Disparate Image Matching using DUDE (Duality Descriptor)

EE604 Course Project
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Motivation

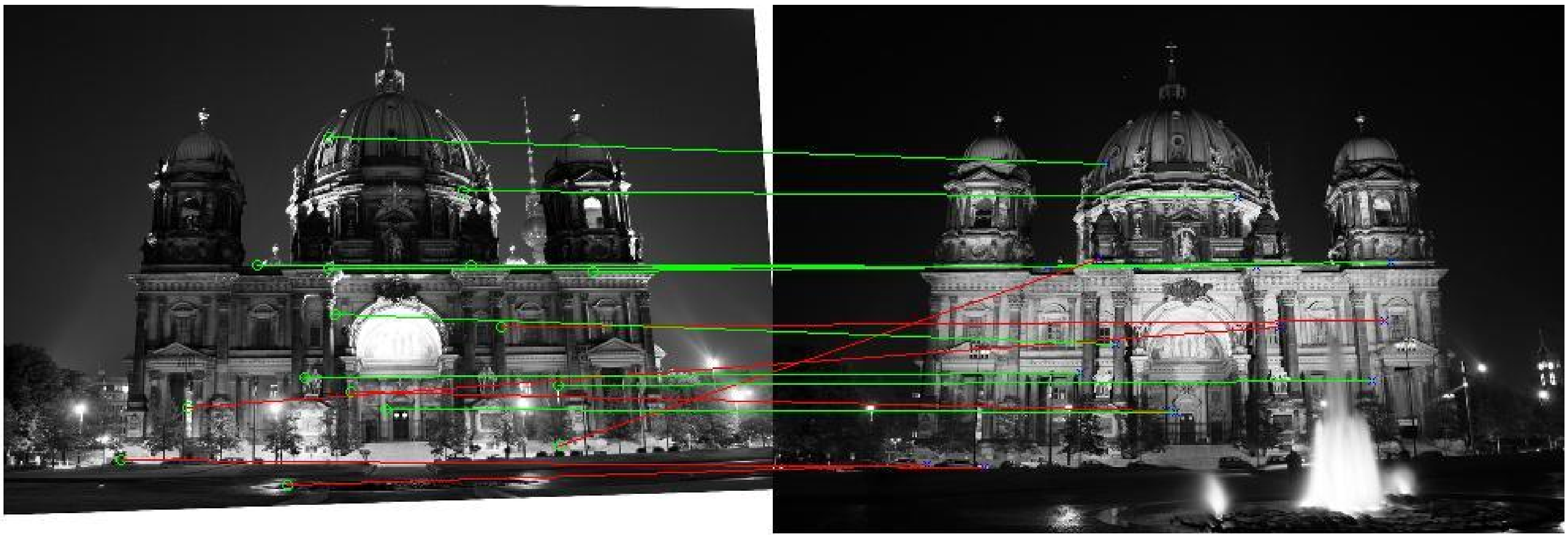

Image Correspondence

- Image matching
- 3D reconstruction
- Object Tracking
- Object Recognition
- Depth Estimation

Disparate Images

Challenging Input: Painting vs. Image, different time of day, different centuries, different image sensors etc.

Image Source: Image Source: Kwon, Youngwook P., et al. "Dude (Duality descriptor): A robust descriptor for disparate images using line segment duality." *Image Processing (ICIP), 2016 IEEE International Conference on*. IEEE, 2016.

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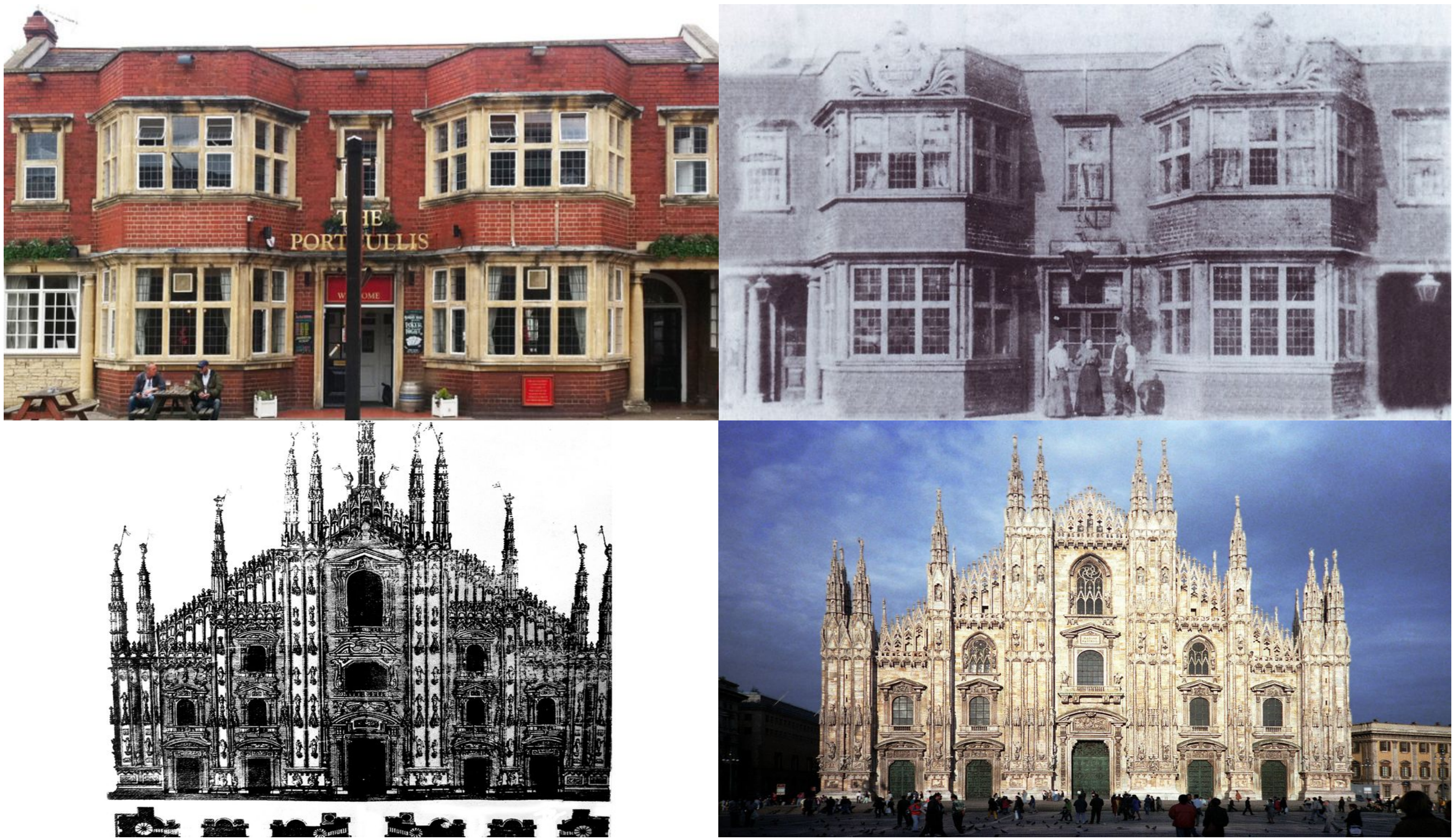
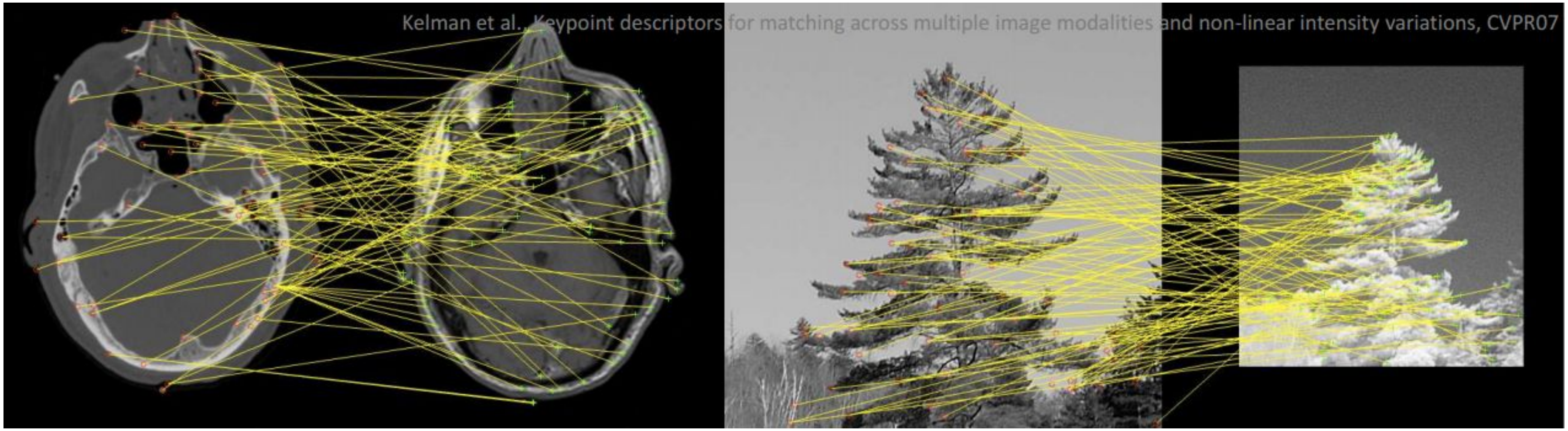


Image Source: Image Source: Kwon, Youngwook P., et al. "Dude (Duality descriptor): A robust descriptor for disparate images using line segment duality." *Image Processing (ICIP), 2016 IEEE International Conference on*. IEEE, 2016.

SIFT on difficult input



CT (Computed Tomography)

MR (Magnetic Resonance)

EO (Electro-Optics)

IR (Infra-Red)

Very few correct matches!

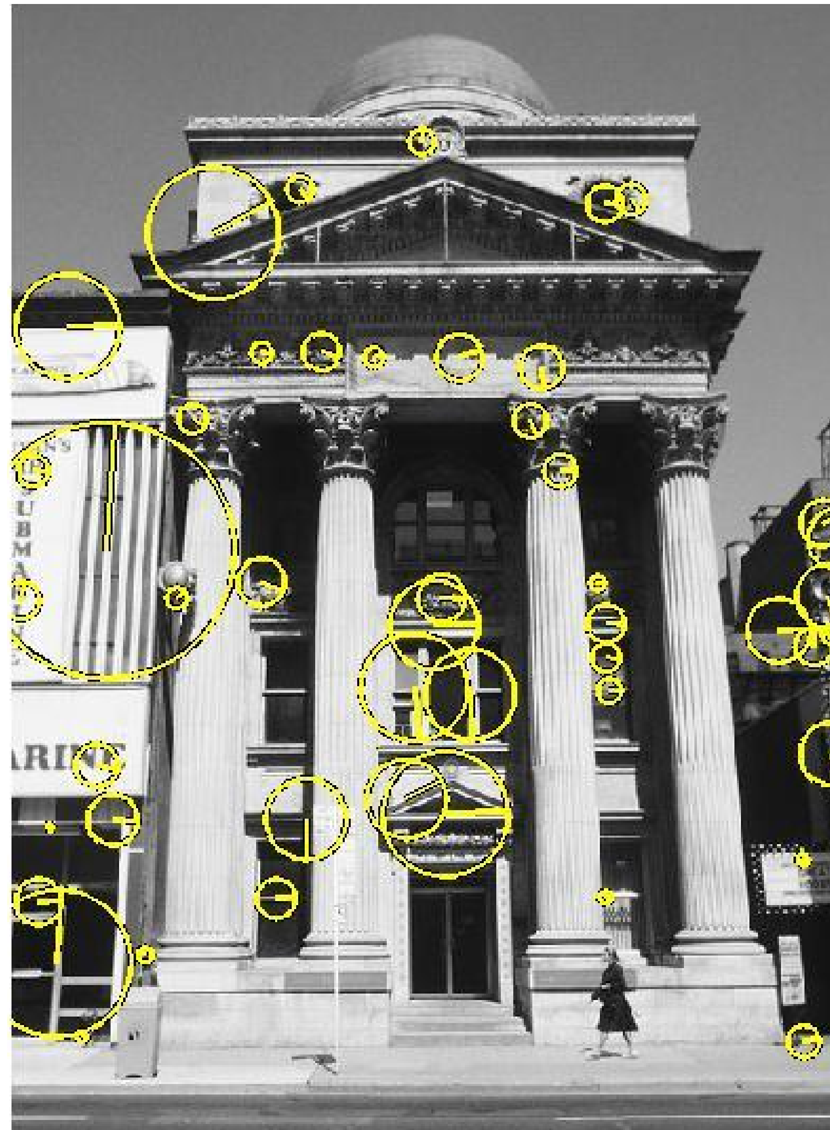
Image Source: Kwon, Youngwook P., et al. "Dude (Duality descriptor): A robust descriptor for disparate images using line segment duality." *Image Processing (ICIP), 2016 IEEE International Conference on*. IEEE, 2016.

Basics of Image Matching

Feature detector
provides a list of (x,y,s,θ)

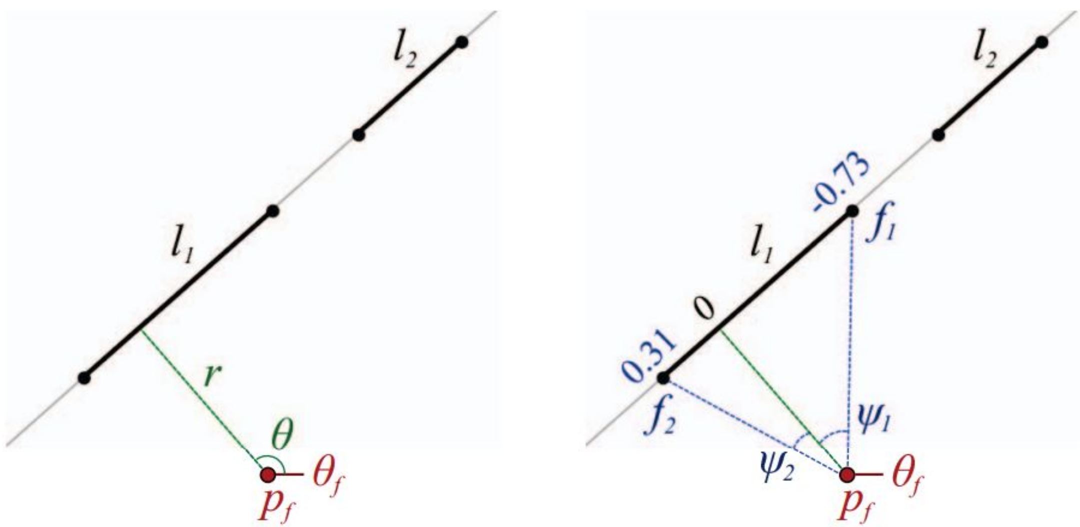
Location Scale Orientation

Feature descriptor
assigns each detected feature a descriptor
"how it looks"



Dual Representation of Line Segments

- DUDE uses a line segment distribution
  - Less parameter sensitive, more information than pixels
  - Mathematically and geometrically easier
- A line represented as (r,θ) in dual space
- f-dimension indicates location of line segment on that infinite line
- Line segment represented by (r,θ,f_1,f_2) in the dual space



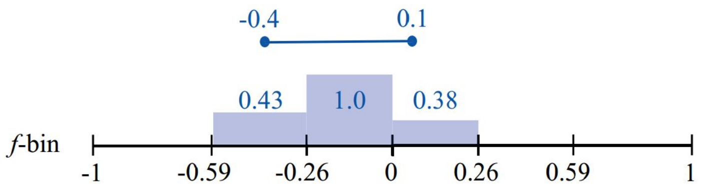
(a) r and θ (b) f

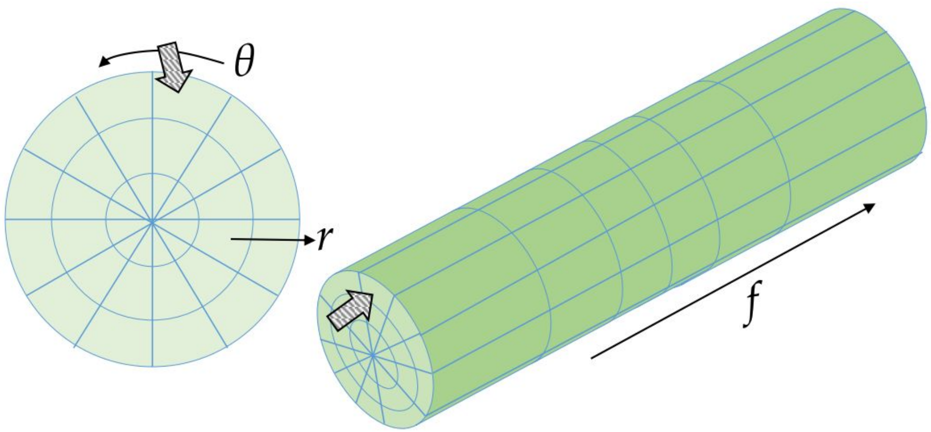
Image Source: Kwon, Youngwook P., et al. "Dude (Duality descriptor): A robust descriptor for disparate images using line segment duality." *Image Processing (ICIP), 2016 IEEE International Conference on*. IEEE, 2016.

DUDE feature descriptor

For each feature $\mathbf{F}_i$ we do the following:

1. Identify the set of line segments ‘near’ $\mathbf{F}_i$
2. Convert that set into the dual space
3. Perform binning in (r, θ, f) to get a 3D histogram
    a. r and theta axis divided uniformly into n_r and n_θ bins, respectively
    b. f_1 and f_2 denote endpoints of line segment, so segments are binned as a range, contributing to bins by coverage percentage
4. We get a (n_r x n_θ x n_f)-dimension descriptor





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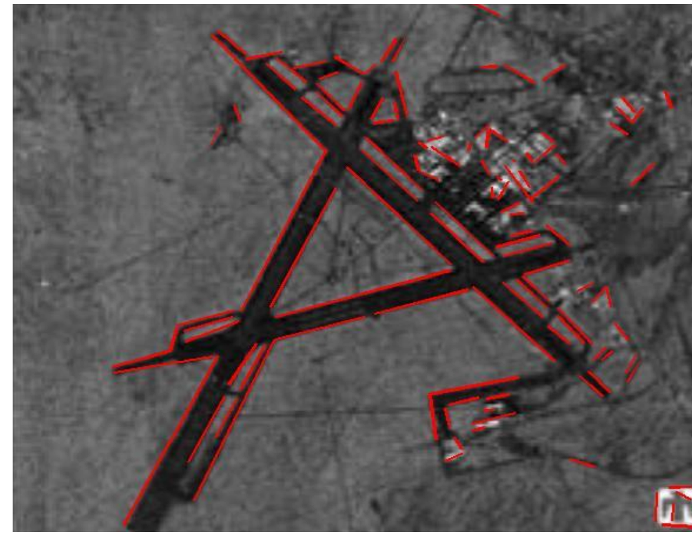
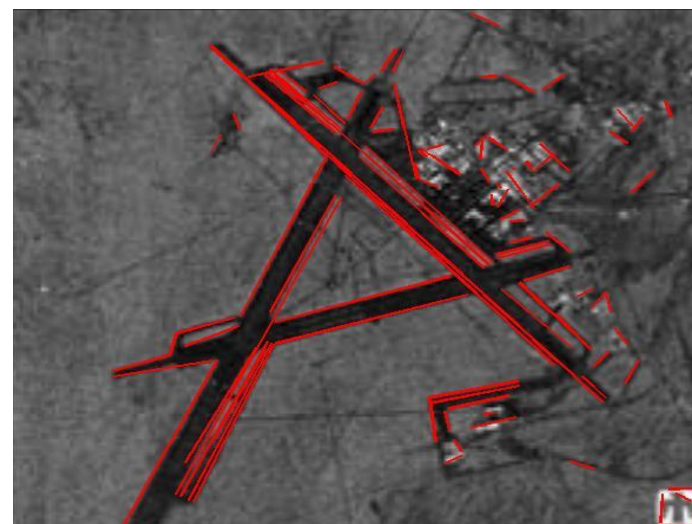
MMID (Multi-Modal Image Detector)

Target: Generate a set of repeatable features across disparate images which are more suited for the DUDE descriptor

- Because DUDE descriptors use line segments, MMID derives a feature per line segment: (x_i, y_i) at its midpoint, s_i as half length, and θ_i its orientation
- For greater consistency of feature detection, MMID generates multiple groupings of line segments from the initial proposals (by existing techniques like LSD) by randomly merging them incrementally
- The merged line segments are then used for extracting features



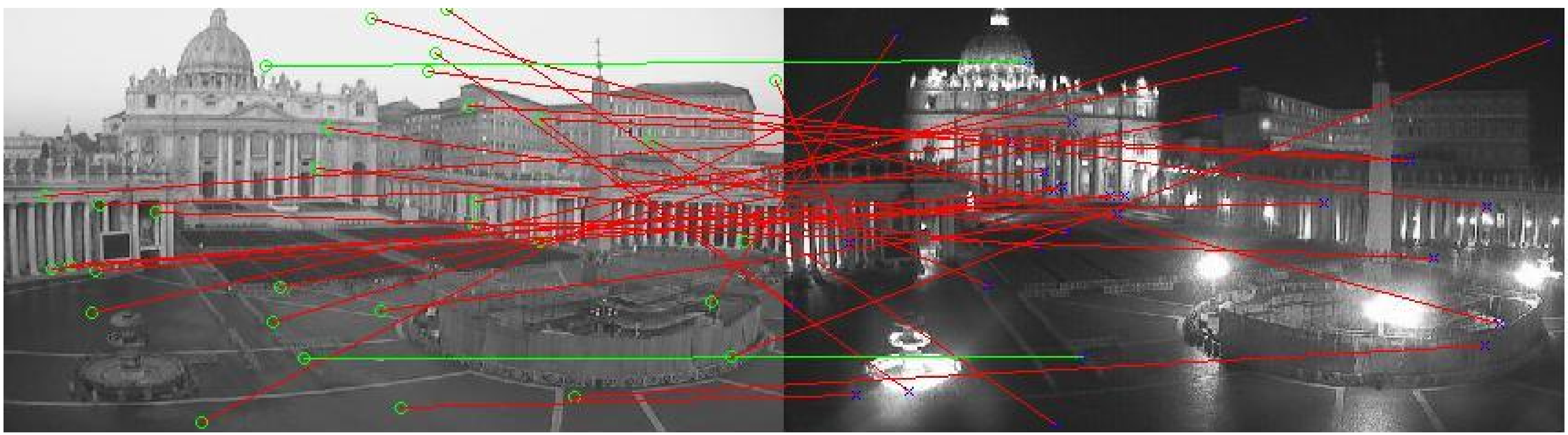


Contribution

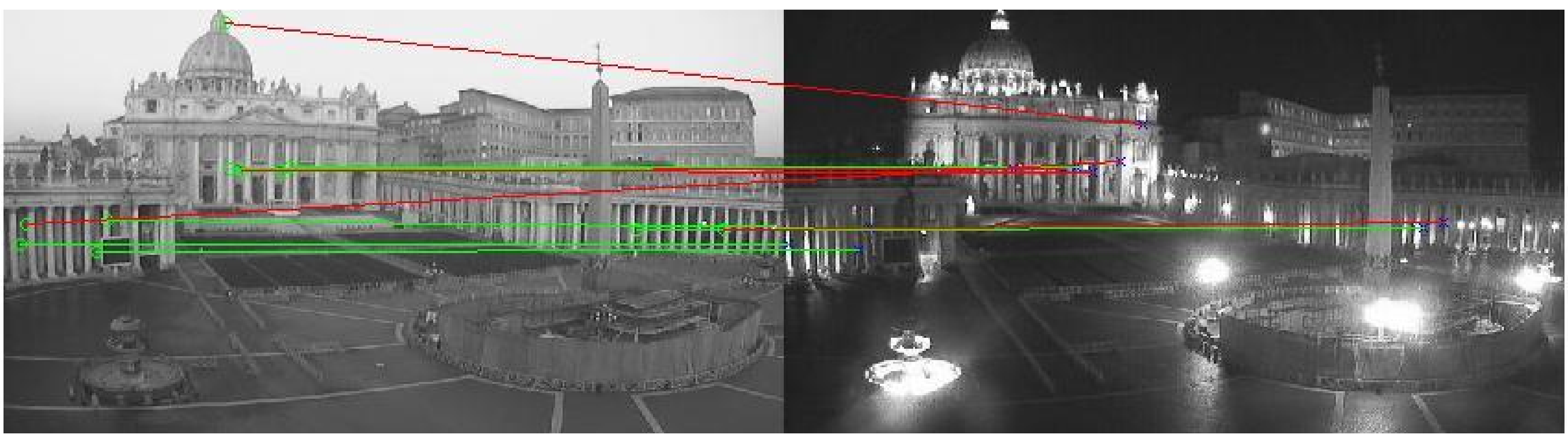
- No implementation of DUDE descriptor or MMID detector available, we implemented both of them ourselves in MATLAB
- Code will be cleaned and released soon on Github
- Used other existing feature descriptors like SIFT, SURF, MSER, SYM-I and SYM-G to compare against our implementation of DUDE

Qualitative Results

SIFT



DUDE



Qualitative Results

SIFT

DUDE

Quantitative Results

mAP on an image pair

Detectors

Descriptors	SIFT	SYM-I	SYM-G	JSPEC	MMID
SIFT	**0.1878**	0.28	0.25	0.61	**0.1**
SYMD	0.22	0.20	0.25	-	0.26
SIFT-SYMD	0.28	0.35	0.36	-	-
DUDE	**0.1121**	**0.1741**	**0.2009**	-	**0.5343**

Quantitative Results

Repeatability on an image pair from dataset

Features

	SIFT	**MMID**
k = 50	0.0327	0.0979
k = 100	0.0524	0.1264
k =200	0.11	0.18
k =300	0.14	0.1825

Conclusion

- We implemented a novel feature detection and description system for disparate image matching
- DUDE outperforms existing descriptors like SIFT, MSER on disparate image dataset
- Combined with the MMID detector, DUDE achieves results close to state-of-the-art with significantly more efficient computation

Thank You