Find me a sky : a data-driven method for color-consistent sky search & replacement

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2018

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* Both the authors contributed equally

Motivation

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Problem Statement

GOAL: Replace the dull sky with a more appealing one
Requirement: Fully automatic, no cumbersome manual editing

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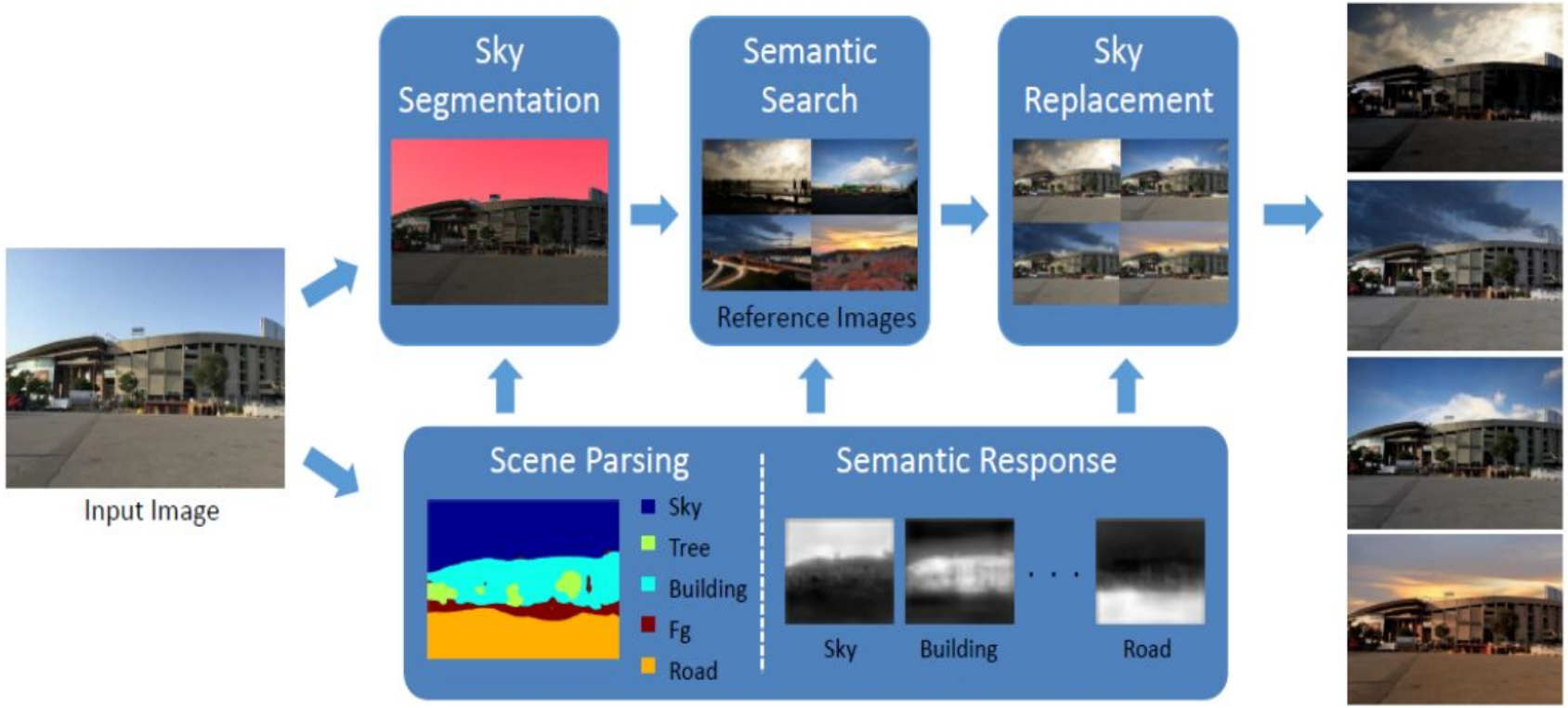
Related Work: Sky is Not the limit [Tsai et al. 2016]



Related Work: Sky is Not the limit [Tsai et al. 2016]

- Color transfer linked with label matching between the source and the target, adds complexity and limitation on source images.
- May also add artifacts in the image.

Related Work: SkyFinder: Attribute-based Sky Image Search [Tao et al]

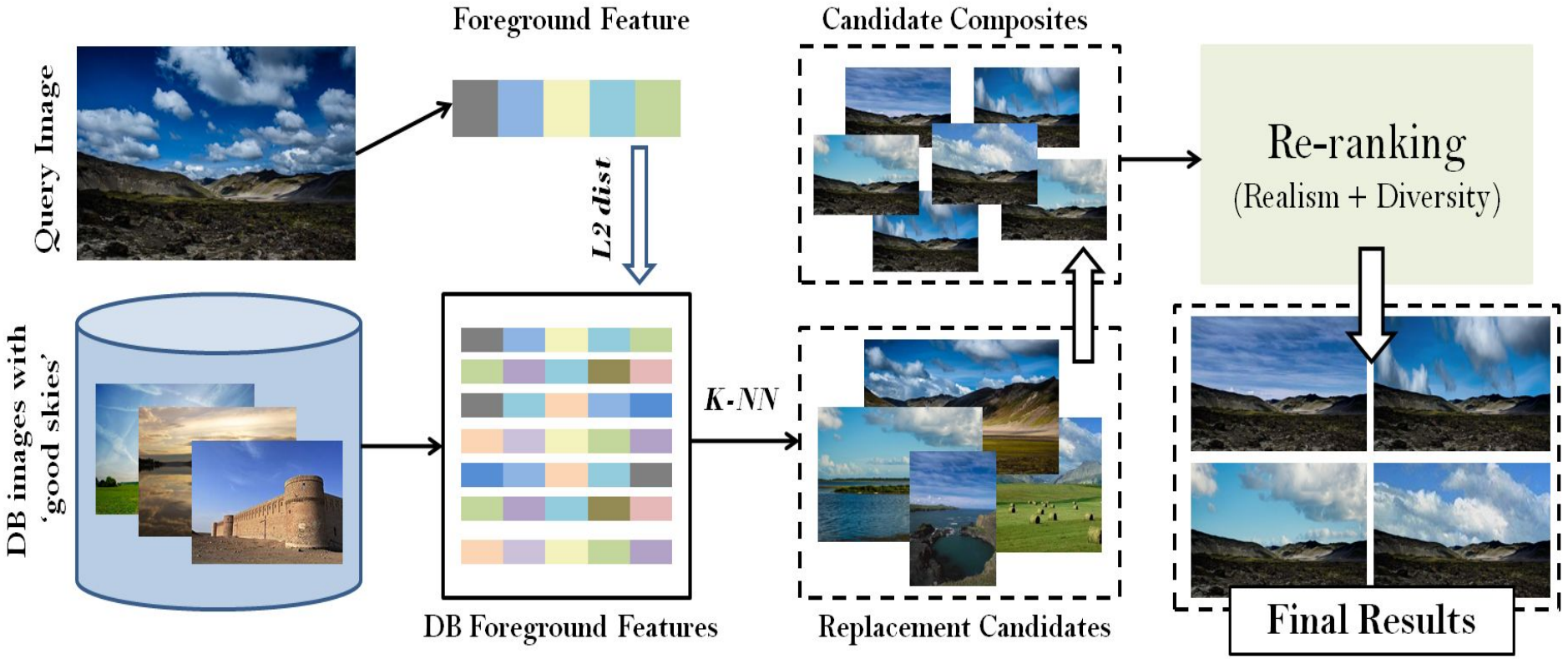
- Look for compatible skies by entering text and perform a horizon based sky replacement.
- Diversity in options
- Horizon estimation based sky replacement, more errors

(a) *blue + normal-sky + horizon + R3*

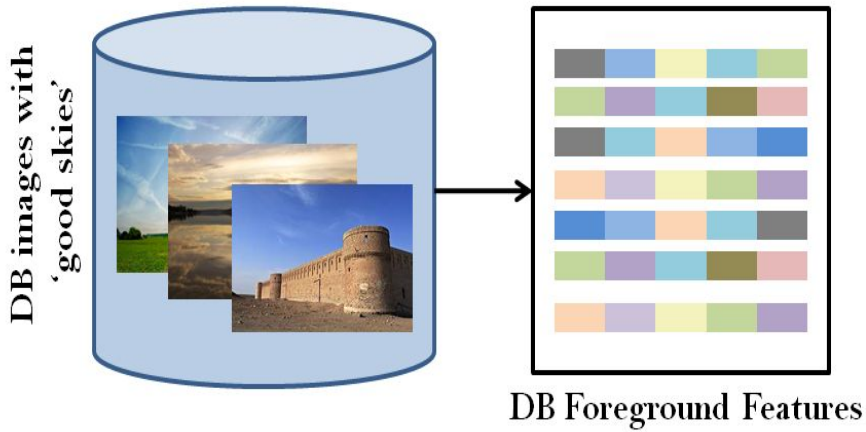
(b) *cloudy + normal-sky + horizon + R5*

(c) *sunset + landscape + horizon + sun*

Pipeline


Query Image
Foreground Feature
L2 dist
DB images with 'good skies'
K-NN
DB Foreground Features
Candidate Composites
Replacement Candidates
Re-ranking
(Realism + Diversity)
Final Results

Pipeline: Preparation of dataset



Pipeline: Preparation of dataset

- Images curated from Flickr(415) and the ADE20K Dataset (831)

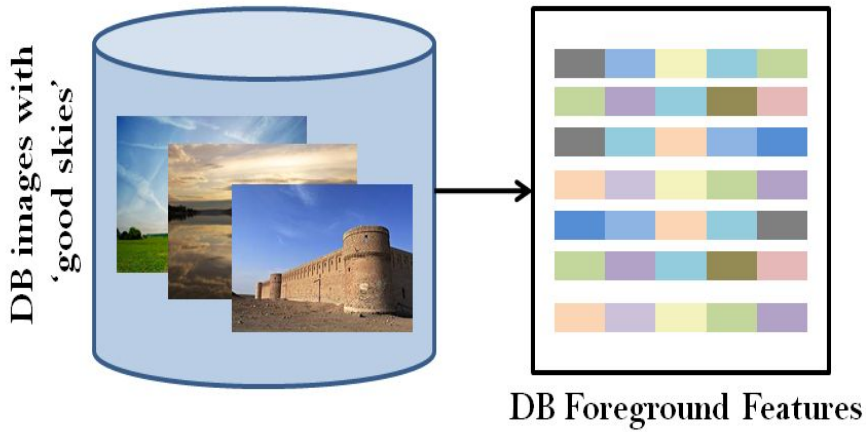
- ADE20K:
  - ~6K sky category images
  - Sky region >40% of total image
  - Manually rated between 1 to 5 on interestingness and aesthetic appeal of the skies
  - Average scores higher than 3 were added to the final database.

Landscapes with sky portions and a few images of buildings

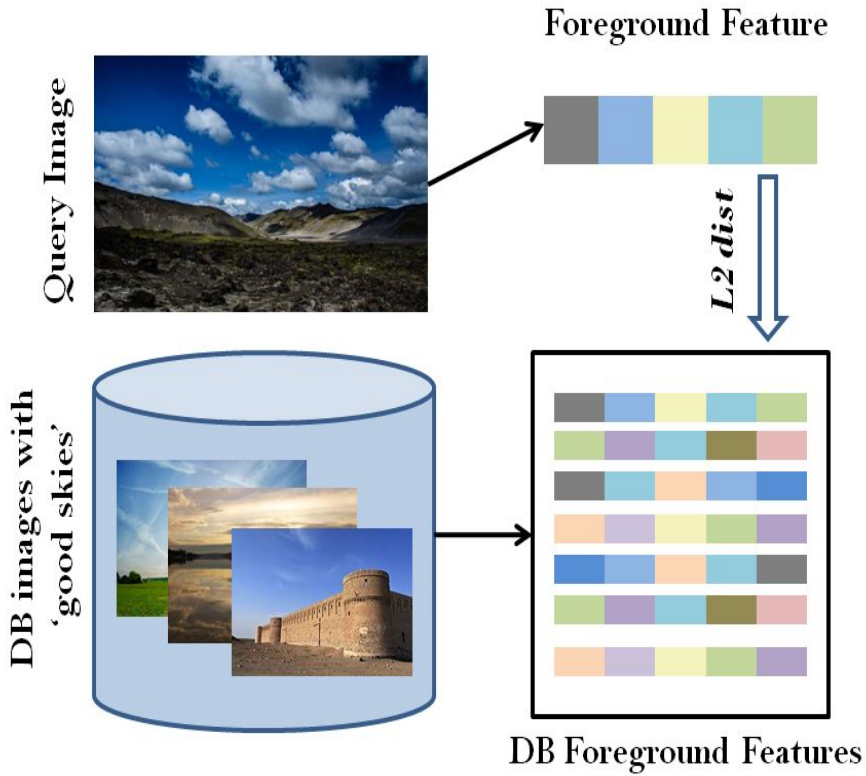
1246 Aesthetically Appealing Images

Pipeline: Preparation of dataset

Pipeline: Feature Vector

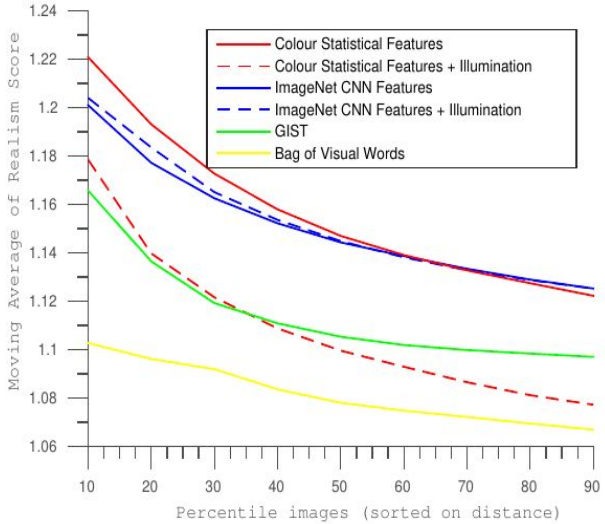


Pipeline: Feature Vector



Feature Vector

- What features can model the foreground-background relationship?
  - Colour statistical features
  - CNN
  - Illumination
  - Bag of visual words
  - GIST
- Ablation study
- RealismCNN
  - [Zhu et al, ICCV ‘15]
  - Trained using only automatically-generated, composites with artifacts in segmentation and blending algorithms
  - VGG model, a 16-layer model with 3×3 convolution filters, fine-tuned on binary classification task



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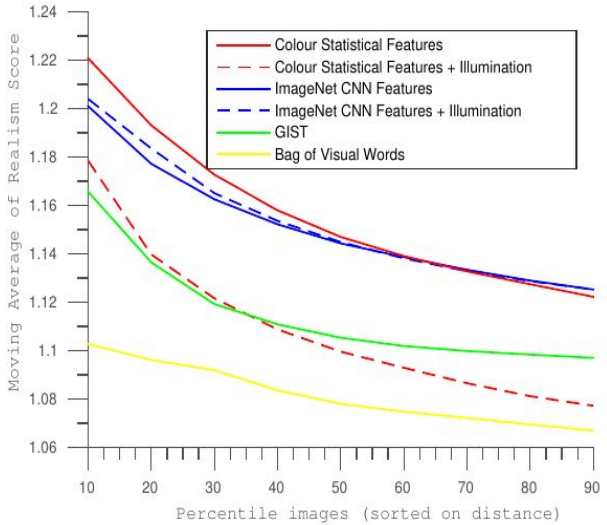
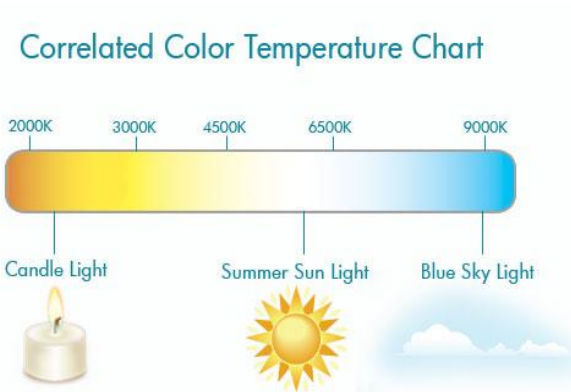
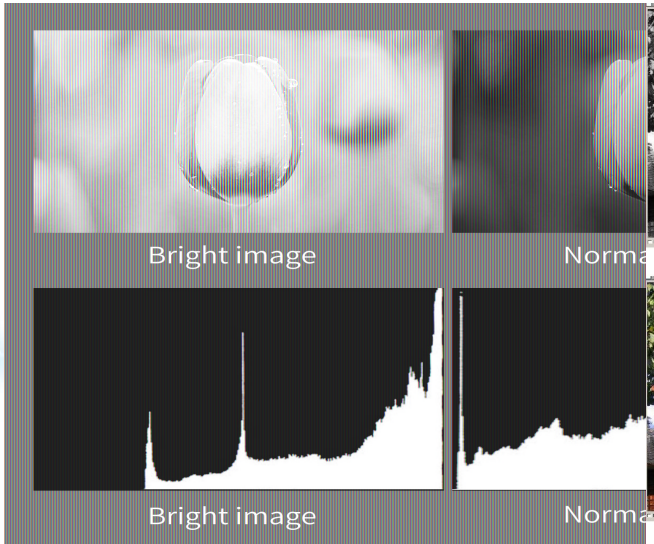
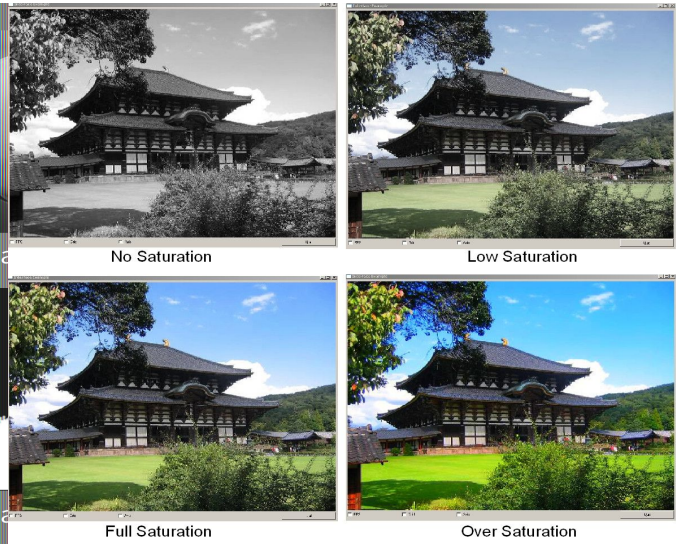


Feature Vector

CCT	Luminance	Saturation







[Xue et al, SIGGRAPH '12]

Feature Vector

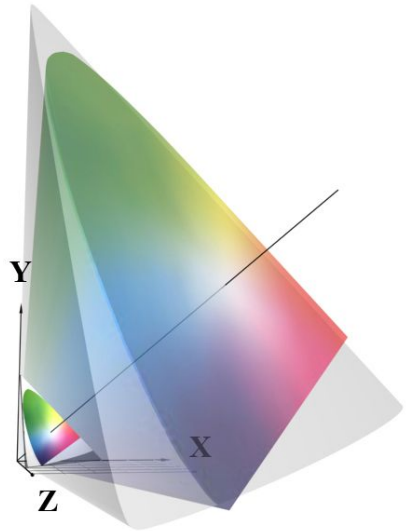
$$CCT = 449n^3 + 3525n^2 + 6823.3n + 5520.33$$

$$\text{where } n = ((0.23881)R + (0.25499)G + (-0.58291)B) / ((0.11109)R + (-0.85406)G + (0.52289)B)$$

- Colour characteristics of light
- Gives a general indication of the apparent "warmth" or "coolness" of the light emitted by the source

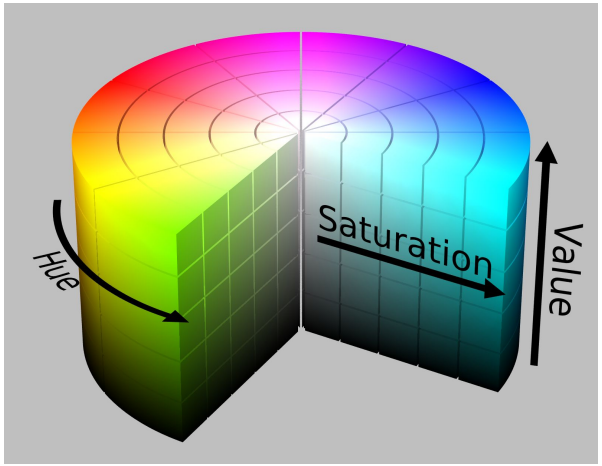
Feature Vector

CCT	Luminance	Saturation



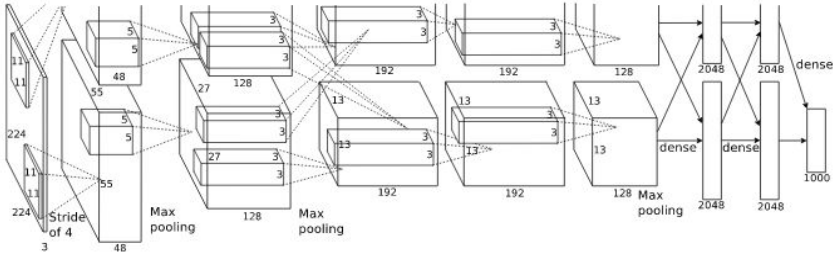
- Amount of energy an observer perceives from a light source
- $Log_2(Z)$

Feature Vector

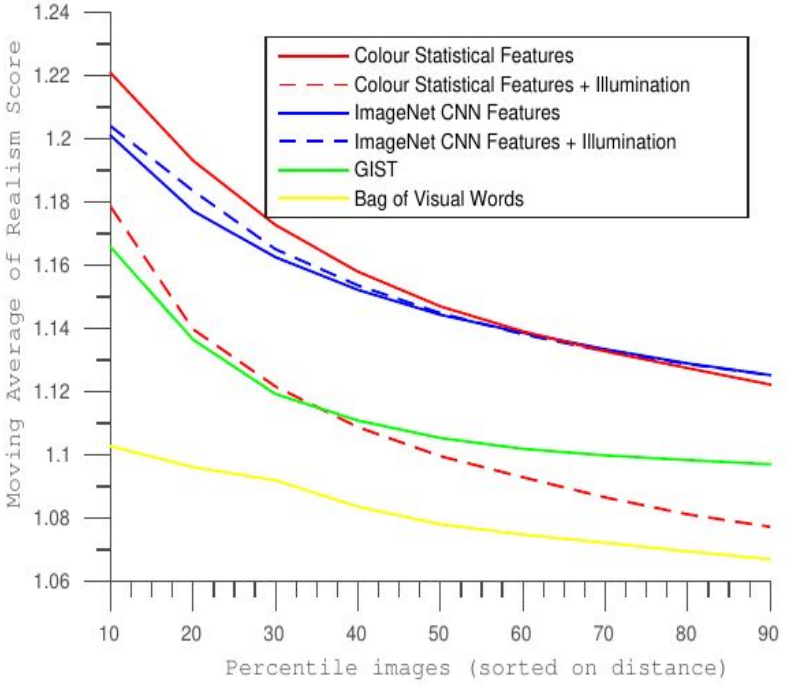


- Degree to which a pure color is dilated by white light.
- $Log_2(S)$

Alternate Features: ImageNet CNN Features



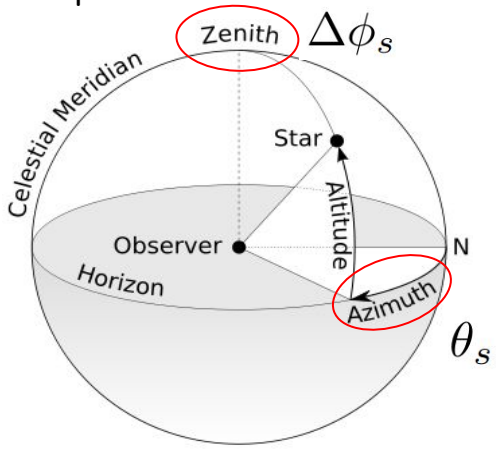
- Pretrained model: VGG19, ImageNet
- Performance close to the best

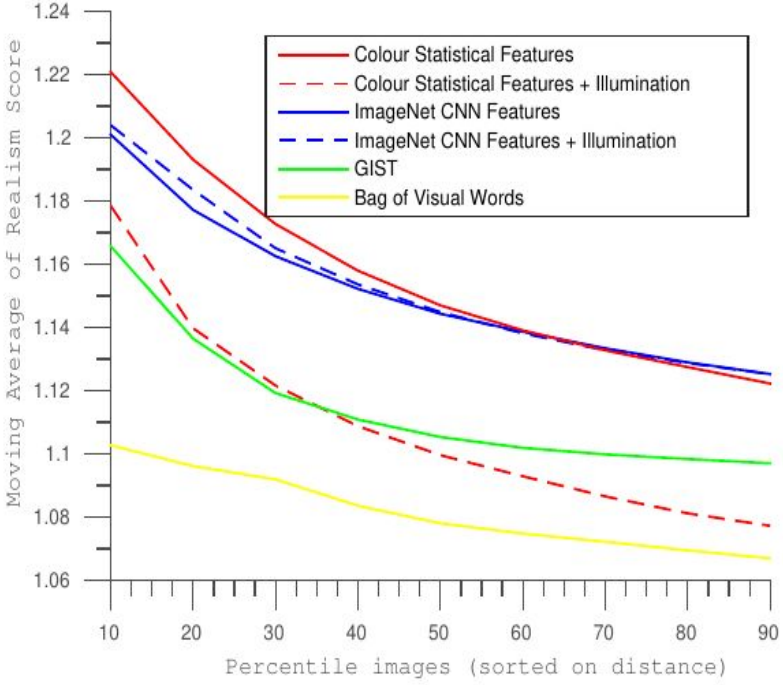


Alternate Features: Illumination Features

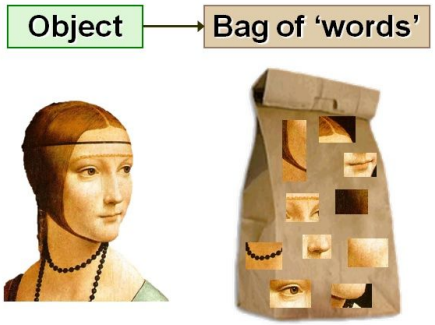
$$I = \{\theta_s, \Delta\phi_s, v_s\}$$

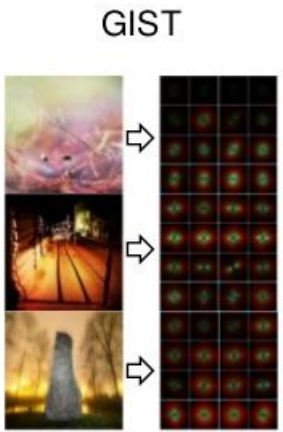
- Approach worked on by [Lalonde et al, ICCV '09]
- Function of sun zenith angle, sun azimuth angle and a binary variable for sun visibility
- Poor performance in ablation study

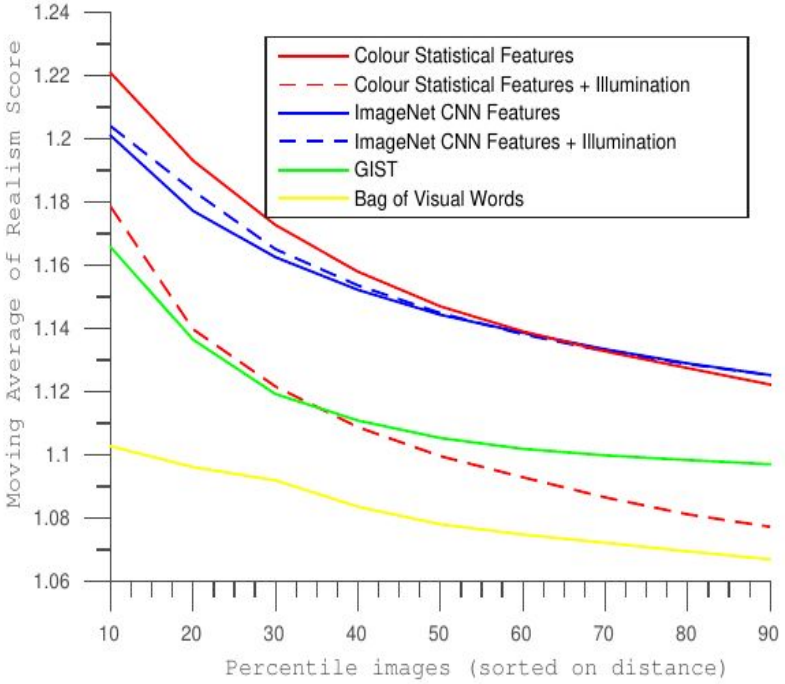




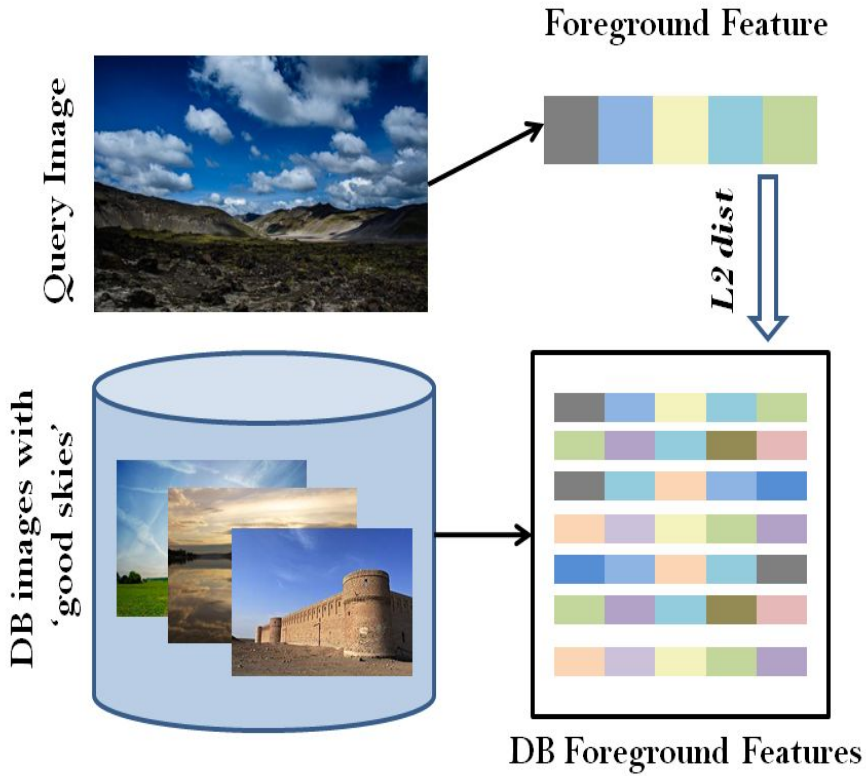
Alternate Features: Bag of Visual Words & GIST







Pipeline: Candidate Selection



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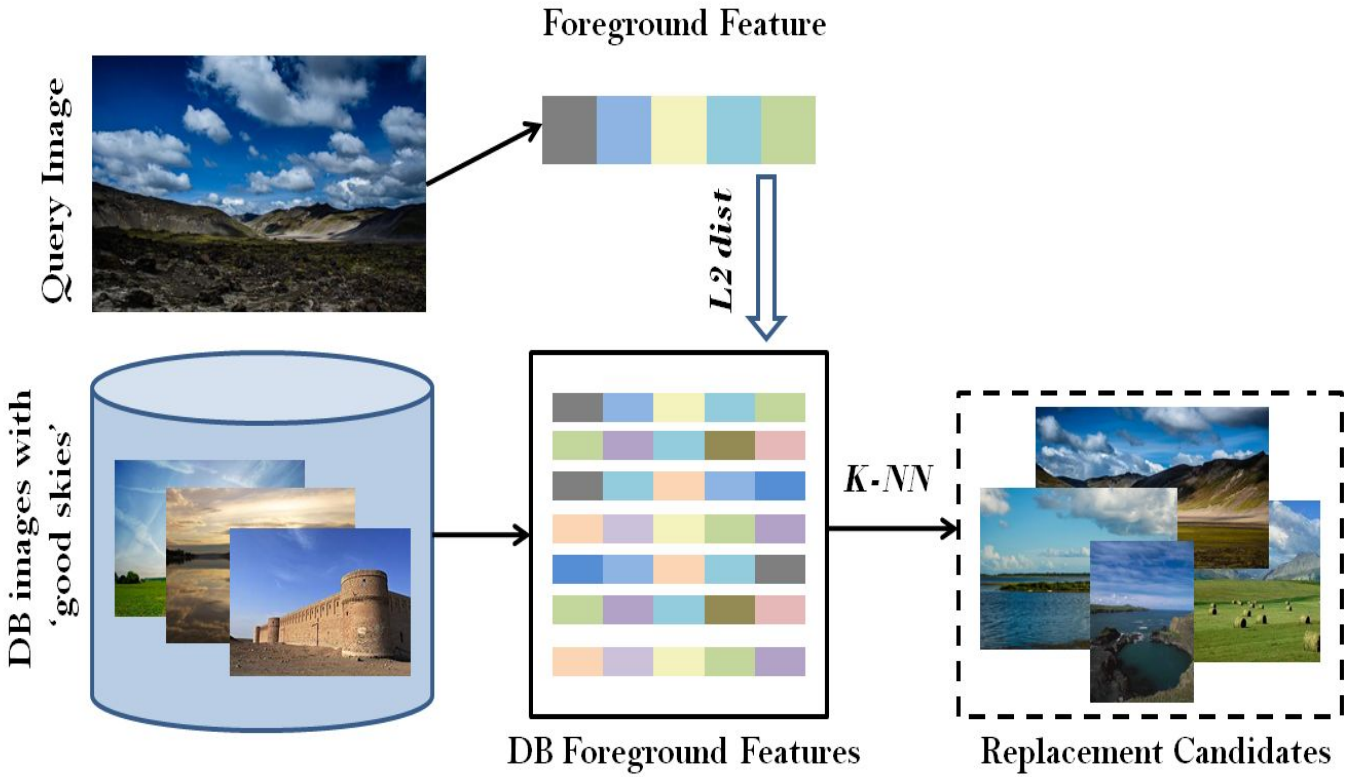
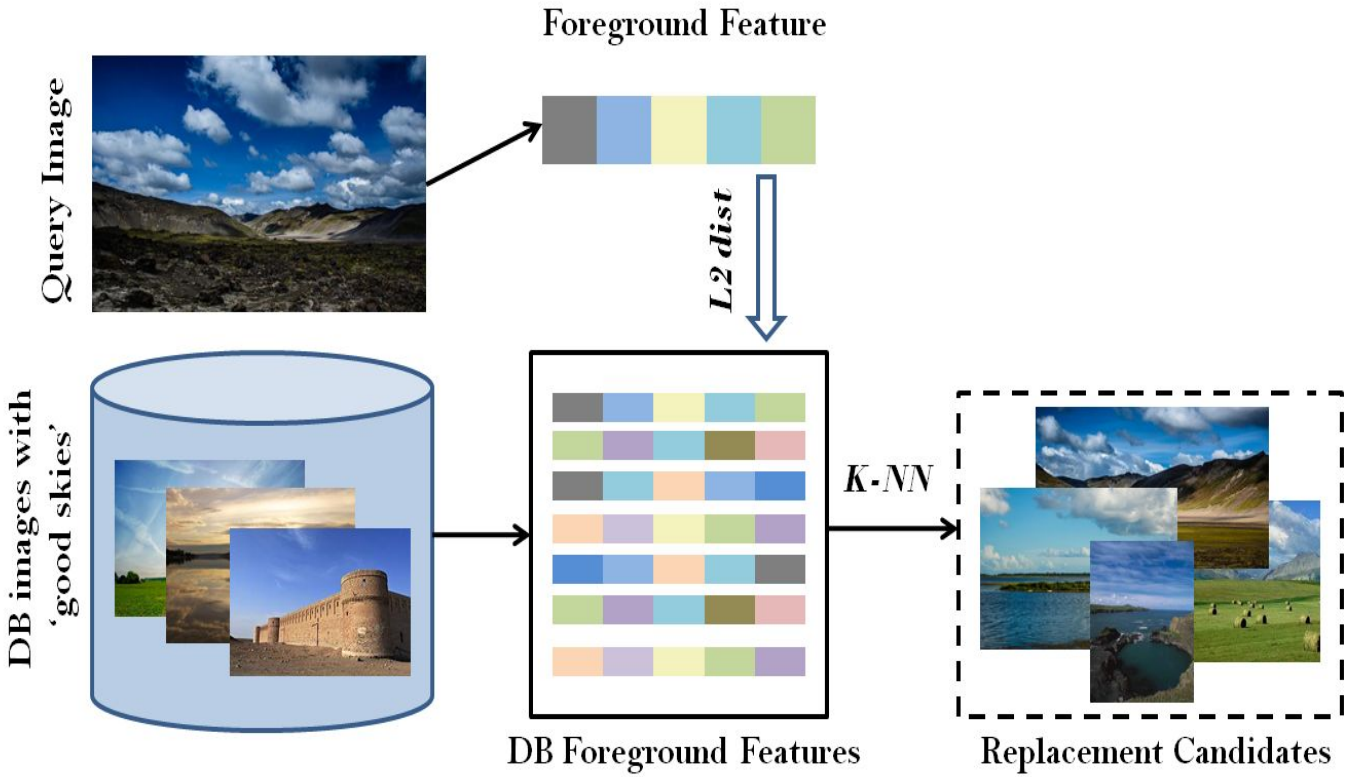


Pipeline: Candidate Selection

Pipeline: Sky Replacement



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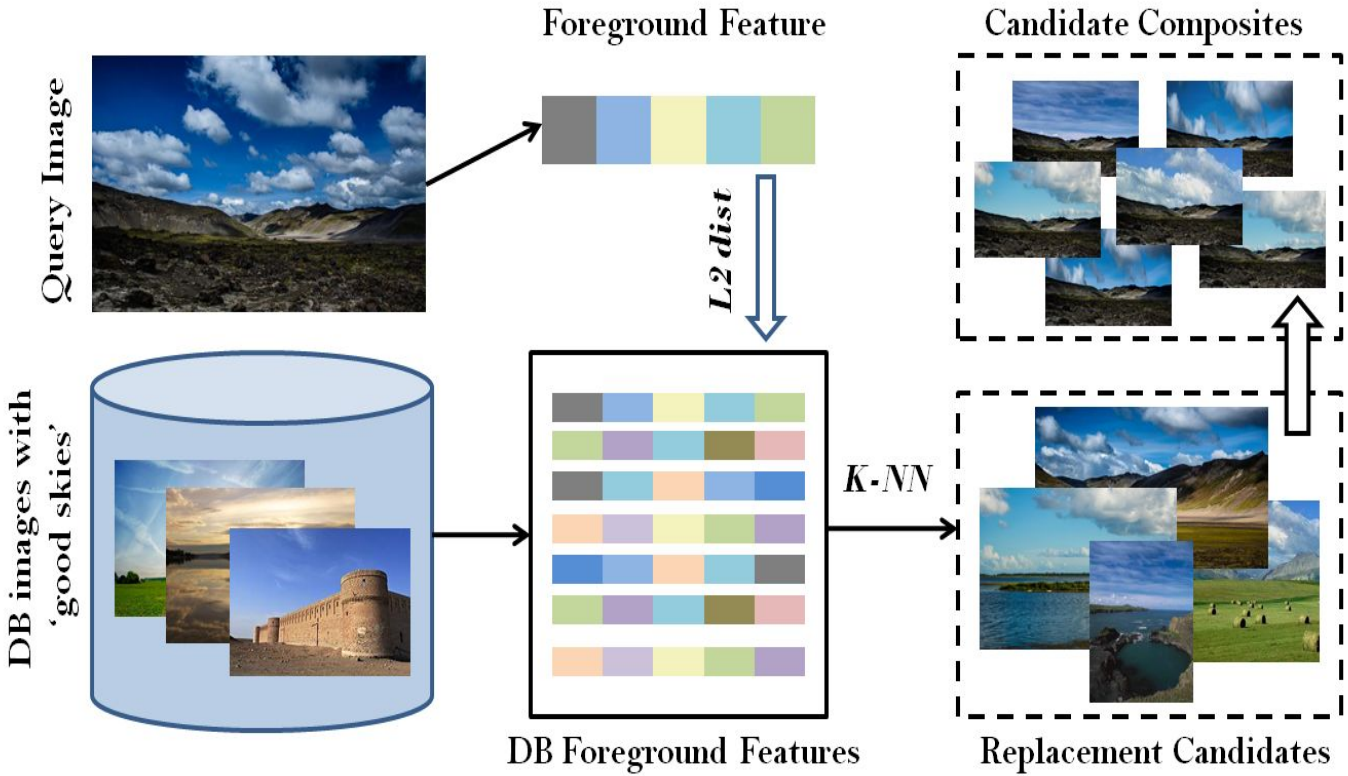
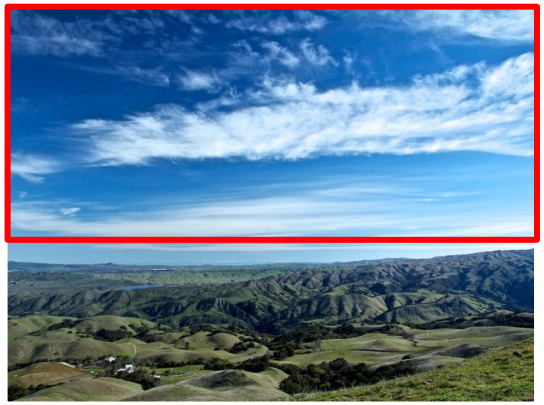


Pipeline: Sky Replacement

Reference

Input

Pipeline: Sky Replacement



Reference

Input

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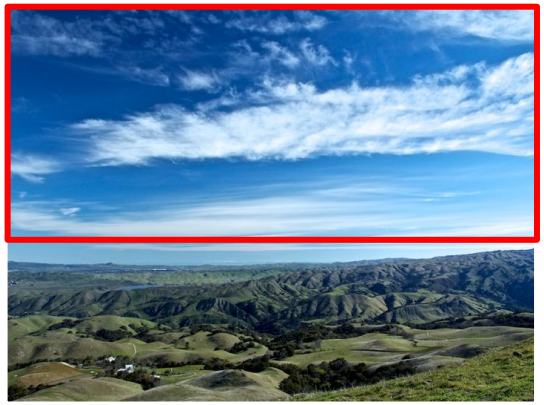

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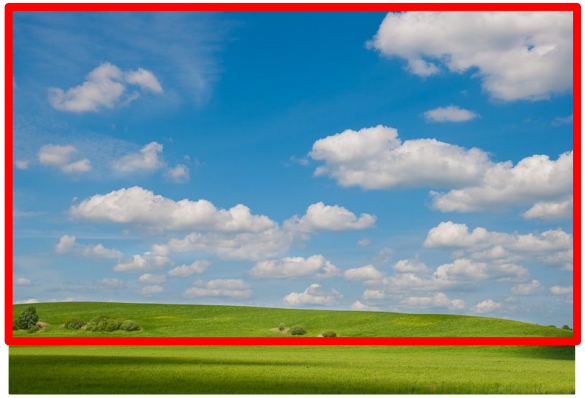

Input

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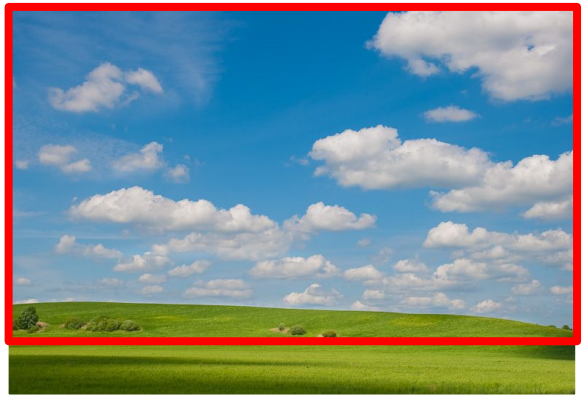
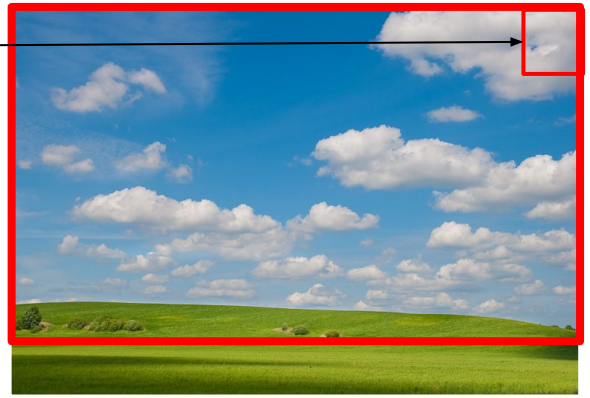


Input

Pipeline: Sky Replacement

Reference



Input

Pipeline: Sky Replacement

Reference

Sky replaced Input

Pipeline: Sky replacement

1

4

Similar

5

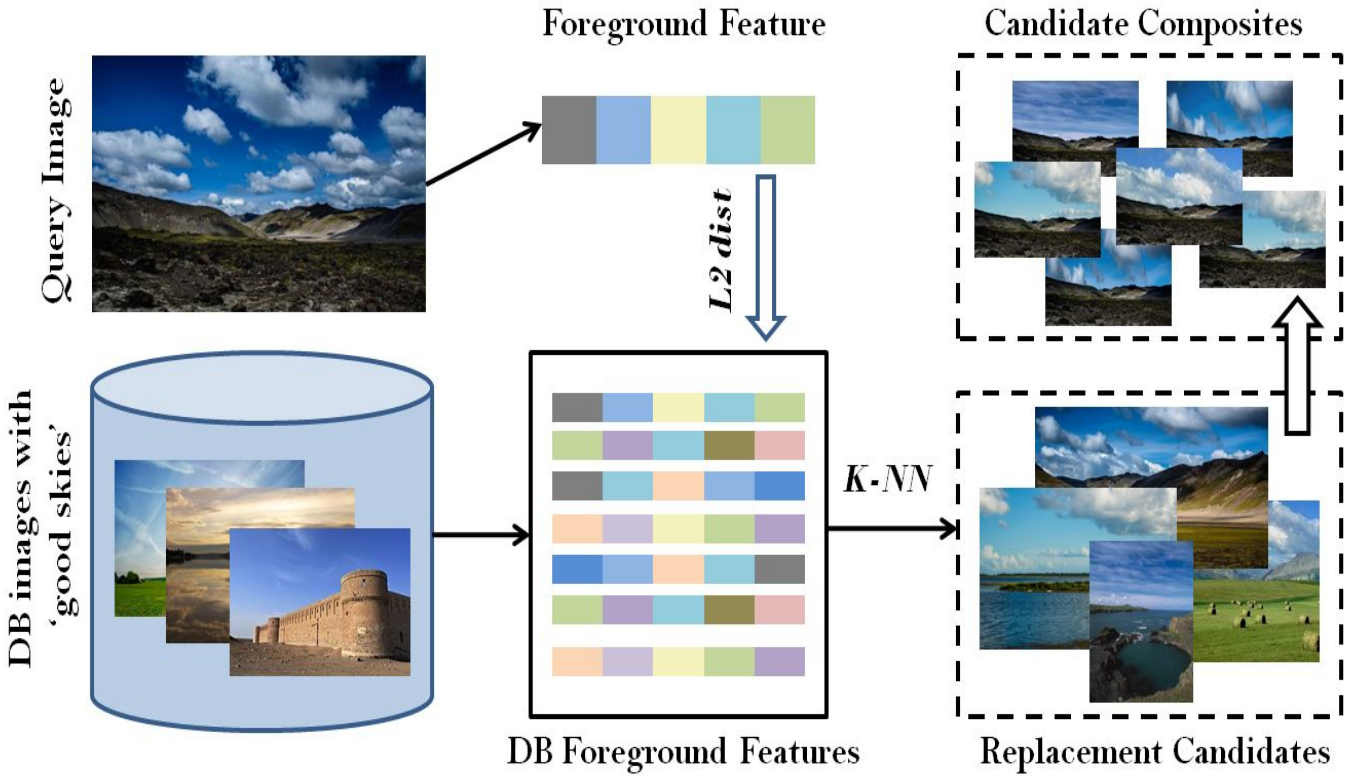
2

3

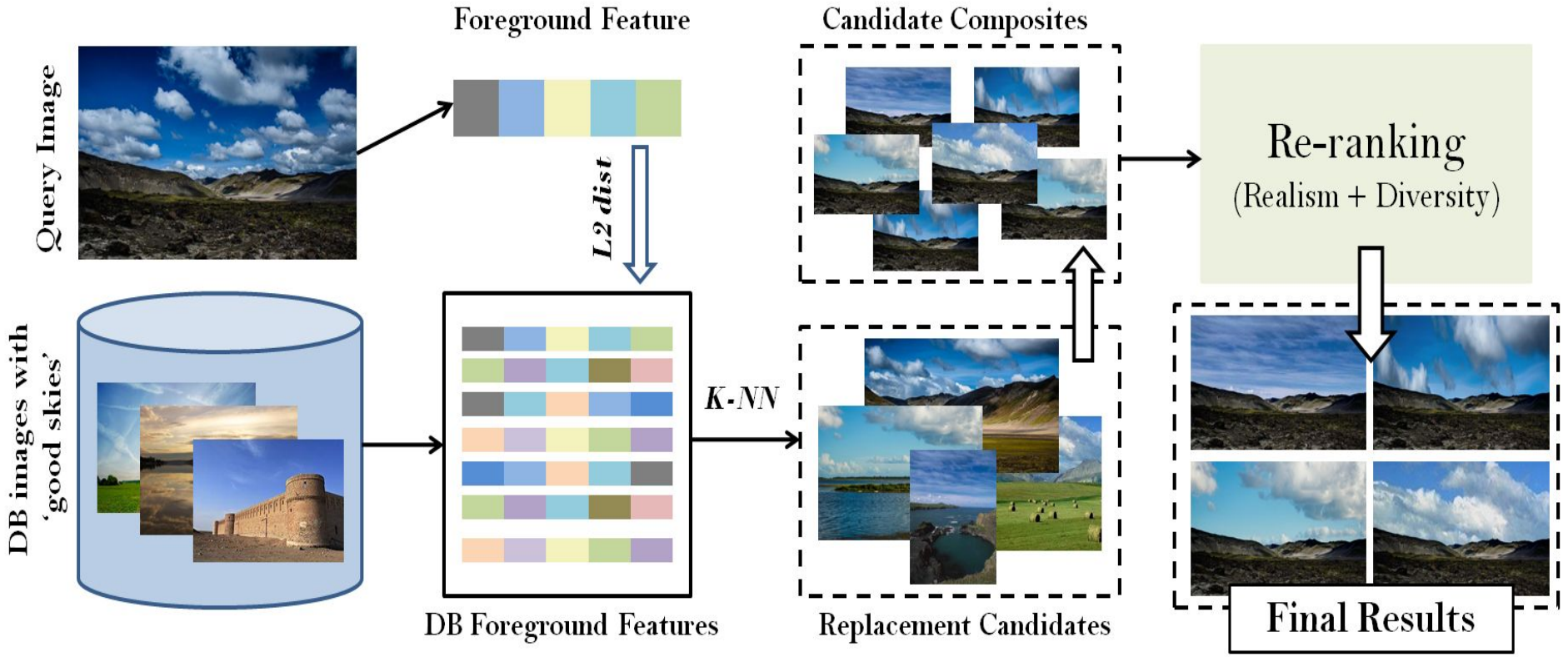
6

Pipeline: Sky replacement

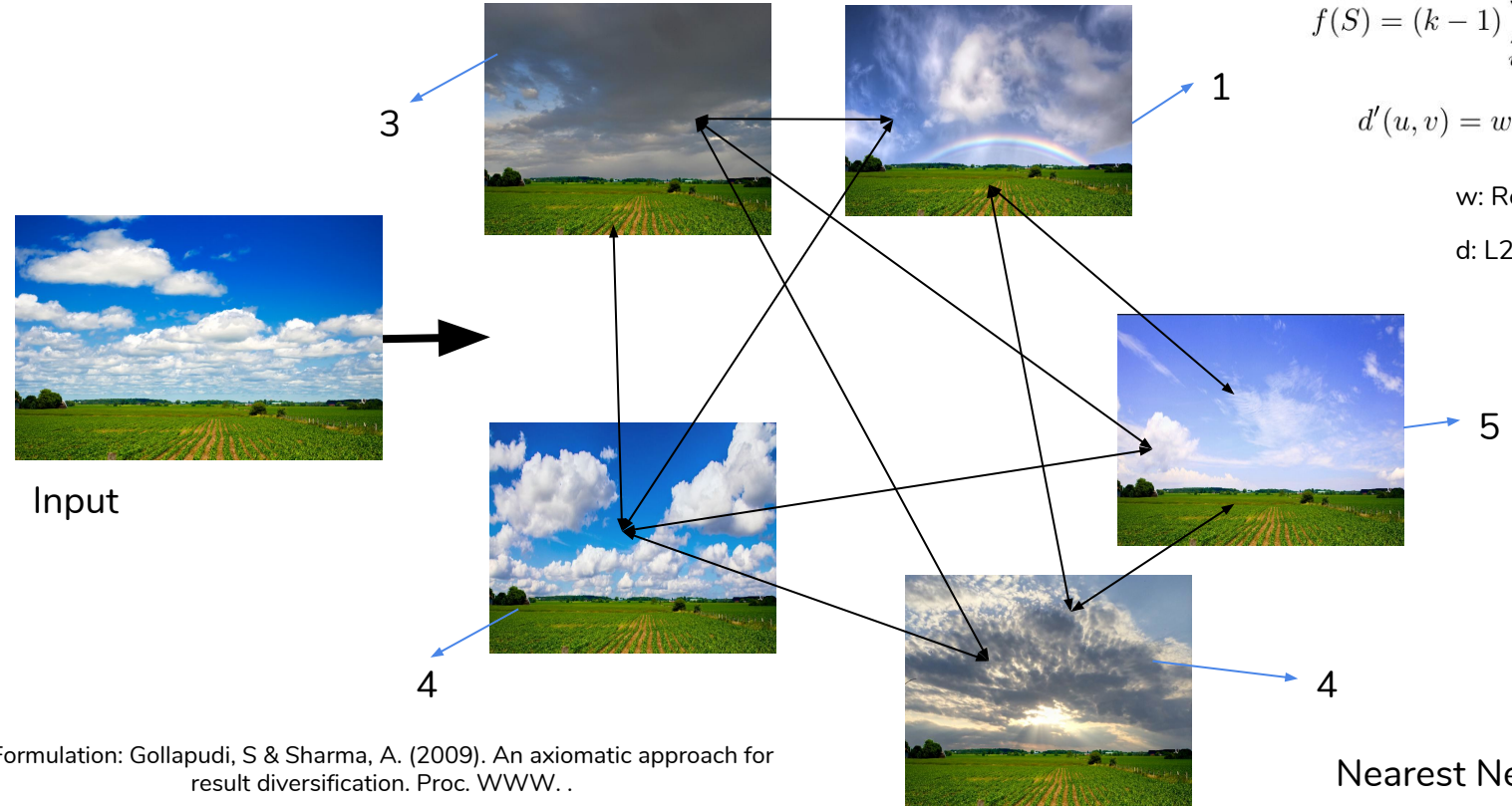
Pipeline: Reranking



Pipeline: Reranking



Pipeline: Reranking



$$f(S) = (k-1)\sum_{u \in S} w(u) + 2\lambda \sum_{u,v \in S} d(u,v)$$

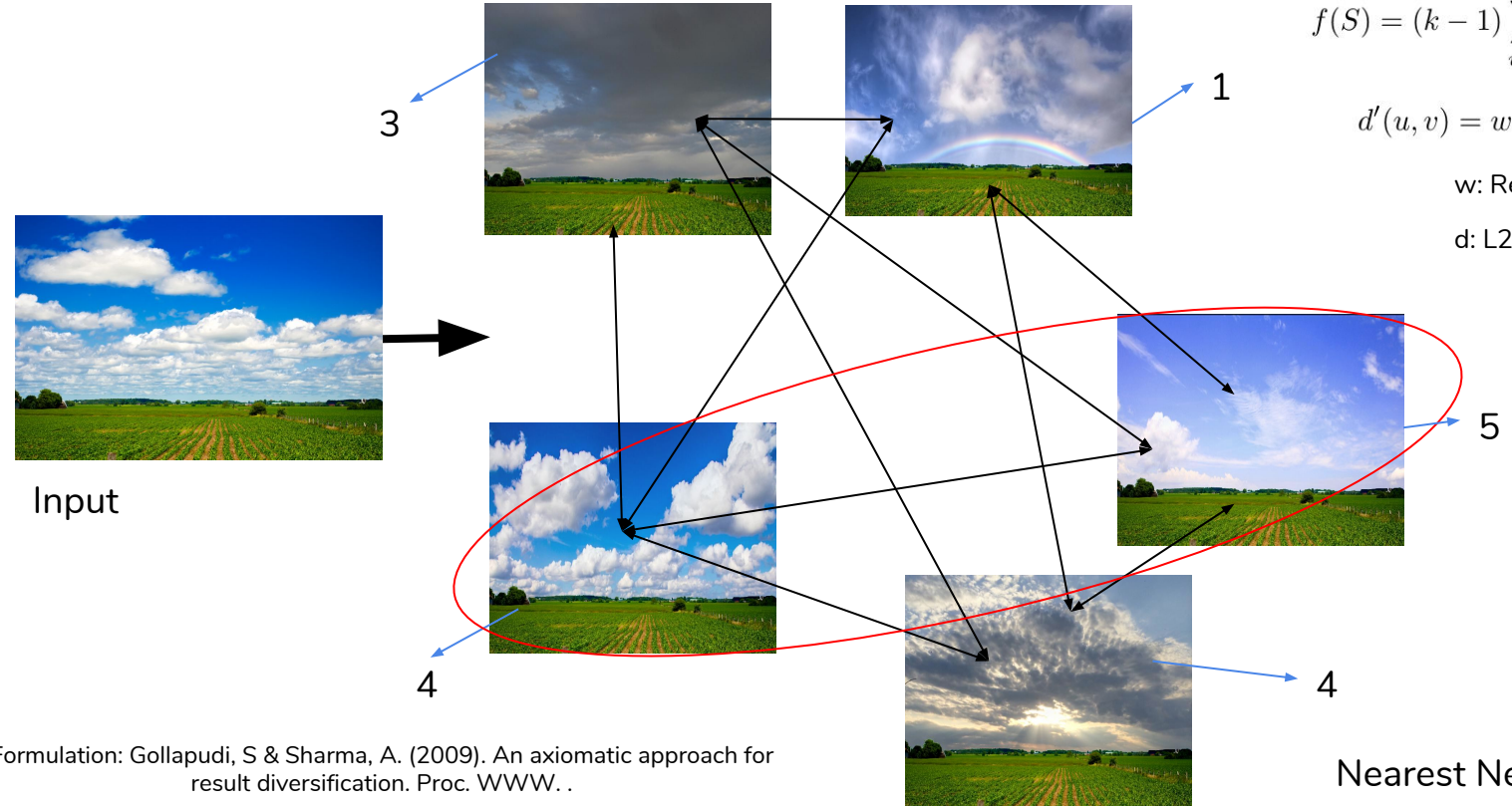
$$d'(u,v) = w(u) + w(v) + 2\lambda d(u,v)$$

w: Realism Score * Scale Ratio

d: L2 distance between sky regions

Formulation: Gollapudi, S & Sharma, A. (2009). An axiomatic approach for result diversification. Proc. WWW. .

Pipeline: Reranking



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Pipeline: Reranking

Input

3

1

4

Nearest Neighbours

Final sky candidates

Formulation: Gollapudi, S & Sharma, A. (2009). An axiomatic approach for result diversification. Proc. WWW. .

Results: Retrieval Of Skies

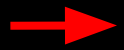
Results: Efficacy of Reranking

Results: Efficacy of Reranking

Results

Results

Results



Results

Results

Results

Validation: User Survey

Guideline : Please rate each picture from Very Bad to Very Good for its overall aesthetic appeal.

IMAGE1

Very bad Bad Okay Good Very Good

IMAGE2

Very bad Bad Okay Good Very Good

IMAGE3

Very bad Bad Okay Good Very Good

IMAGE4

Very bad Bad Okay Good Very Good

Submit Query

Validation: User Survey

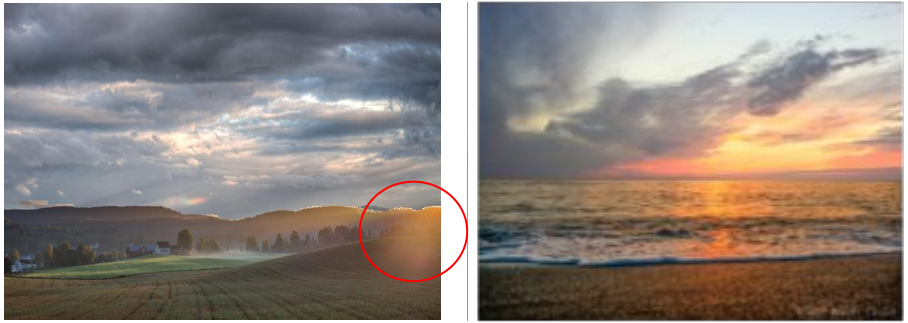
- Each image rated by >40 participants aged 20 to 35
- Median score: original image: 2.82 (below ‘okay’) ; composites: **3.12** (above ‘okay’)
- **83.33%** composites received a rating > query image

	min	max	mean	median
$\mathcal{R}_q > \text{all } \mathcal{R}_c$	0%	52%	12.72%	8.6%
$\text{any } \mathcal{R}_c \geq \mathcal{R}_q$	48.48%	100%	87.32%	91.4%
$\text{any } \mathcal{R}_c > \mathcal{R}_q$	10.5%	81.67%	43.38%	43.31%

Limitations

The visual appearance of specular reflections is not accounted for in the feature vector currently.

Limitations



Future Scope

Scope

Also spatial colour properties need to be accounted for in cases such as the following.

Conclusion

- Data driven model for Automatic Sky Replacement
- No need for manual edits
- Images with matching foreground color statistical properties have interchangeable backgrounds

Original blown out sky image

Future Work

- Compatible sky generation by training VAEs.
- Visual feature learning algorithm driven by context-based pixel prediction for sky pixels.

Generate an artificial sky

Get in touch!

Project page:
https://cvit.iiit.ac.in/research/projects/cvit-projects/findmeasky

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siddhartha.gairola@research.iiit.ac.in
rajvi.shah@research.iiit.ac.in
pjn@iiit.ac.in

Image & Video Sources

Introduction clip: A SOCIAL LIFE - A Short Film Written & Directed By Kerith Lemon

Motivation image #2: Photoshop Tutorial: How to Replace a Burnt-out Sky in a Photo, BlueLighteningTV

Feature Vector Illustration:

- CCT: DSP stackexchange
- Saturation: Canvas, Stackoverflow
- Luminance: A Problem with the Use of XYZ Colour Space for Photorealistic Rendering Computations [Ulbricht et. al]
- CNN: ImageNet Classification with Deep Convolutional Neural Networks [Krizhevsky et. al]

Thank You!