Exploring uncertainties and subjective decisions in ecosystem modeling: the Icelandic Atlantis model

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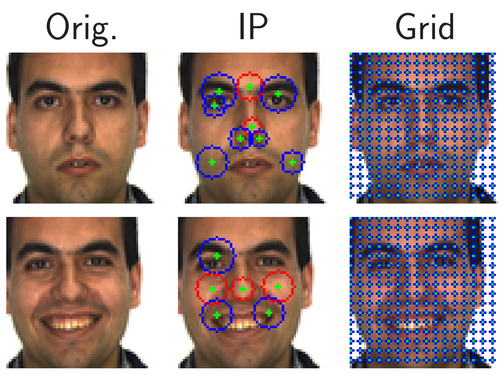
MareFrame

Introduction

- Atlantis[1] is a whole-of-system ecosystem model
- Deterministic biodemographic and biogeochemical box model
- Tracks the flow of nitrogen through biological and detrital groups
- Includes the following submodels:
  - Oceanographic
  - Biological
  - Fisheries
  - Economic
  - Assessment
- Models all the major processes
- Models invertebrates as biomass pools (mg N/m^2 or mg N/m^3) and vertebrates as age-structured models
- Intended to be used strategically not tactically
- Data intensive
- Uncertainty and subjective during model development and calibration

Feature Extraction

- Interest point based feature extraction
  - SIFT or SURF interest point detector
  - leads to a very sparse description
- Grid-based feature extraction
  - overlaid regular grid
  - leads to a dense description



Feature Description

- Scale Invariant Feature Transform (SIFT)
  - 128-dimensional descriptor, histogram of gradients, scale invariant
- Speeded Up Robust Features (SURF)
  - 64-dimensional descriptor, histogram of gradients, scale invariant
- face recognition: invariance w.r.t. rotation is often not necessary
  - rotation dependent upright-versions U-SIFT, U-SURF-64, U-SURF-128

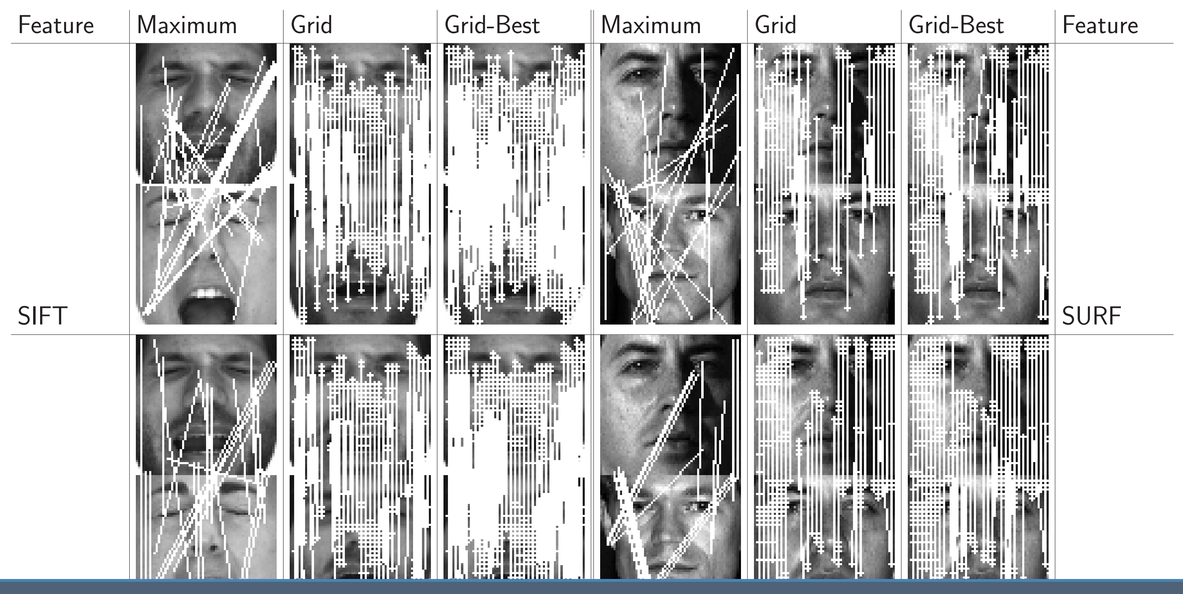
Feature Matching

- Recognition by Matching
  - nearest neighbor matching strategy
  - descriptor vectors extracted at keypoints in a test image X are compared to all descriptor vectors extracted at keypoints from the reference images $Y_n, n = 1, \cdots, N$ by the Euclidean distance
  - decision rule:

$$X \to r(X) = \arg\max_c \left\{ \max_n \left\{ \sum_{x_i \in X} \delta(x_i, Y_{n,c}) \right\} \right\}$$

  - additionally, a ratio constraint is applied in $\delta(x_i, Y_{n,c})$
- Viewpoint Matching Constraints
  - maximum matching: unconstrained
  - grid-based matching: absolute box constraints
  - grid-based best matching: absolute box constraints, overlapping
- Postprocessing
  - RANSAC-based outlier removal
  - RANSAC-based system combination

Matching Examples for the AR-Face and CMU-PIE Database



Databases

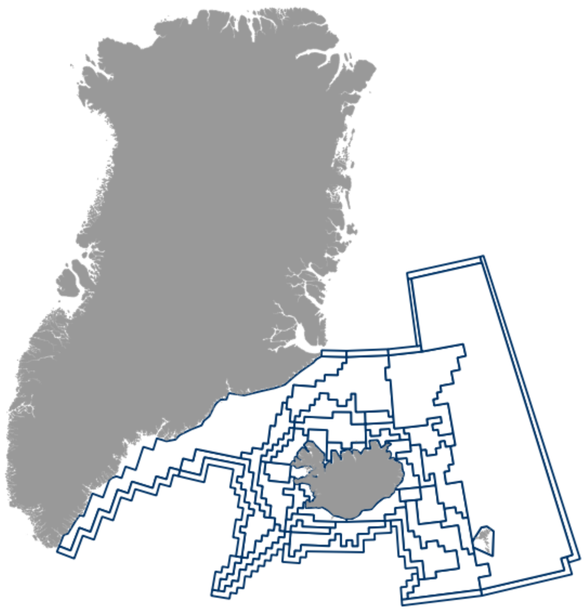


Figure 1. The Atlantis Iceland Model Domain.

Results: Manually Aligned Faces

- AR-Face: 110 classes, 770 train, 770 test

Descriptor	Extraction	# Features	Error Rates [%]		
			Maximum	Grid	Grid-Best
SURF-64	IPs	164 × 5.6 (avg.)	80.64	84.15	84.15
SIFT	IPs	128 × 633.78 (avg.)	1.03	95.84	95.84
SURF-64	64x64-2 grid	164 × 1024	0.90	0.51	0.90
SURF-128	64x64-2 grid	128 × 1024	0.90	0.51	0.38
SIFT	64x64-2 grid	128 × 1024	11.03	0.90	0.64
U-SURF-64	64x64-2 grid	164 × 1024	0.90	1.03	0.64
U-SURF-128	64x64-2 grid	128 × 1024	1.55	1.29	1.03
U-SIFT	64x64-2 grid	128 × 1024	**0.25**	**0.25**	**0.25**

- CMU-PIE: 68 classes, 68 train ("one-shot" training), 1360 test

Descriptor	Extraction	# Features	Error Rates [%]		
			Maximum	Grid	Grid-Best
SURF-64	IPs	164 × 6.80 (avg.)	93.95	95.21	95.21
SIFT	IPs	128 × 723.17 (avg.)	43.47	99.33	99.33
SURF-64	64x64-2 grid	164 × 1024	13.41	4.12	7.82
SURF-128	64x64-2 grid	128 × 1024	12.45	3.68	3.24
SIFT	64x64-2 grid	128 × 1024	27.92	7.00	9.80
U-SURF-64	64x64-2 grid	164 × 1024	**3.83**	**0.51**	**0.66**
U-SURF-128	64x64-2 grid	128 × 1024	5.67	0.95	0.88
U-SIFT	64x64-2 grid	128 × 1024	16.28	1.40	6.41

Results: Unaligned Faces

- Automatically aligned by Viola & Jones

Descriptor	Error Rates [%]	
	AR-Face	CMU-PIE
SURF-64	5.97	15.32
SURF-128	5.71	11.42
SIFT	5.45	8.32
U-SURF-64	5.32	5.52
U-SURF-128	5.71	**4.86**
U-SIFT	**4.15**	8.99

- Manually aligned faces

- Unaligned faces

Results: Partially Occluded Faces

- AR-Face: 110 classes, 110 train ("one-shot" training), 550 test

Descriptor	Error Rates [%]					
	AR1scarf	*AR1sun*	*ARneutral*	*AR2scarf*	*AR2sun*	Avg.
SURF-64	2.72	30.00	0.00	4.54	47.27	16.90
SURF-128	1.81	23.63	0.00	3.63	40.90	13.99
SIFT	1.81	24.54	0.00	2.72	44.54	14.72
U-SURF-64	4.54	23.63	0.00	4.54	47.27	15.99
U-SURF-128	1.81	**20.00**	0.00	3.63	41.81	13.45
U-SIFT	**1.81**	20.90	**0.00**	**1.81**	**38.18**	**12.54**
U-SURF-128+R	1.81	19.09	0.00	3.63	43.63	13.63
U-SIFT+R	2.72	**14.54**	0.00	**0.90**	35.45	10.72
U-SURF-128+U-SIFT+R	**0.90**	16.36	**0.00**	2.72	**32.72**	**10.54**

Conclusions

- Grid-based local feature extraction instead of interest points
- Local descriptors:
  - upright-descriptor versions achieved better results

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