FATREC 2018

Using Image Fairness Representations in Diversity-Based Reranking for Recommendations

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Discovery Algorithms @ Shopify

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Recommendations & Personalization

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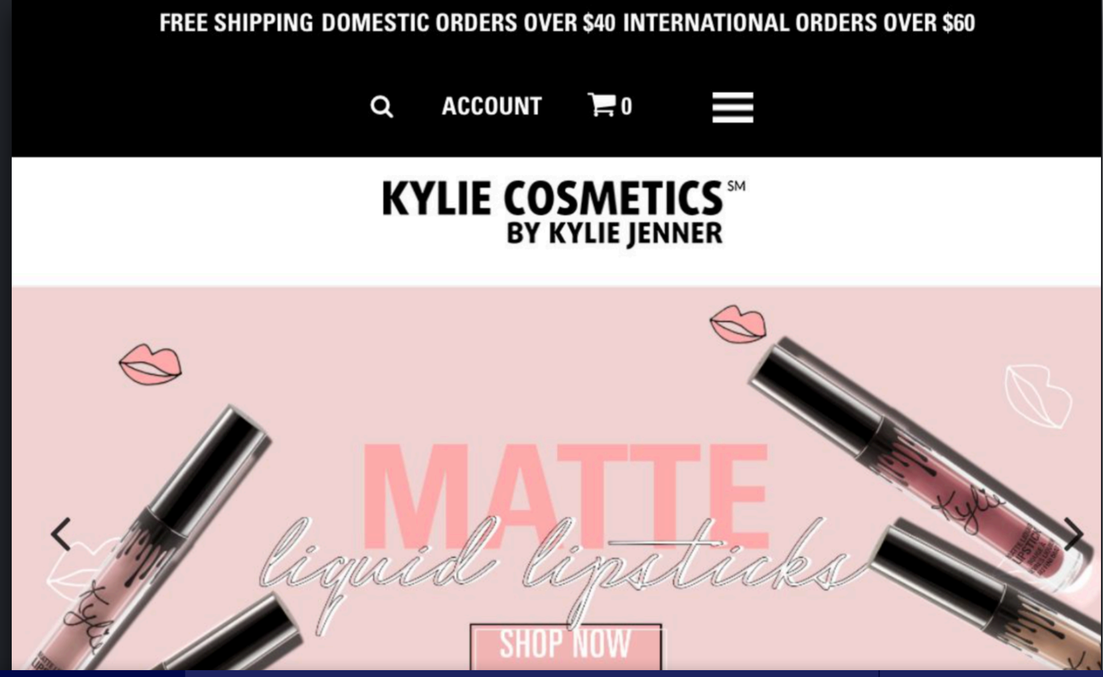
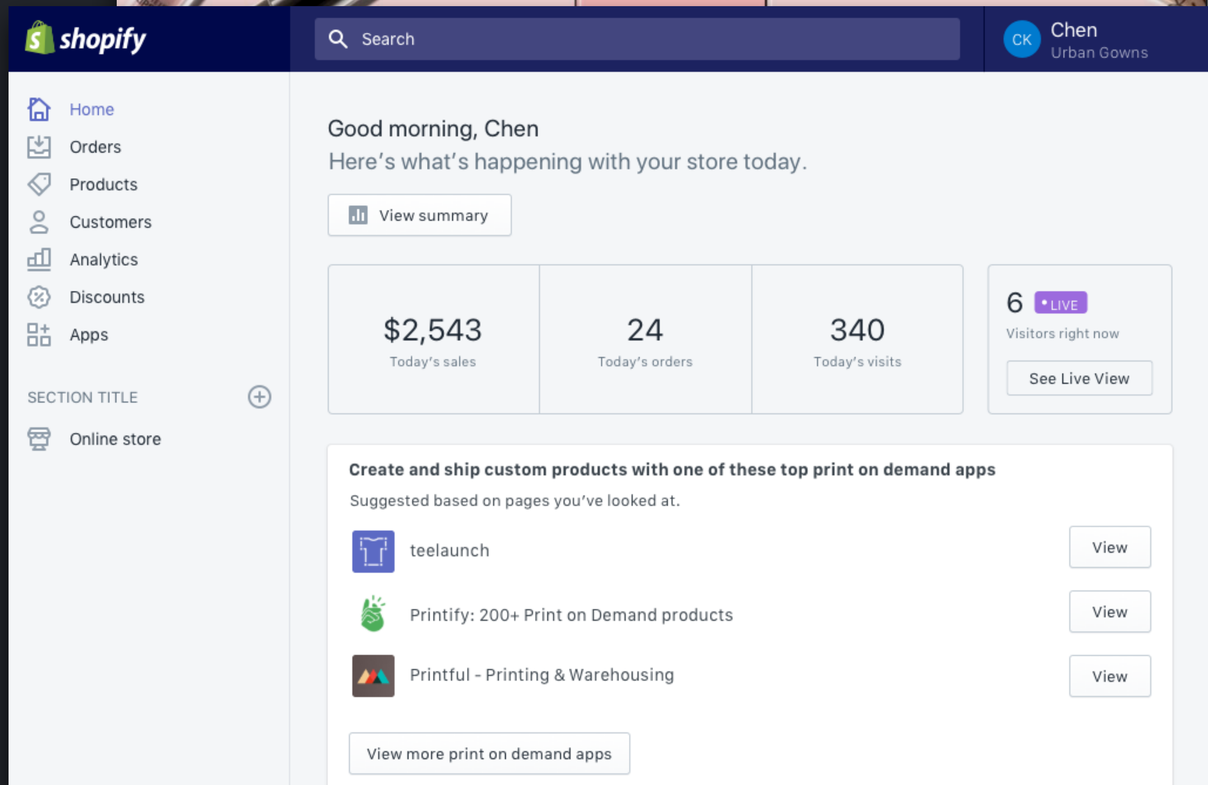
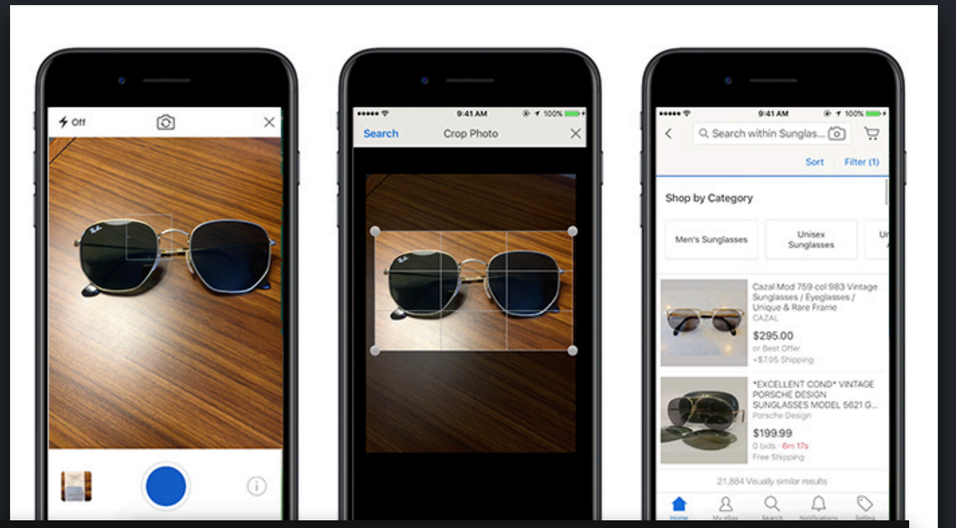
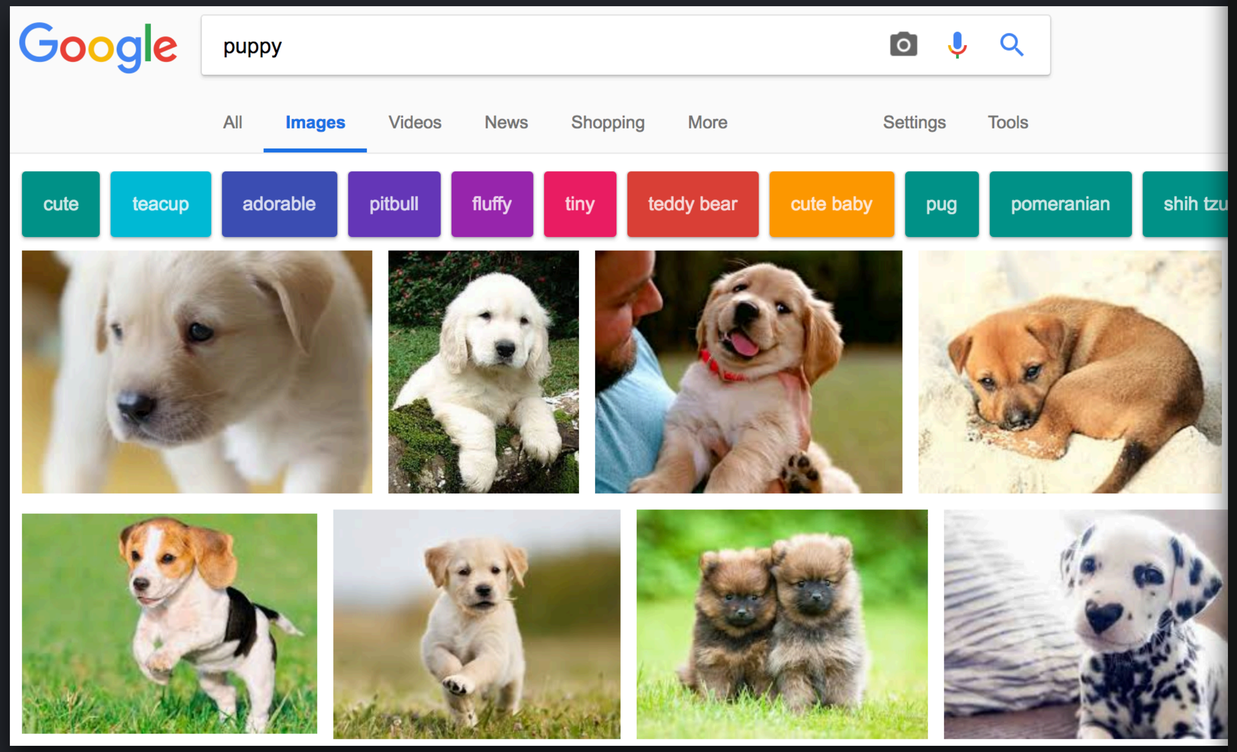


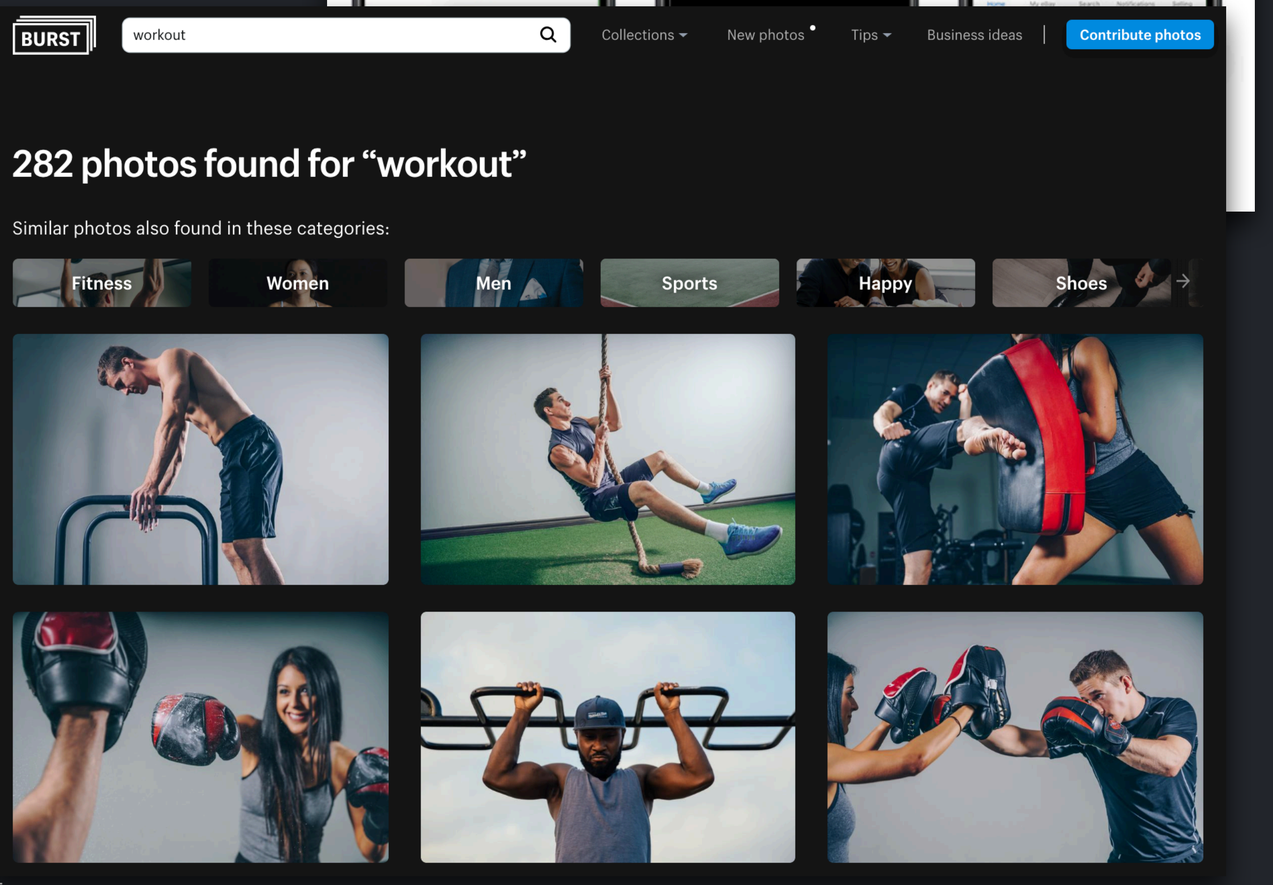


Can we incorporate fairness into search results and recommendations?

Image search







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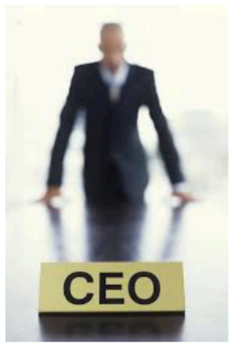

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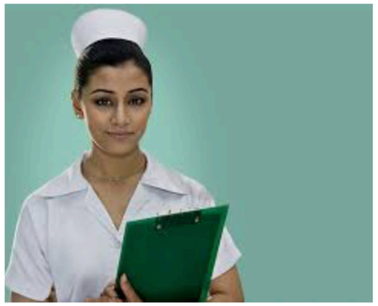
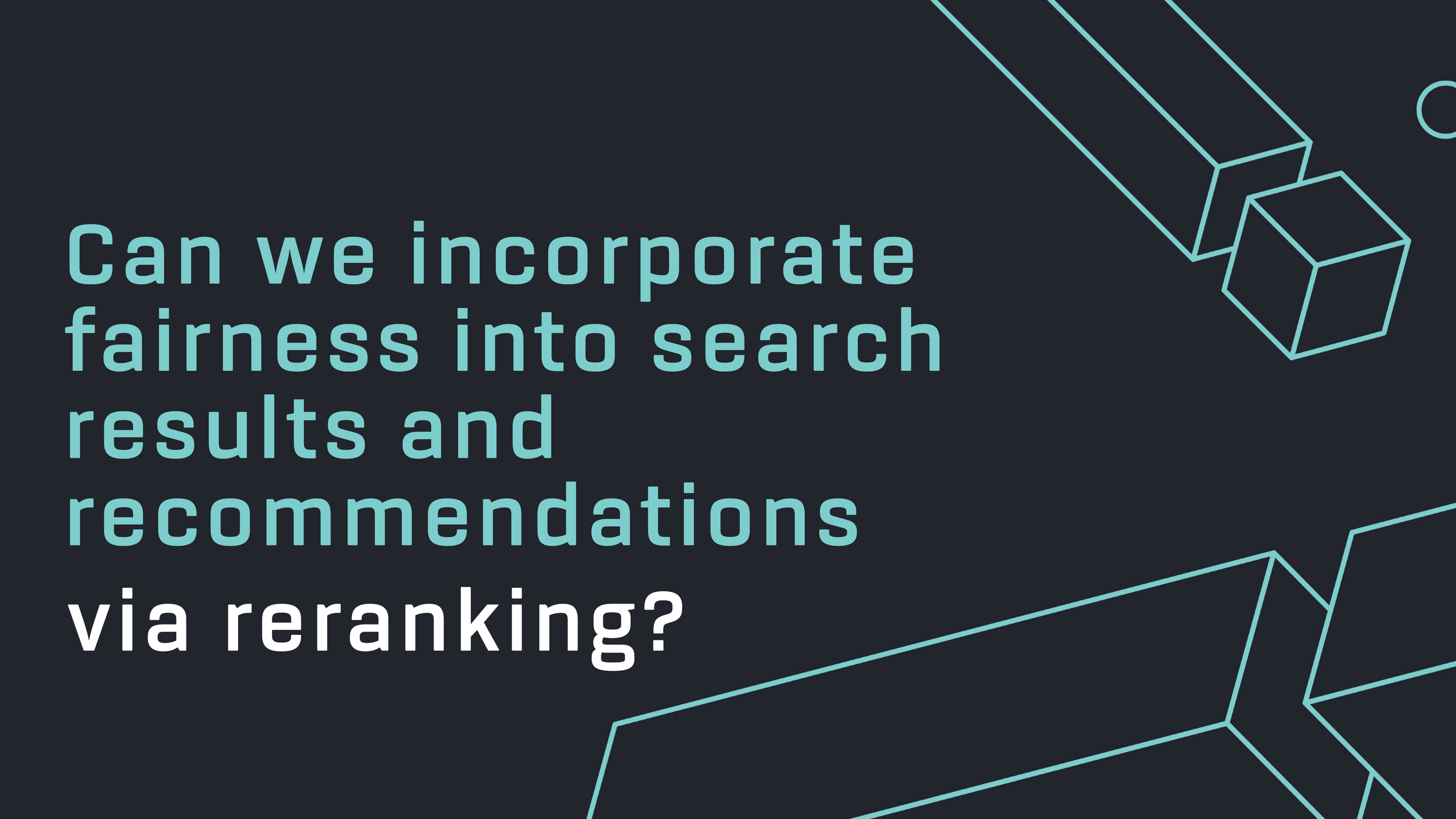
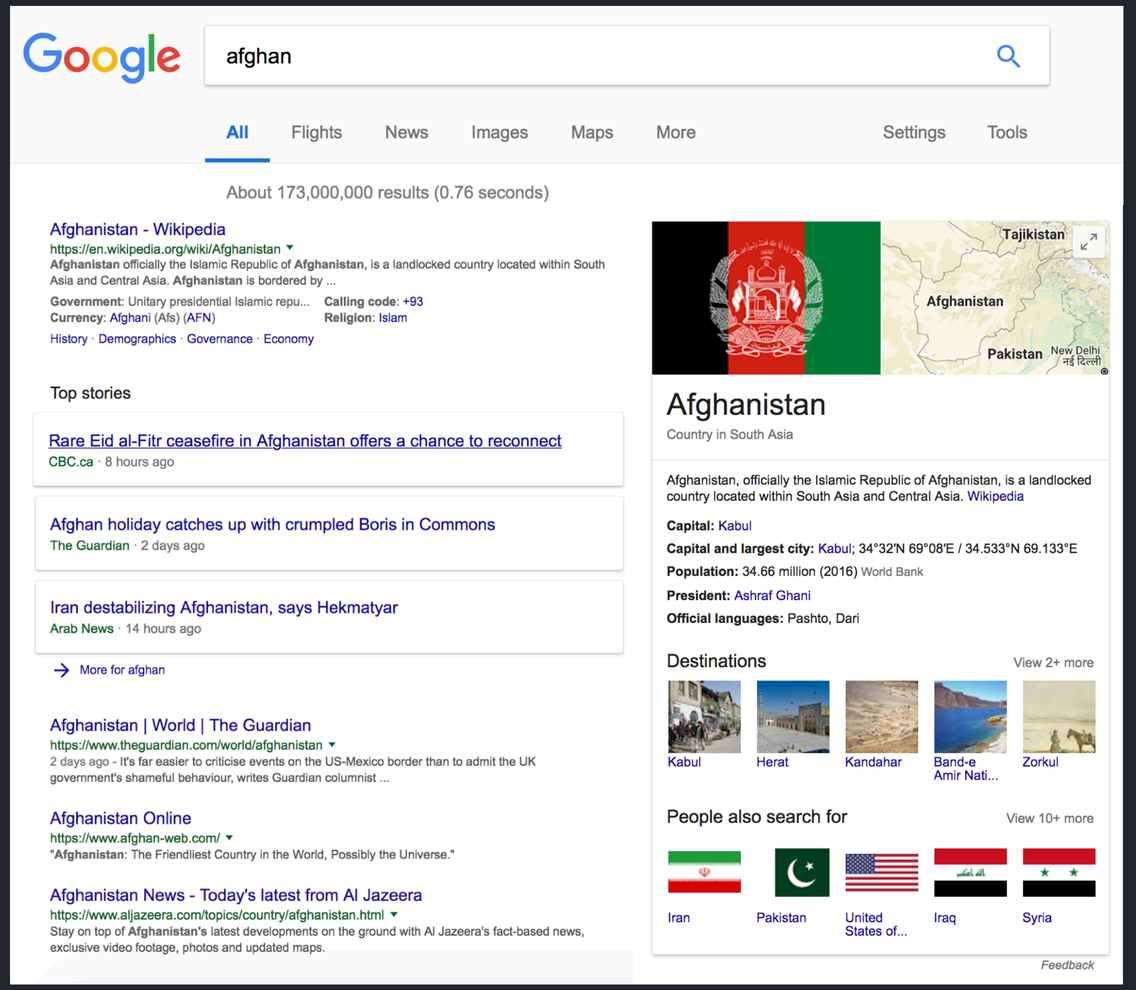


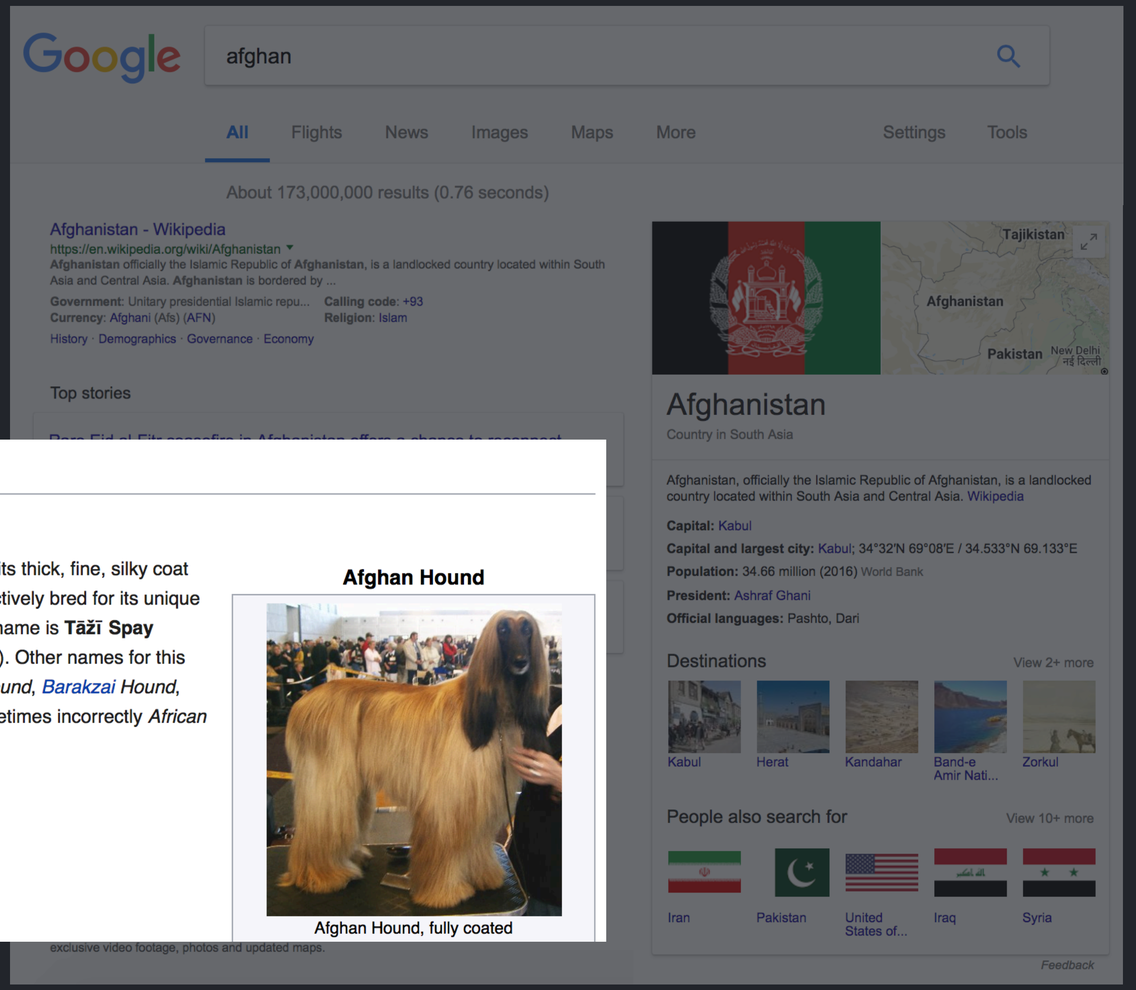
Can we incorporate fairness into search results and recommendations via reranking?



Base relevance model



Limitations



Afghan Hound

From Wikipedia, the free encyclopedia

The **Afghan Hound** is a hound that is distinguished by its thick, fine, silky coat and its tail with a ring curl at the end. The breed is selectively bred for its unique features in the cold mountains of Afghanistan. Its local name is **Tāžī Spay** (Pashto: تاژي سپی) or **Sag-e Tāzī** (Dari Persian: سگ تازی). Other names for this breed are *Kuchi Hound*, *Tāzī*, *Balkh Hound*, *Baluchi Hound*, *Barakzai Hound*, *Shalgar Hound*, *Kabul Hound*, *Galanday Hound* or sometimes incorrectly *African Hound*.

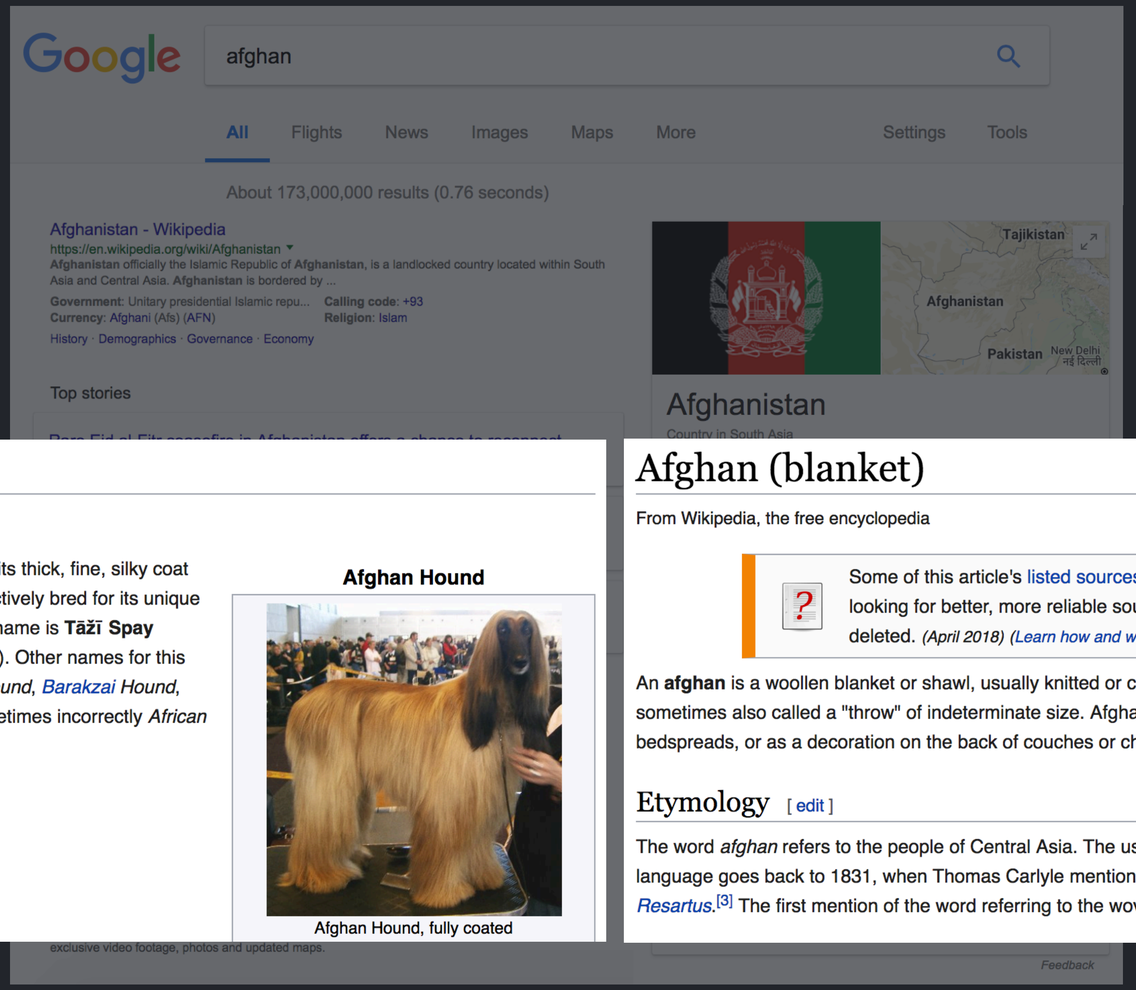
Contents [hide]

1 History
2 Description
3 Variants
4 Health

Afghan Hound

Afghan Hound, fully coated

Limitations



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Afghan Hound

Afghan Hound, fully coated

Afghan (blanket)

From Wikipedia, the free encyclopedia

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An **afghan** is a woollen blanket or shawl, usually knitted or crocheted.[1] It is sometimes also called a "throw" of indeterminate size. Afghans are often used as bedspreads, or as a decoration on the back of couches or chairs.[2]

Etymology [edit]

The word *afghan* refers to the people of Central Asia. The use of *afghan* in the English language goes back to 1831, when Thomas Carlyle mentioned it in his *Sartor Resartus*.[3] The first mention of the word referring to the woven rug was in 1877.[4]

An afghan blanket

MMR re-ranking

- Used for increasing the diversity of a result set
- Objective function:

relevance gain in diversity

Carbonell & Goldstein. 1998.

MMR re-ranking

- Used for increasing the diversity of a result set
- Objective function:

$$\lambda \text{ relevance } + (1 - \lambda) \text{ gain in diversity}$$

Carbonell & Goldstein. 1998.

MMR re-ranking

- Used for increasing the diversity of a result set
- Objective function:

$$\lambda \text{ relevance } + (1-\lambda) \underbrace{\text{gain in diversity}}_{- \max_{i \in S_{\text{chosen items}}} \text{Sim}(i_{\text{new}}, i)}$$

Carbonell & Goldstein. 1998.

MMR re-ranking

- Done in a greedy iterative process to obtain the top-k results

$$\underset{i_{\text{new}} \in S_{\text{unchosen items}}}{\operatorname{argmax}} \quad \lambda \ \text{relevance}\,(i_{\text{new}}) + (1-\lambda) \underbrace{\text{gain in diversity}\,(i_{\text{new}})}$$

$$- \max_{i \in S_{\text{chosen items}}} \operatorname{Sim}(i_{\text{new}}, i)$$

Carbonell & Goldstein. 1998.

MMR re-ranking

1. Afghanistan
2. Afghanistan
3. Afghanistan
4. Afghanistan
5. Dog
6. Dog
7. Blanket

MMR re-ranking

1. Afghanistan
2. Afghanistan
3. Afghanistan
4. Afghanistan
5. Dog
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1. Afghanistan

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MMR re-ranking

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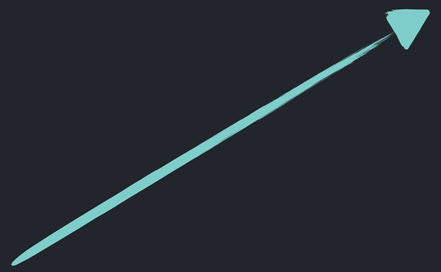
7. Blanket

1. Afghanistan

MMR re-ranking

1. Afghanistan
2. Afghanistan
3. Afghanistan
4. Afghanistan
5. Dog
6. Dog
7. Blanket



1. Afghanistan
2. Dog

MMR re-ranking

1. Afghanistan
2. Afghanistan
3. Afghanistan
4. Afghanistan
5. Dog
6. Dog
7. Blanket

1. Afghanistan
2. Dog

MMR re-ranking

1. Afghanistan
2. Afghanistan
3. Afghanistan
4. Afghanistan
5. Dog
6. Dog
7. Blanket

1. Afghanistan
2. Dog
3. Blanket

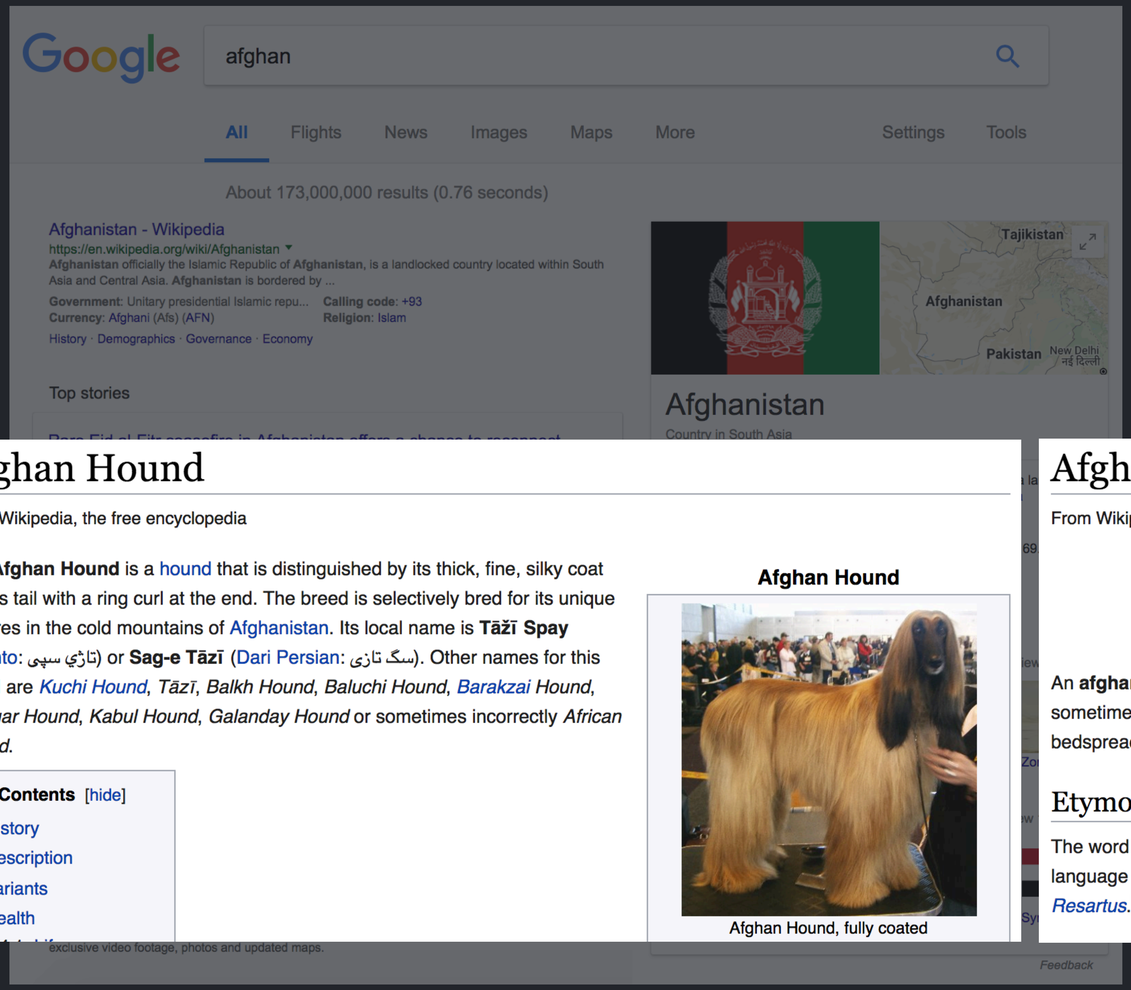
MMR re-ranking

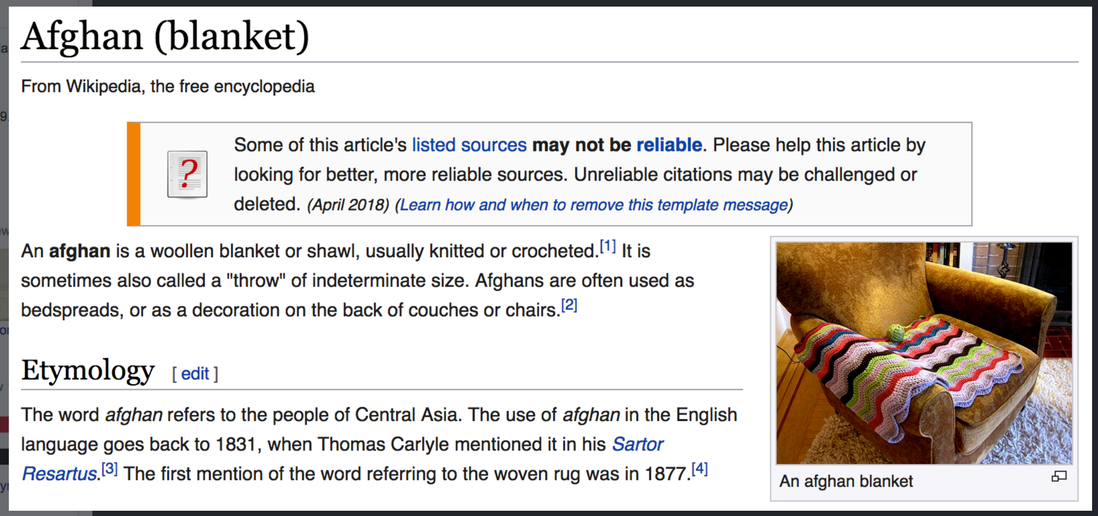
1. Afghanistan
2. Afghanistan
3. Afghanistan
4. Afghanistan
5. Dog
6. Dog
7. Blanket

1. Afghanistan
2. Dog
3. Blanket

⋮

MMR re-ranking



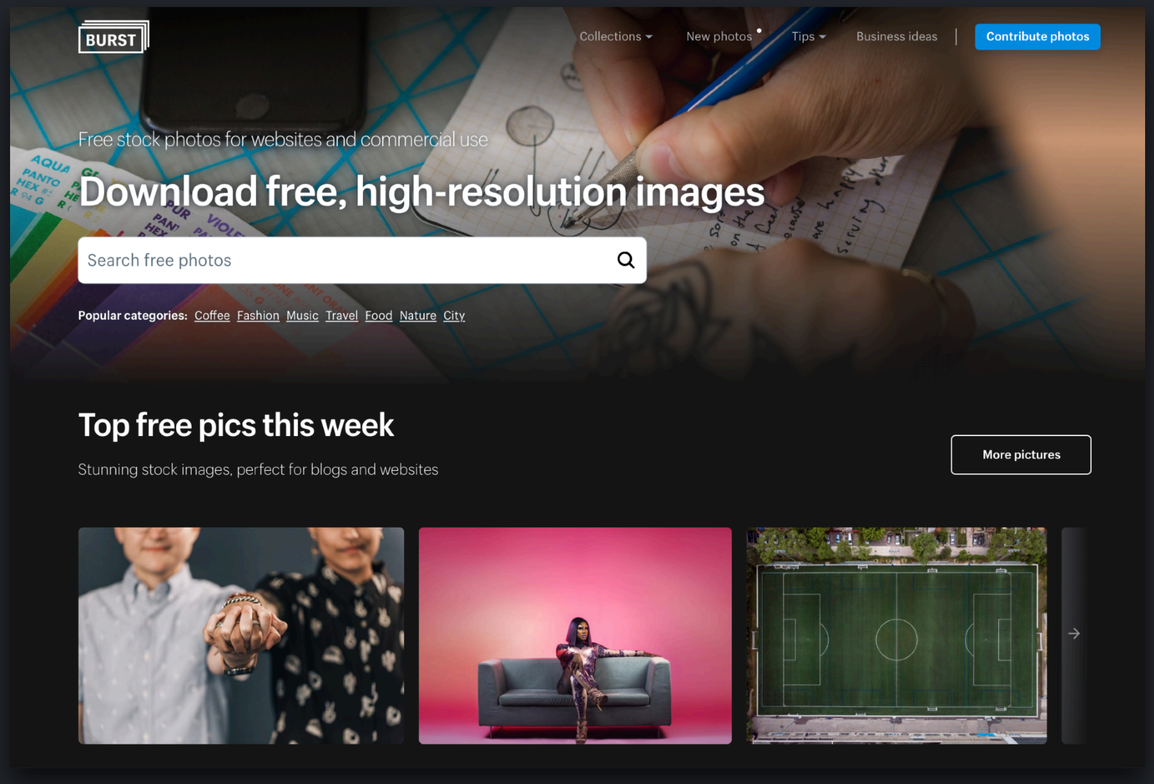


gain in diversity = $-\max_{i \in S_{\text{chosen items}}} \text{Sim}(i_{\text{new}}, i)$

Ex: Image search in Burst

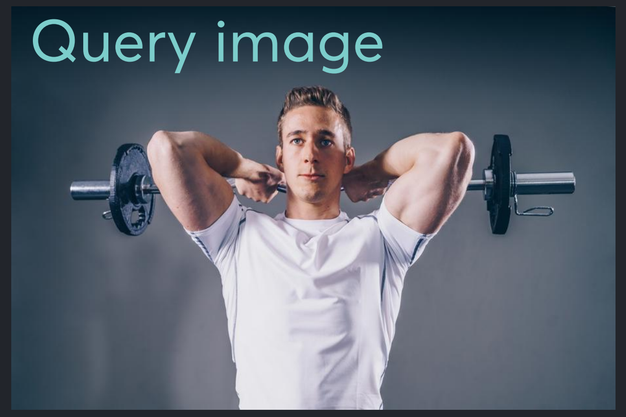
Burst: stock photo website

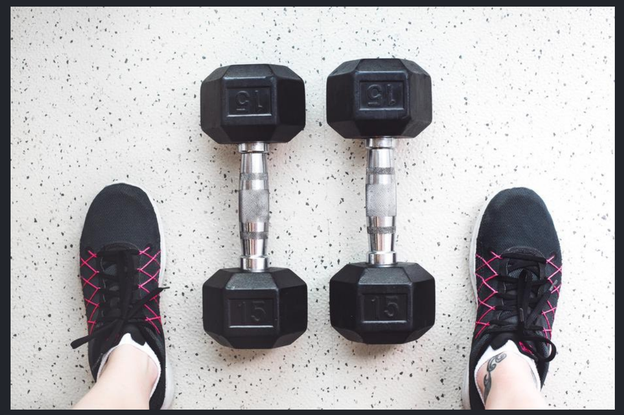
Task: similar image search

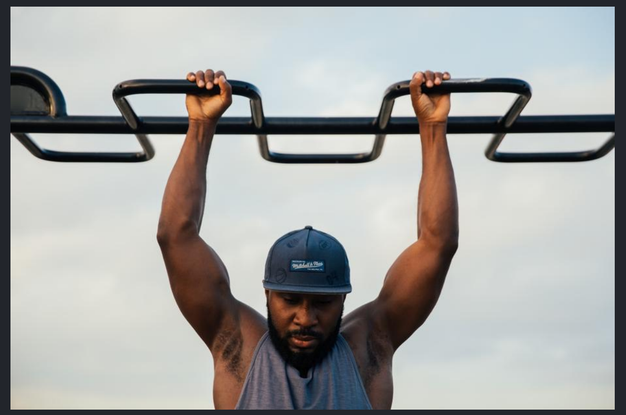


https://burst.shopify.com

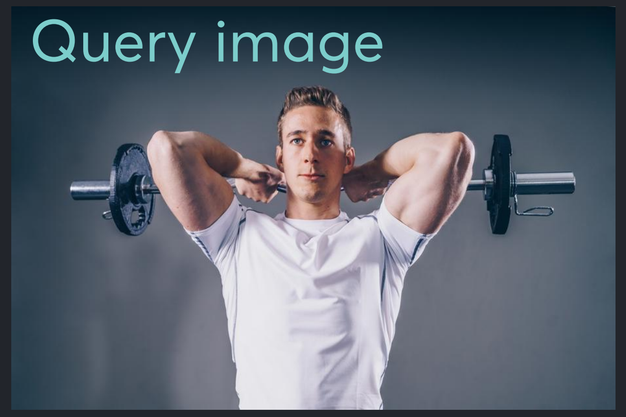
Related images: relevance

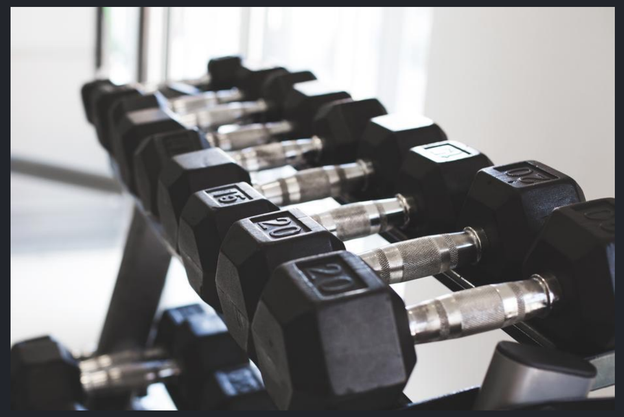






Related images: MMR





MMR reranking

Can we use this instead for fairness?

$$\lambda \text{ relevance } + (1 - \lambda) \text{ gain in } \cancel{\text{diversity}} \text{ fairness}$$

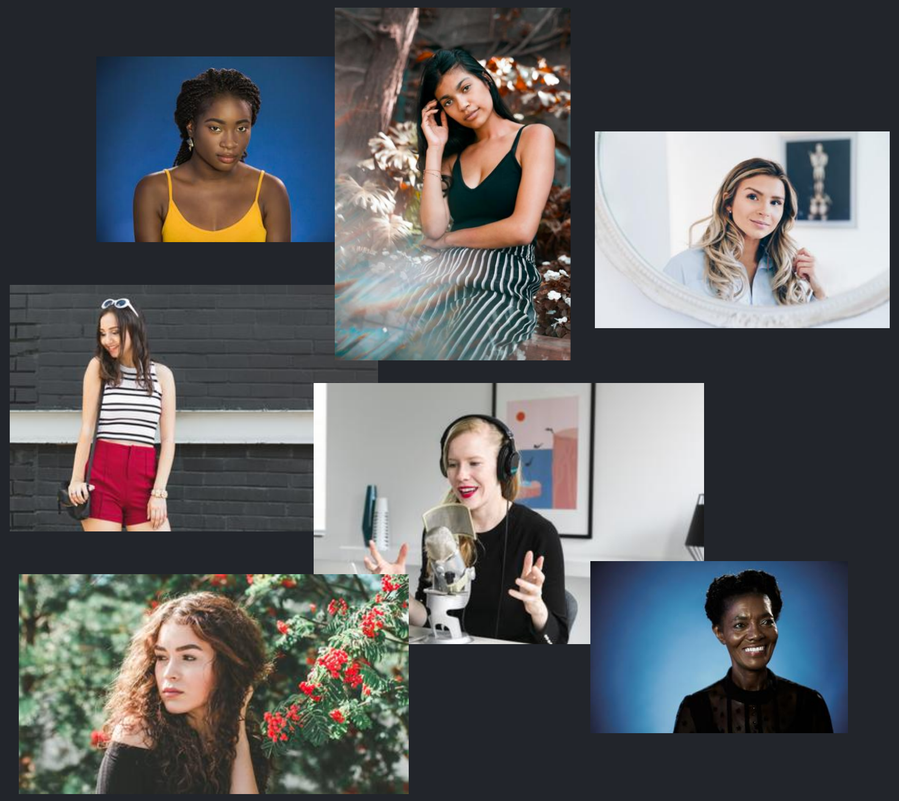
$$- \max_{i \in S_{\text{chosen items}}} \text{Sim}(i_{\text{new}}, i)$$

Image representations

- Richer representations of image content
- Inception-v3: pre-trained CNN
- Learns image representations: 2048-dimensional vectors
  - pairwise similarity

Szegedy et al. 2016.

Image fairness representations



tag: ‘woman’

Inception

[0.1, 0.3, 2.4, …]

[4.5, 1.7, 0.4, …]

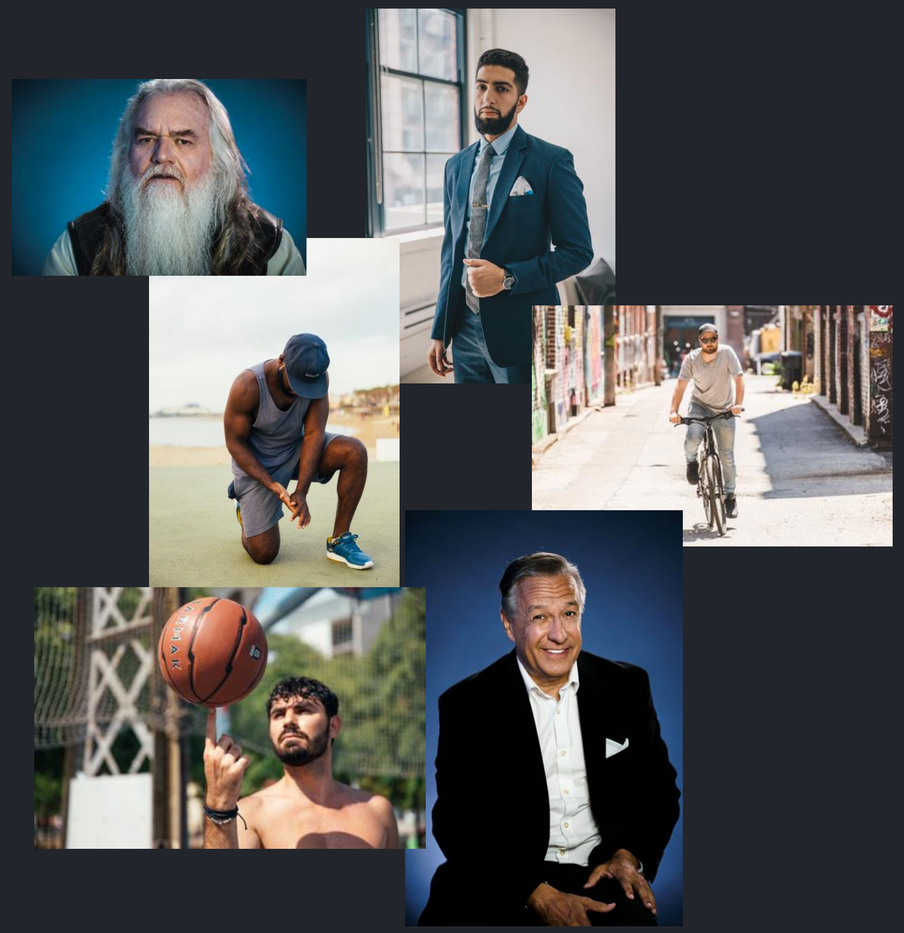
…

[6.1, 0.5, 1.2, …]

Average

$v_{\text{woman}} = [3.6, 0.8, 1.3, \ldots]$

Image fairness representations



tag: 'man'

Inception

[6.1, 2.3, 7.3, …]

[1.5, 1.7, 0.5, …]

…

[2.0, 1.5, 4.2, …]

Average

$v_{\text{man}} = [3.2, 1.8, 4.0, \ldots]$

Fairness-aware MMR reranking (FMMR)

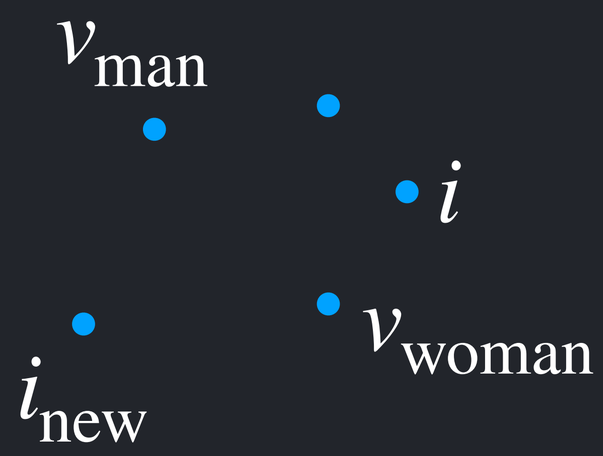
λ relevance $+(1-\lambda)$ gain in fairness

$$- \max_{i \in S_{\text{chosen items}}} \text{Sim}(i_{\text{new}}, i)$$

Fairness-aware MMR reranking

λ relevance $+(1-\lambda)$ gain in fairness

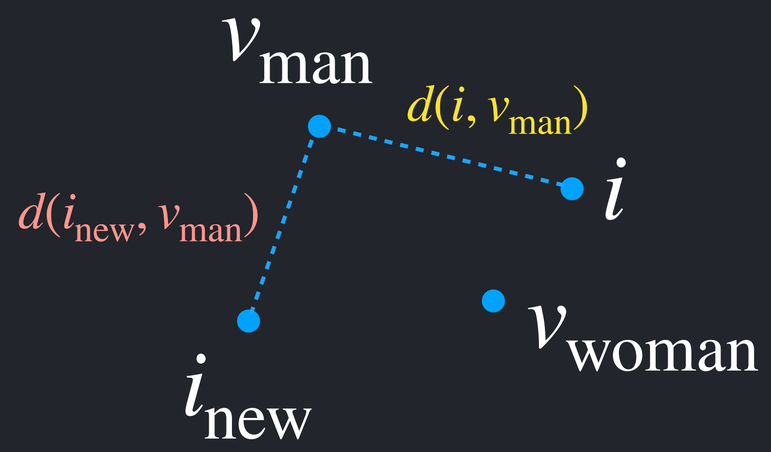
$\mathrm{Sim}(i_{\mathrm{new}}, i)$?



Fairness-aware MMR reranking

λ relevance $+(1-\lambda)$ gain in fairness

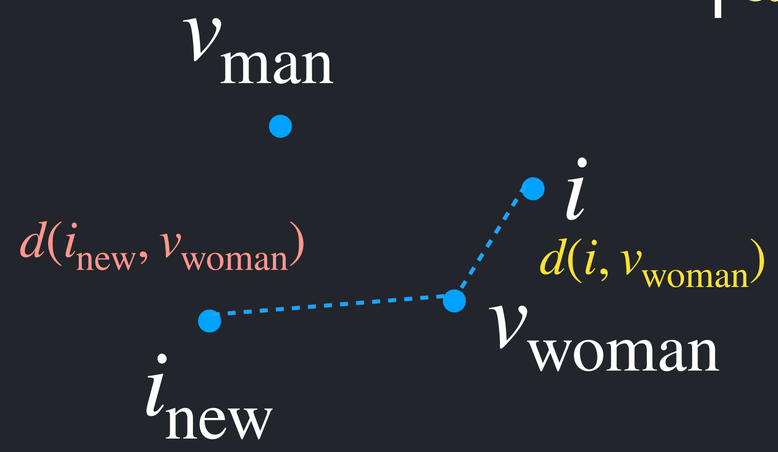
$$\text{Sim}(i_{\text{new}}, i) \; ? \qquad -|\,d(i, v_{\text{man}}) - d(i_{\text{new}}, v_{\text{man}})\,|$$



Fairness-aware MMR reranking

λ relevance $+(1-\lambda)$ gain in fairness

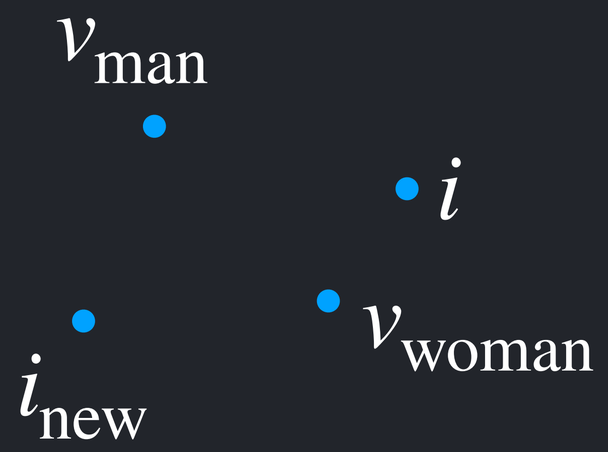
$$\begin{aligned}\text{Sim}(i_{\text{new}}, i) \;=\; & -|\,d(i, v_{\text{man}}) - d(i_{\text{new}}, v_{\text{man}})\,| \\ & + \\ & -|\,d(i, v_{\text{woman}}) - d(i_{\text{new}}, v_{\text{woman}})\,|\end{aligned}$$



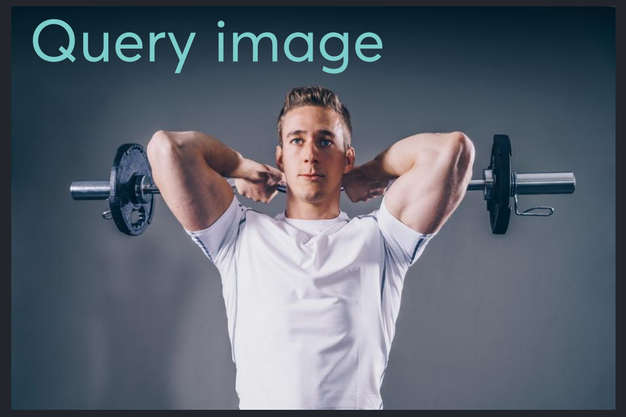
Fairness-aware MMR reranking

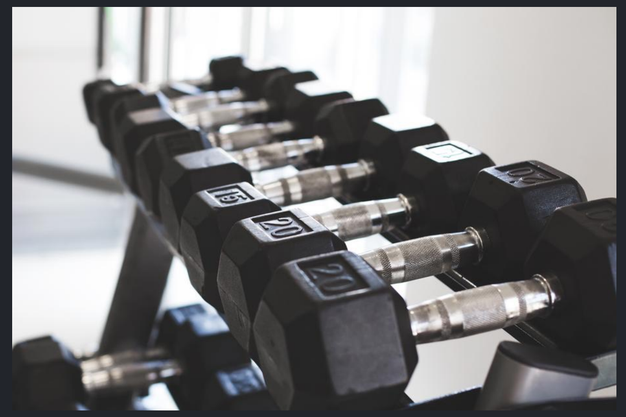
λ relevance $+(1-\lambda)$ gain in fairness

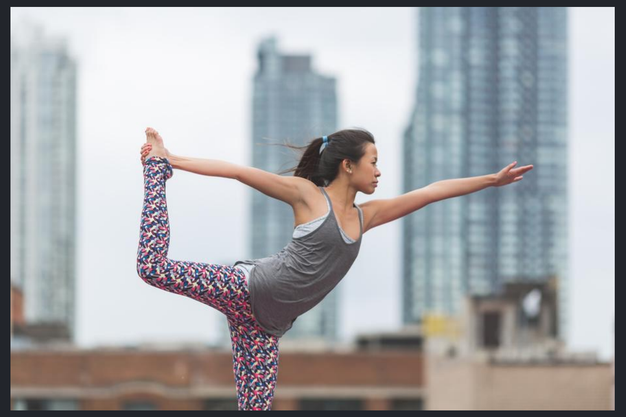
$$\text{Sim}(i_{\text{new}}, i) = -\sum_{v \in \{v_{\text{man}}, v_{\text{woman}}\}} |\, d(i, v) - d(i_{\text{new}}, v) \,|$$



Related images: FMMR







Experiment:
Image search in Burst

BURST

Search

Collections ▾ New photos Tips ▾ Business ideas Contribute photos

Woman Applying Lip Balm

Woman applying lip balm from tube container.

Photo size

- High resolution
  High quality for web and print
- Low resolution
  Best for small web graphics

Download free photo

Featured in:

Women, Makeup, Lifestyle, Craft/DIY, Nails, Relax, Beauty

Creative Commons

BURST

Search

Collections ▾ New photos Tips ▾ Business ideas Contribute photos

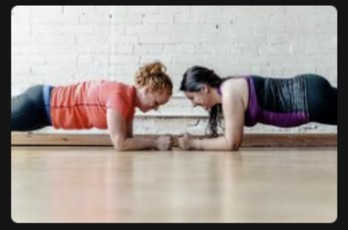
Fitness Balancing

A man balancing on a bar.

Photo size

- (•) High resolution
  High quality for web and print
- ( ) Low resolution
  Best for small web graphics

Download free photo



Featured in:

Fitness, Sports, Gym, Exercise, Crossfit

Task: similar image search

Dataset

3249 images used in search (objects, places, people).

291 men images, 458 women images used to create fairness representations.

738 sample human images used as query images for evaluation.

Metrics: relevance

Relevance: precision at k (p@k).

Based on tags: require at least 1/4 of query image tags to be matched by search result

Metrics: fairness

Tradeoff between relevance and fairness.

Fairness: fairness ratio at k (fr@k), defined as:

$$\frac{\#\text{ woman images}}{\#\text{ man images} + \#\text{ woman images}}$$

in top-k results.

Experiment: FMMR vs MMR

- Euclidean distance for all distance calculations
- For each algorithm, λ tuned using 100 query images to heuristically optimize the fairness-relevance tradeoff
- Evaluation done on remaining 638 images: use tuned λ to get top-10 results per query, compute p@10, fr@10.

p@10

0.59 ± 0.02	0.53 ± 0.02
FMMR	MMR

fr@10

0.65 ± 0.02	0.64 ± 0.02
FMMR	MMR

Results

When producing **gender-balanced results**, FMMR had **higher precision** than MMR (using same relevance model and hyperparameter tuning).

Conclusion & Applications

- ✔ Developed algorithm to incorporate fairness in image results
- ✔ Can be extended to other demographics (race, age)
- ✗ ✔ Small number of tagged images required
- ✔ Trade-off can be controlled by choice of hyperparameters
- ✔ Apply in post-processing for search + recommendations in many domains; not limited to images!

THANK YOU

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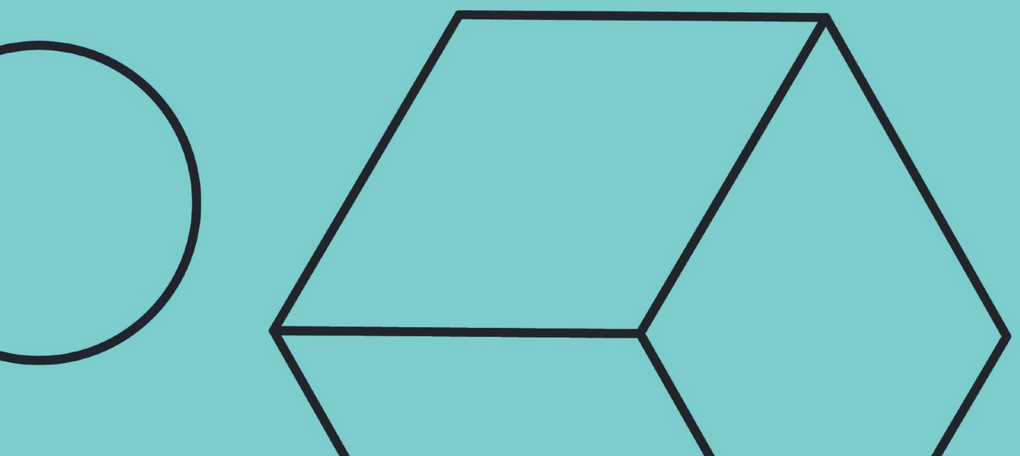
@chennerzz



Appendix 1: hyperparameter tuning heuristics

Grid search on λ by optimizing for fairness while satisfying a pre-defined guarantee of precision.

Guarantee of precision for λ by this constraint:

$$\frac{p_{\lambda=1}@10 - p_{\lambda}@10}{p_{\lambda=1}@10} \geq d \text{ (allowable degradation ratio)}$$