Comparing Shape and Texture Features for Pattern Recognition in Simulation Data

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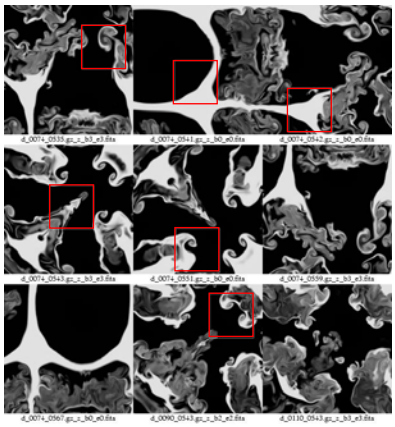
http://www.llnl.gov/casc/sapphire/

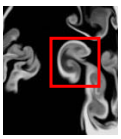
Regions of interest in 2D simulation data



3-D shock tube simulation obtained on IBM-SP Sustained Stewardship TeraOp system at Lawrence Livermore National Laboratory
http://www.llnl.gov/CASC/asciturb/

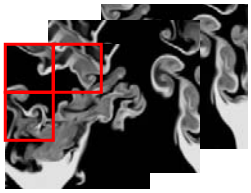
Feature-based similarity retrieval

Query image



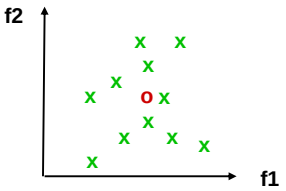
T_q: $f1_q$ $f2_q$ $f3_q$ $f4_q$ .... fn_q

Database



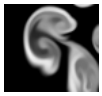
T_1: $f1_1$ $f2_1$ $f3_1$ $f4_1$ .... fn_1
T_2: $f1_2$ $f2_2$ $f3_2$ $f4_2$ .... fn_2
T_3: $f1_3$ $f2_3$ $f3_3$ $f4_3$ .... fn_3
....

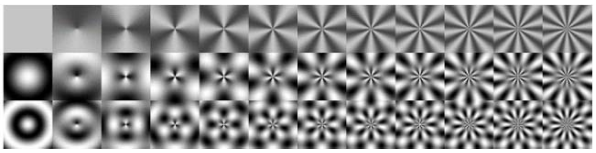
- Extract "objects"
- Represent using features
- Similarity search



Region-based shape features

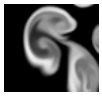
- Angular Radial Transform (ART)
- Projection onto basis functions
  - Angular = complex exponential function
  - Radial = cosine function
- MPEG-7 standard
- Rotationally invariant





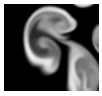
Region-based shape features

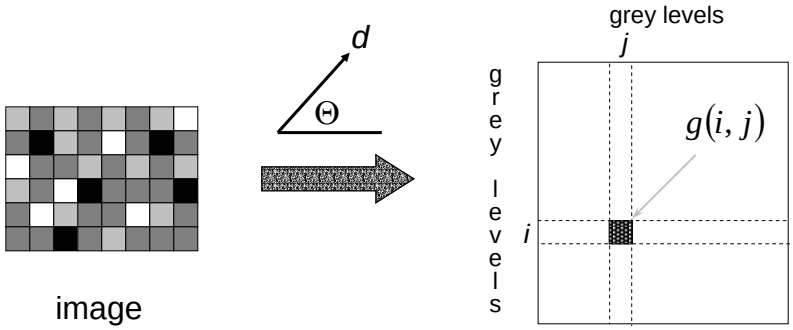
- Geometric moments (Hu)
- Seven moments
- Invariant to:
  - Rotation
  - Scaling
  - Translation
  - Reflection



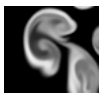
Texture features

- Grey-level co-occurrence matrices (GLCM)
- 5 of Haralick's original 14 features

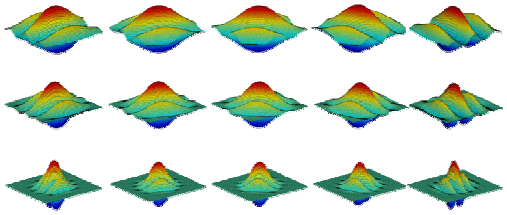




Texture features



- Gabor texture features
- Filtered using Gabor functions
- Tunable:
  - Scale
  - Orientation
- MPEG7
- Rotation-invariant (RI) Gabor texture features



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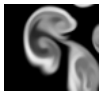
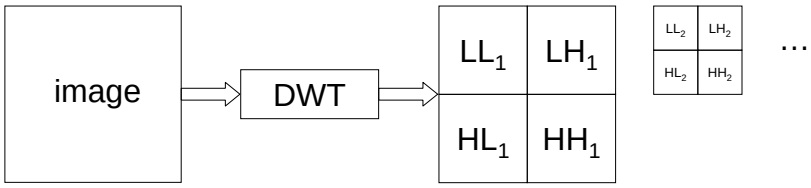


- Wavelet decomposition
- Daubechies-4 in a 3 level decomposition
- Features = band energies



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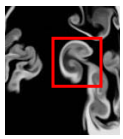

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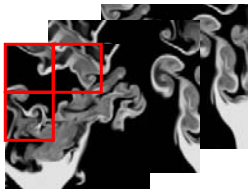

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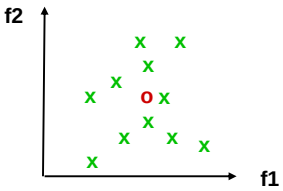
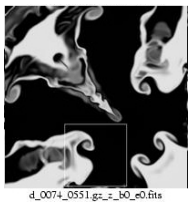
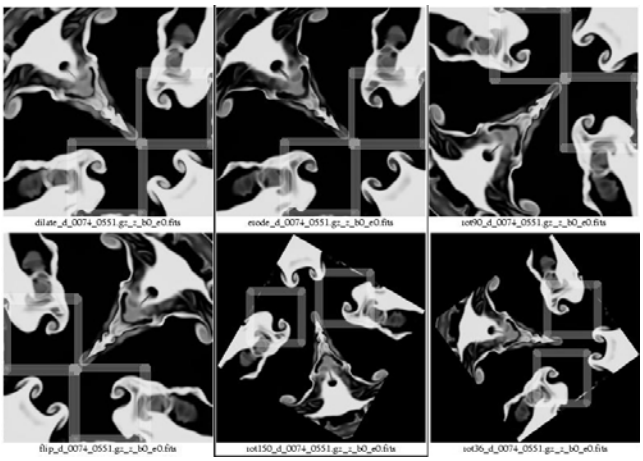


Target and ground truth datasets





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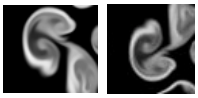

250470 tiles

90-100% overlap with query → 32 tiles (ground truth)

50-90% overlap with all queries → 

remainder → 243947 tiles (target dataset)

Quantitative performance evaluation

- **Average Normalized Mean Retrieval Rate (ANMRR)**
- **6 queries with different ground truth sizes**
- **MPEG7**

0 ← **ANMRR** → **1**

good **bad**

Quantitative performance evaluation

- Ground truth = 90-100% overlap with query
- Discard tiles with 50-90% overlap

	SHAPE		TEXTURE			
	ART	moments	GLCM	Gabor	GaborRI	wavelets
ANMRR	0.52	0.98	0.72	0.67	0.57	0.73

Conclusion

- ART features performed best
- Not conclusive, though
- Ground truth selection is critical

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