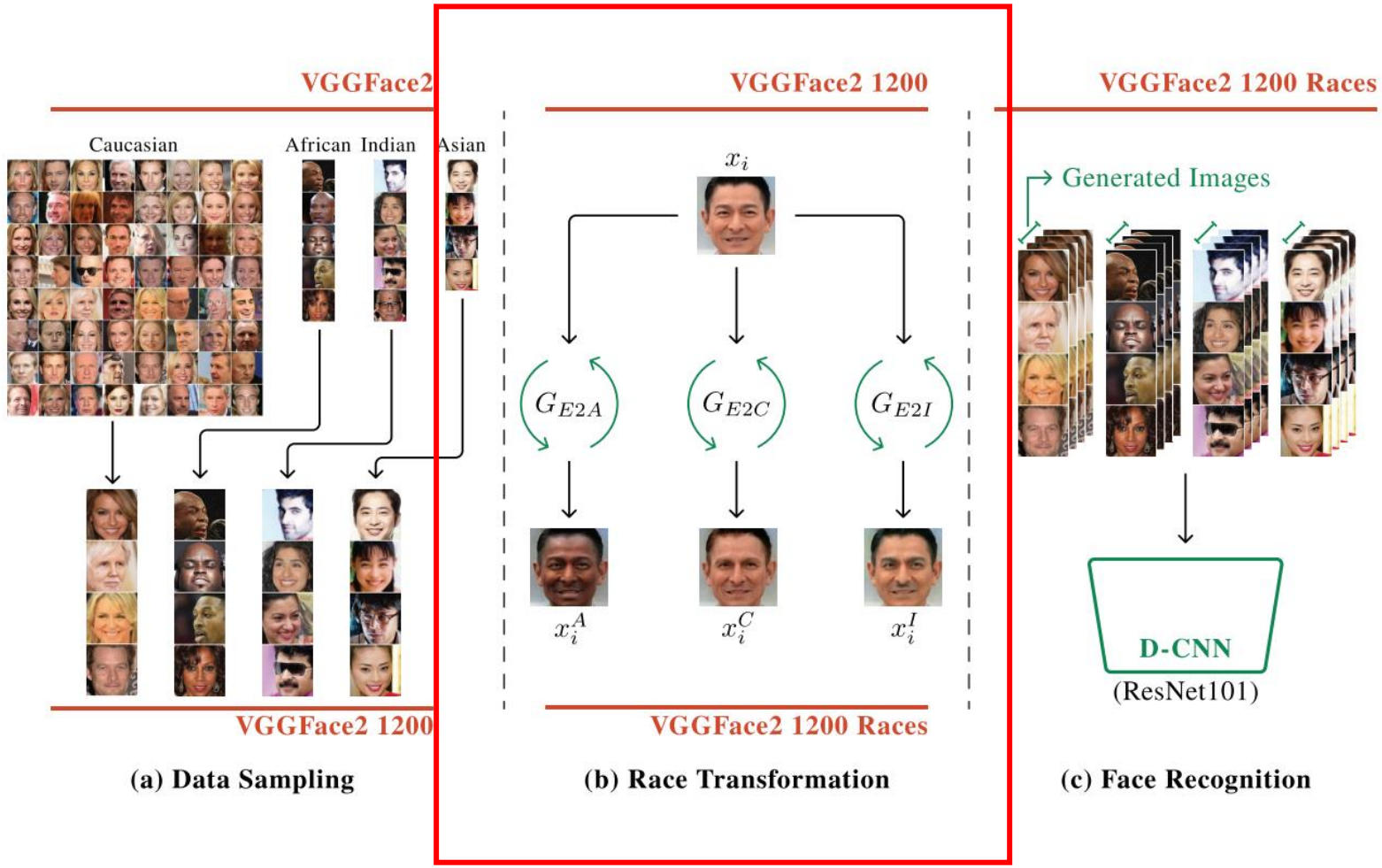
[22] Exploring racial bias within face recognition via per-subject adversarially-enabled data augmentation



Data augmentation 을 통한 dataset 생성 하는 것이 주목적

Seyma Yucer, Samet Akc¸ay, Noura Al-Moubayed, and Toby P Breckon. Exploring racial bias within face recognition via per-subject adversarially-enabled data augmentation. In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops, pages 18–19, 2020.

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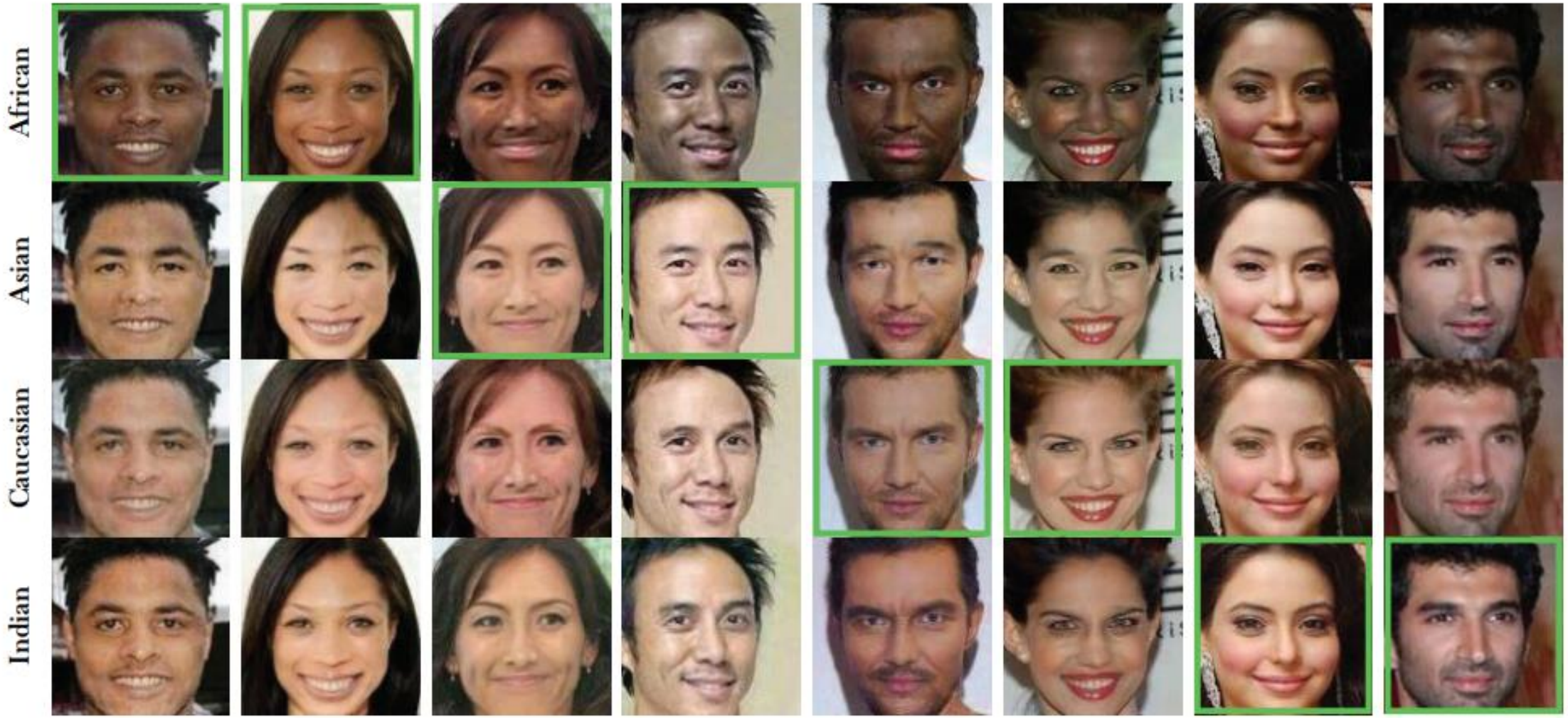

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