A SPATIAL ANALYSIS OF SELECTED ART: A GISCIENCE-HUMANITIES INTERFACE

spatial autocorrelation at work
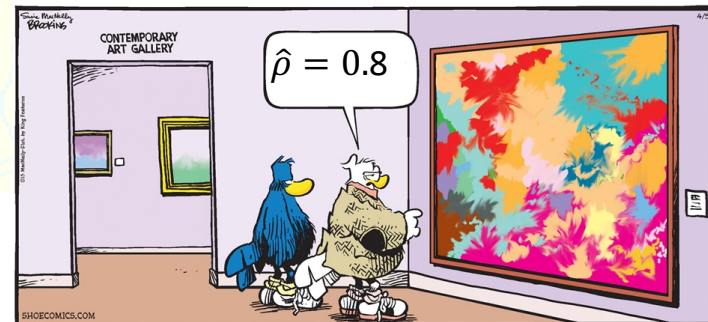
Daniel A. Griffith
University of Texas at Dallas

the UCGIS 2019 Symposium:

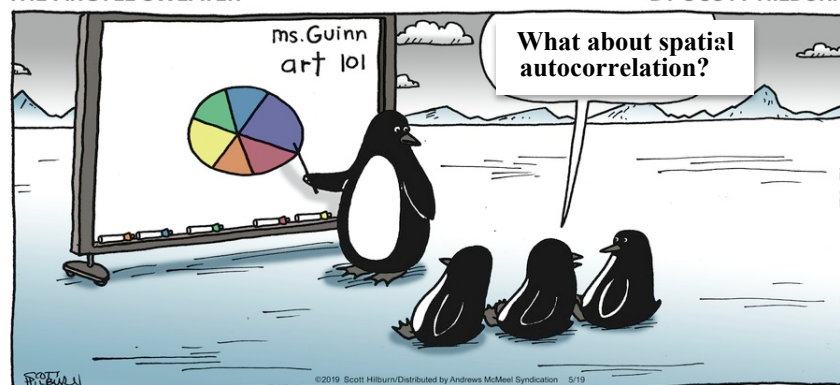*The Geospatial Humanities: Transdisciplinary Opportunities for the GIScience Community*

June 10 - 13, 2019 • Dupont Circle Hotel • Washington, D.C.

SHORT ABSTRACT

THE ARGYLE SWEATER — BY SCOTT HILBURN

Geography, in part through cartography—such as map making and decorating—and now through visualization in geographic information systems (GISs), maintains a historical connection to art. **Mathematics**, in part through geometry—such as origami, Archimedian polyhedra, Gaussian cyclic supercharacter images, and more recently Escher's non-Euclidean (i.e., hyperbolic) prints—and now through computational mathematics (i.e., scientific computing that produces, for example, pictures of fractals), also maintains a historical connection to and rich affiliation with art. Because **art tends to focus on pattern** rather than randomness (even for Pollock's drip and pointillism paintings), **spatial autocorrelation**—attribute values of neighboring geographic locations are far more similar than those of more distant locations—a fundamental concept of geospatial information science, almost always is conspicuous in art paintings. This connection allows spatial statistics to be extended to the **geohumanities** and **spatial humanities**, as well as to humanistic mathematics, by an **integration of geography's and mathematics' interfaces with art**.

MOTIVATION & BACKGROUND

2013 AAAS ANNUAL MEETING
THE BEAUTY AND BENEFITS OF SCIENCE
14-18 FEBRUARY • HYNES CONVENTION CENTER • BOSTON

AAAS 2013
ANNUAL MEETING
14-18 FEBRUARY • BOSTON

cybergeo

Cybergeo : European Journal of Geography

Transversalités - les 20 ans de Cybergeo

Référence électronique
Daniel A. Griffith, « Spatial autocorrelation and Art », *Cybergeo : European Journal of Geography* [En ligne],
Transversalités - les 20 ans de Cybergeo, mis en ligne le 22 janvier 2016, consulté le 25 janvier 2016. URL : http://
cybergeo.revues.org/27429 ; DOI : 10.4000/cybergeo.27429

Daniel A. Griffith

Spatial autocorrelation and Art

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ART AND SPATIAL STATISTICS: EIGENVECTOR SPATIAL FILTERING (ESF)

ESF uses a **set of synthetic proxy variables**, which are extracted as eigenvectors from a **spatial connectivity matrix that ties geographic objects together in space**, and then **adds these vectors as control variables to a model specification**.

These control variables identify and isolate the stochastic spatial dependencies among georeferenced observations, thus **allowing model building to proceed as if the observations are independent**.

Constructing eigenfunctions for filtering spatial autocorrelation out of georeferenced variables:

$$MC = (n/\mathbf{1}^T \mathbf{C}\mathbf{1})x$$

$$\mathbf{Y}^T(\mathbf{I} - \mathbf{1}\mathbf{1}^T/n)\mathbf{C}\,(\mathbf{I} - \mathbf{1}\mathbf{1}^T/n)\mathbf{Y}/\,\mathbf{Y}^T(\mathbf{I} - \mathbf{1}\mathbf{1}^T/n)\mathbf{Y}$$

the eigenfunctions come from

$$(\mathbf{I} - \mathbf{1}\mathbf{1}^T/n)\mathbf{C}\,(\mathbf{I} - \mathbf{1}\mathbf{1}^T/n)$$

ESF Theorem

The first eigenvector is the set of real numbers that has the largest MC achievable by any set for the geographic arrangement defined by the spatial connectivity matrix **C**
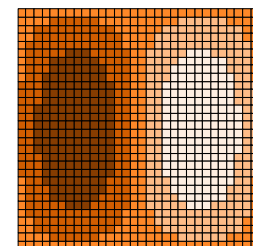
the second eigenvector is the set of real numbers that has the largest achievable MC by any set that is orthogonal and uncorrelated with the 1st eigenvector
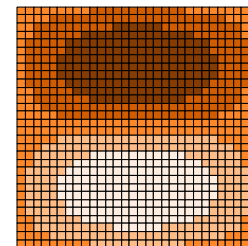
so on through the nth eigenvector, which is the set of real numbers that has the largest negative MC achievable by any set that is orthogonal and uncorrelated with the preceding (n – 1) eigenvectors.
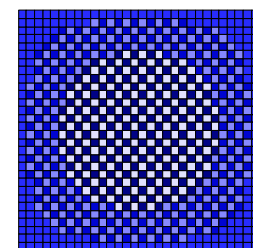
THE MEANING OF ESFs
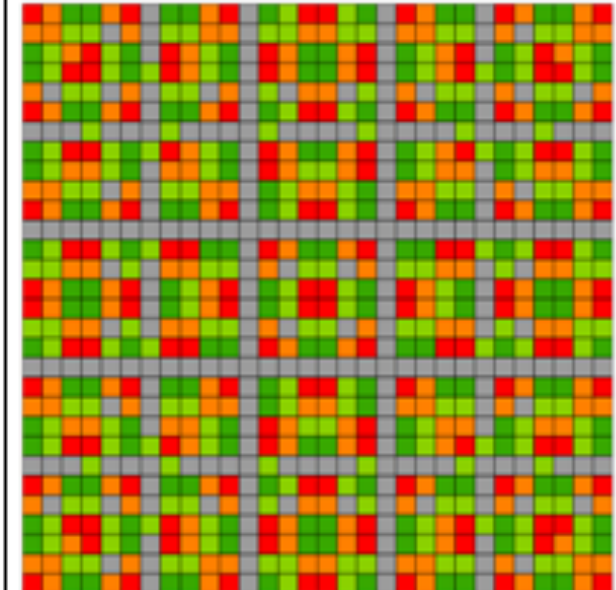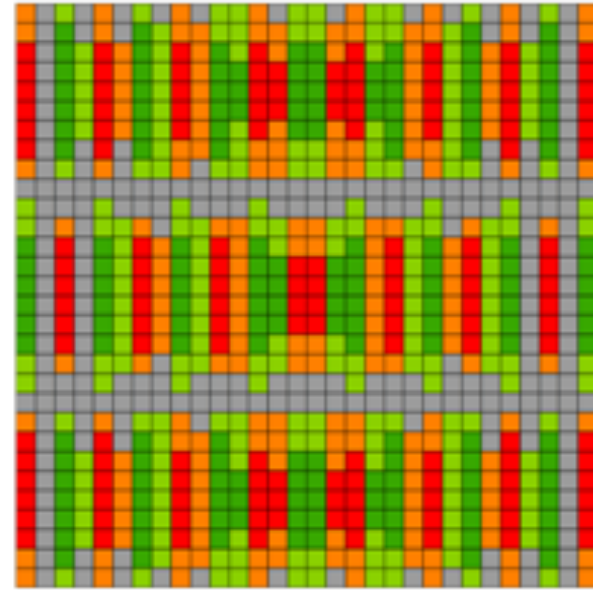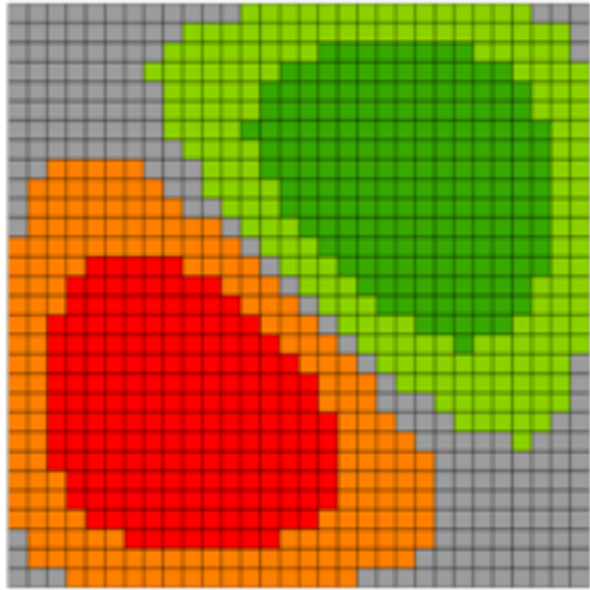
global   regional   local

VISUALIZATION OF EIGENVECTOR $\mathbf{E}_{k,k}$
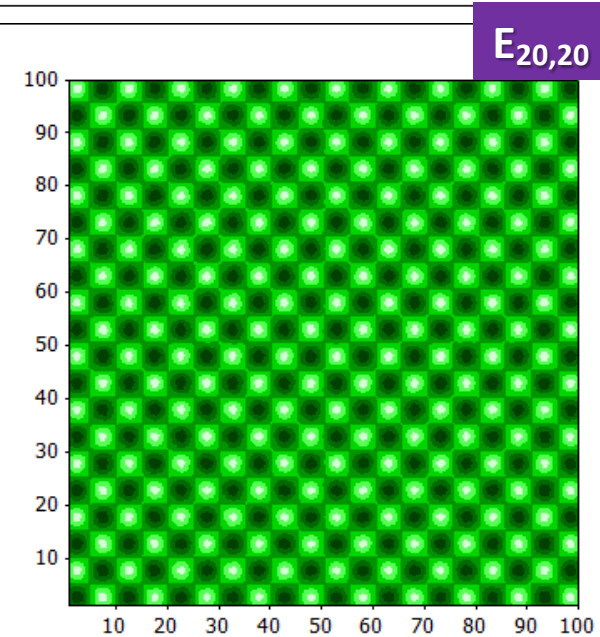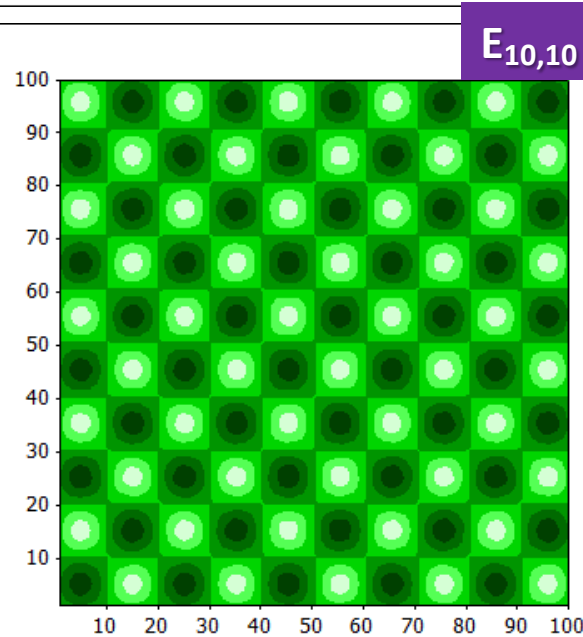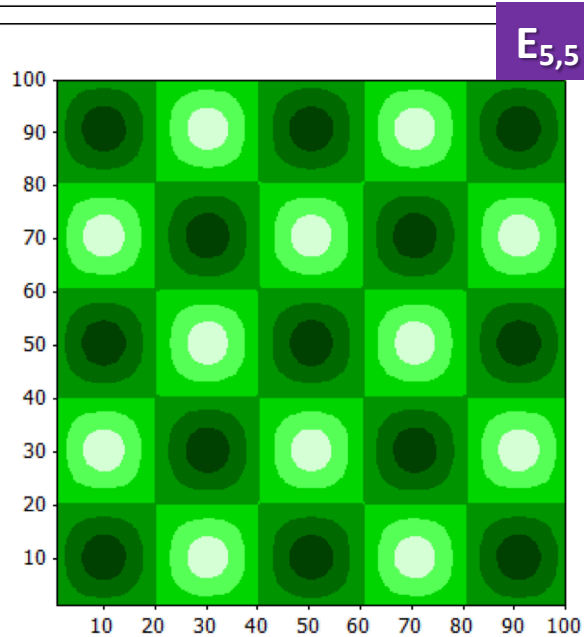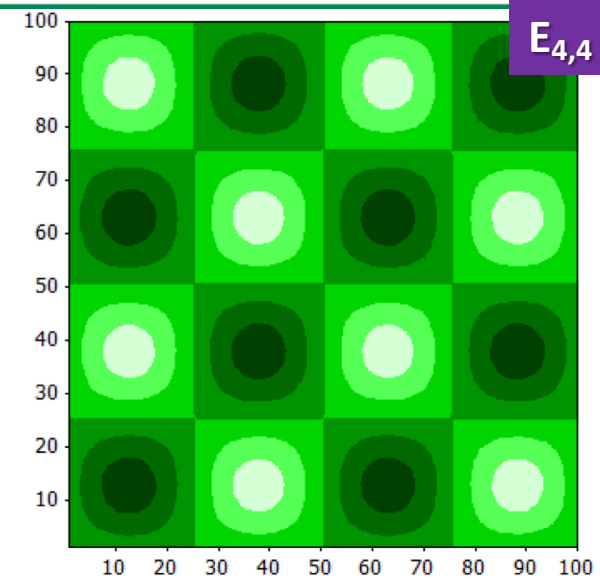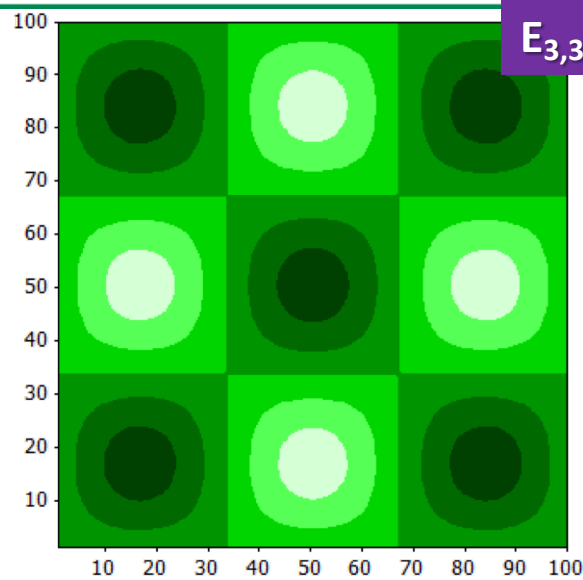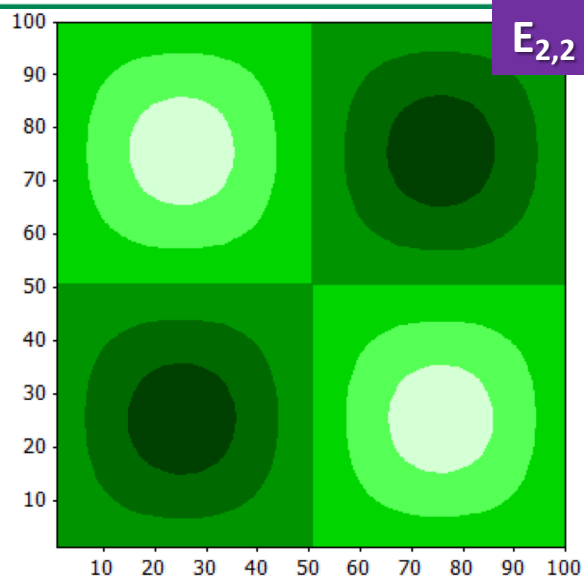
Paintings by Artist Susie Rosmarin

San Antonio Museum of Art 2010 exhibit *Psychedelic: Optical and Visionary Art since the 1960s*: a mind bending op art painting that stood out.
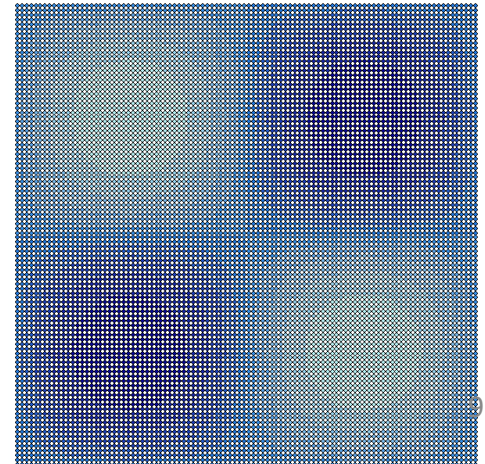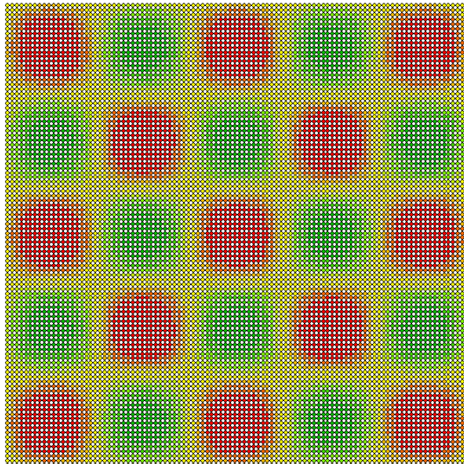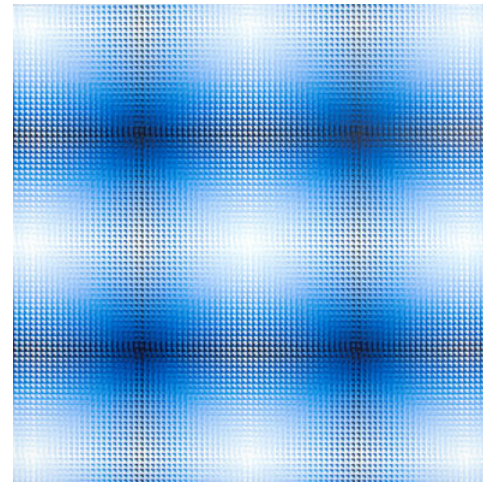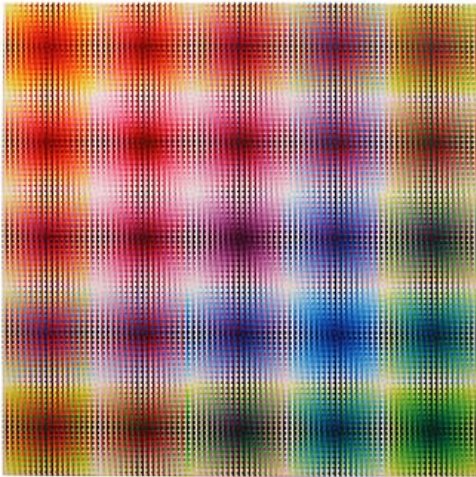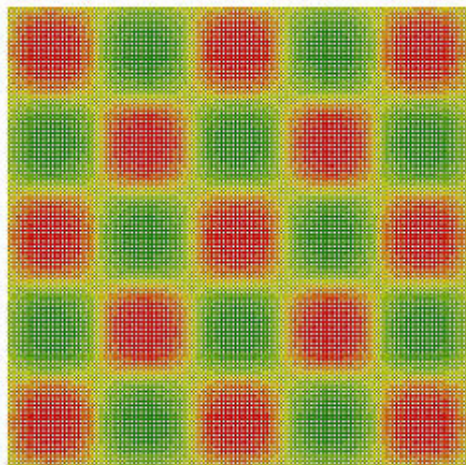
eigenvector $E_{5,5}$
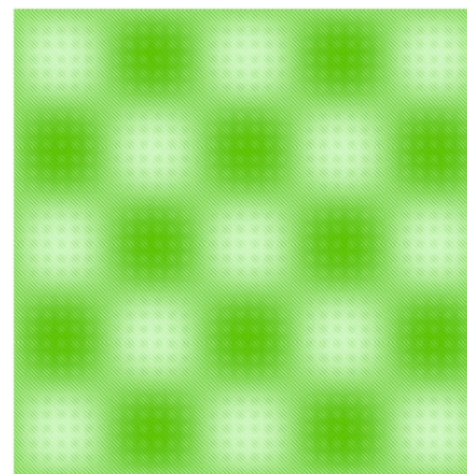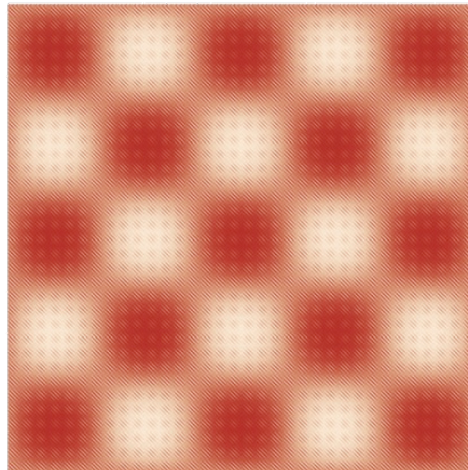
eigenvector $E_{207,208}$
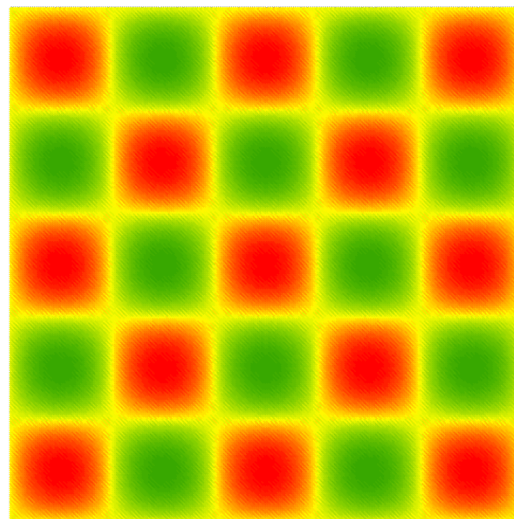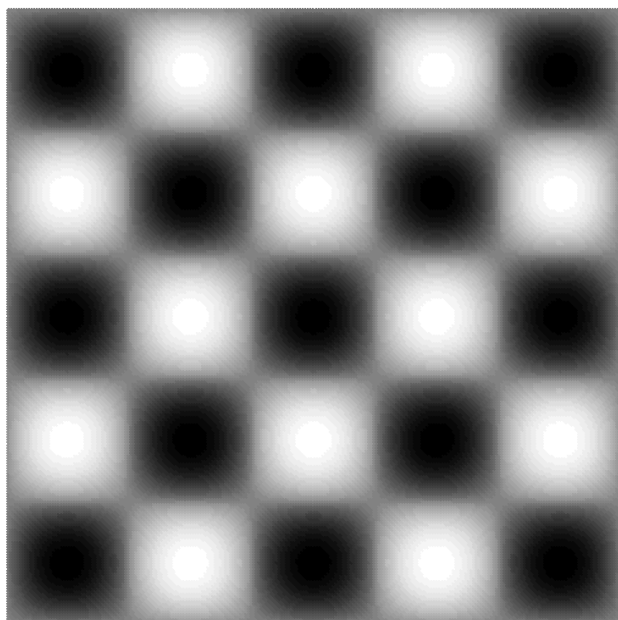
simple ESF

APPROXIMATING ESFs

5-by-5

8-by-8

10-by-10

20-by-20

25-by-25
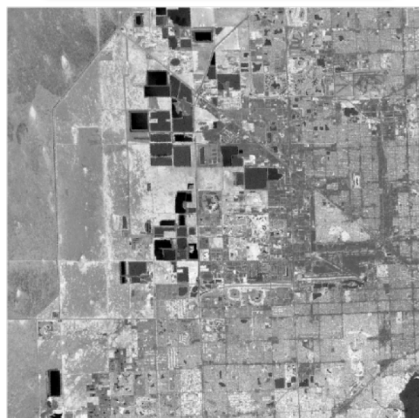
40-by-40
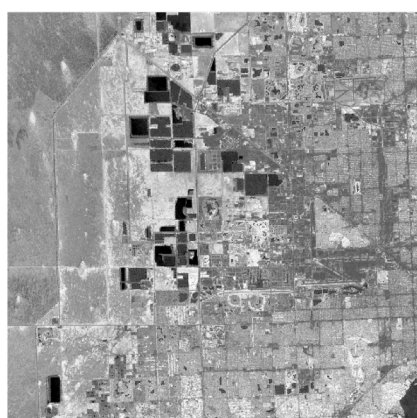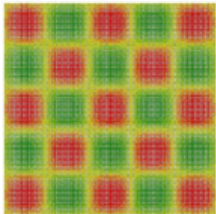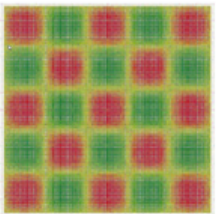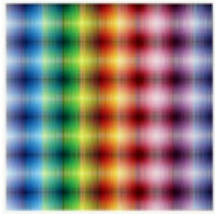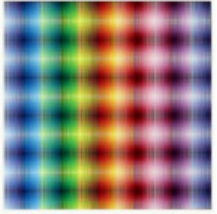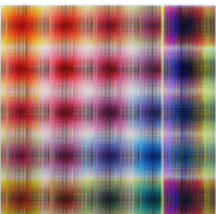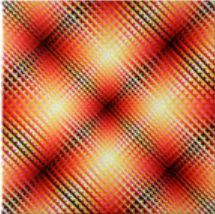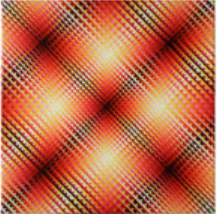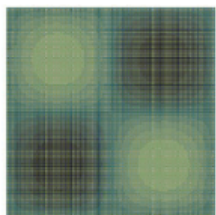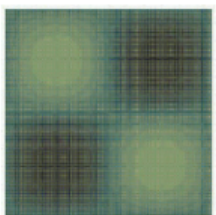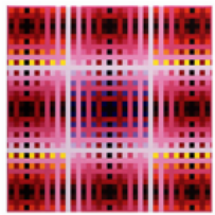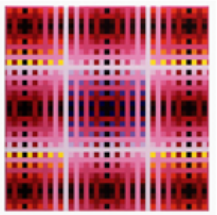
50-by-50
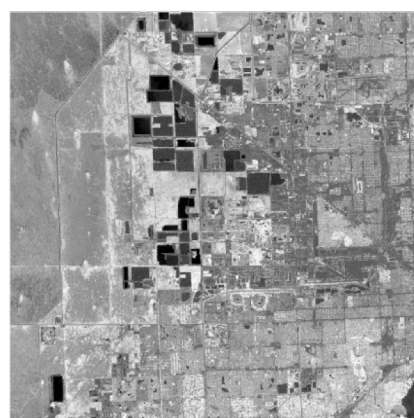
data
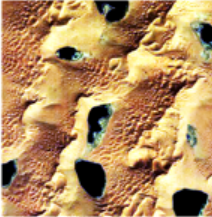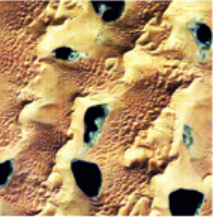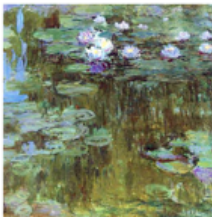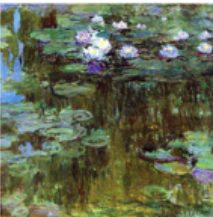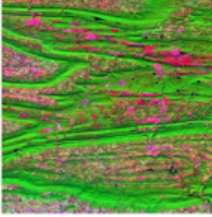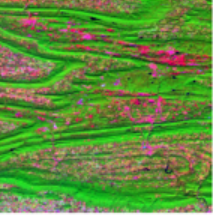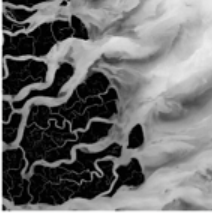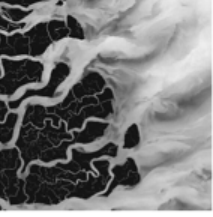
ROSMARIN'S PAINTINGS

name	painting	ESF-reconstructed painting	name	painting	ESF-reconstructed painting
Unknown title #1			Spectrum #10, 2008 (see http://www.next-after-this.com/2011/11/exhibition-hana-hillerova-susie.html)		
#412: Spectrum #9, 2008 (seehttp://www.minusspace.com/2009/01/susie-rosmarin-danese-gallery-new-york-ny/)			#414: Yellow, 2008 (see http://www.next-after-this.com/2011_10_23_archive.html)		
Unknown title #2			Unknown title #3		
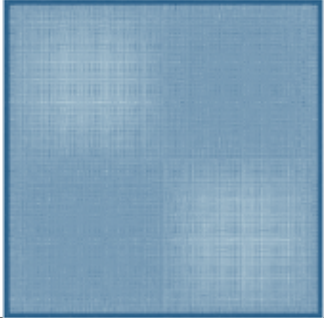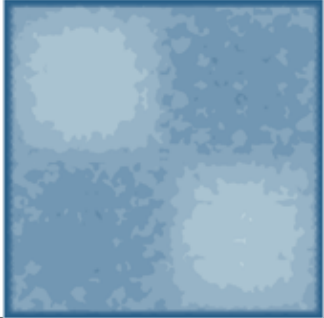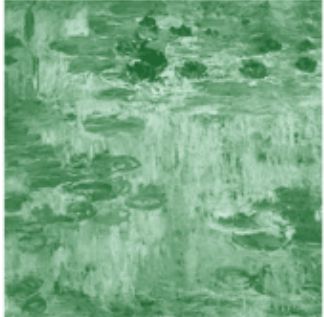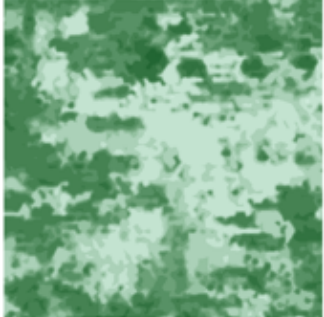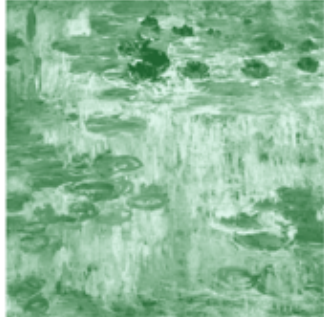
REMOTELY SENSED IMAGES & PAINTINGS

from Stephen Young

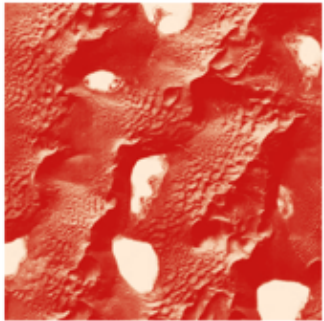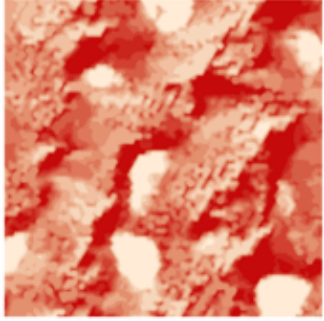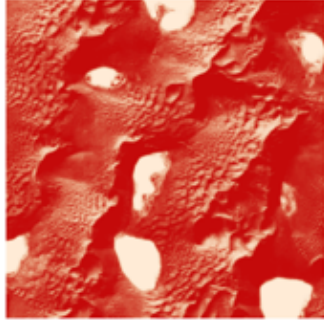| name	Painting/image	ESF-reconstructed painting/image
Gobi Desert lakes, in China's Inner Mongolia, surrounded by steep sand dunes (data downloaded from the European Space Agency; additional image processing by S. Young).		
Thermal infrared and visible wavelengths central PA image—red denotes warm, and green denotes forest dominated, areas (raw data downloaded from the Global Land Cover Facility and processed by S. Young)		
November 15, 1999 Landsat ETM Ganges-Brahmaputra Delta image—a created RGB 741 image was converted to a black-and-white image; black denotes mangroves and white denotes water with silt (raw data downloaded from the Global Land Cover Facility and processed by S. Young)		

from world-famous painters

name	Painting/image	ESF-reconstructed painting/image
Monet: from the water lilies series (see https://learnodo-newtonic.com/claude-monet-famous-paintings; the original .jpg image has undergone cropping; this image, as analyzed in this paper for research purposes, is believed to qualify for Fair Use.)		
Rembrandt: The Night Watch (see https://commons.wikimedia.org/wiki/File:The_Nightwatch_by_Rembrandt_-_Rijksmuseum.jpg, Wikimedia Commons)		
Van Gogh: The Starry Night (see https://commons.wikimedia.org/wiki/File:VanGogh-starry_night.jpg, Wikimedia Commons)		

KRIGING & SPATIAL AUTOREGRESSION COMPARISONS

name	ESF-reconstructed	Kriging reconstructed (exponential & K Bessel)	SAR reconstructed
Gobi Desert lakes			
Rosmarin Unknown title #2			
Monet: from the water lilies series			

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CONCLUSIONS & IMPLICATIONS

➢ This paper summarizes little-known connections between geography (a la GIS), mathematics (a la matrix algebra), and art, **adding to the geohumanities, spatial humanities, and humanistic mathematics literature**.

➢ Comparisons with output generated by geostatistical and spatial autoregressive techniques establishes that **MESF renders superior visualization outcomes**.

➢ This paper initiates the establishment of a foundation for analytical art that utilizes spatial statistical theory and methodology

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QUESTIONS?

The ESF wizard