WARSAW UNIVERSITY OF TECHNOLOGY
DEVELOPMENT PROGRAMME

ENTERPRISE IRELAND

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Pattern Recognition and Computer Vision

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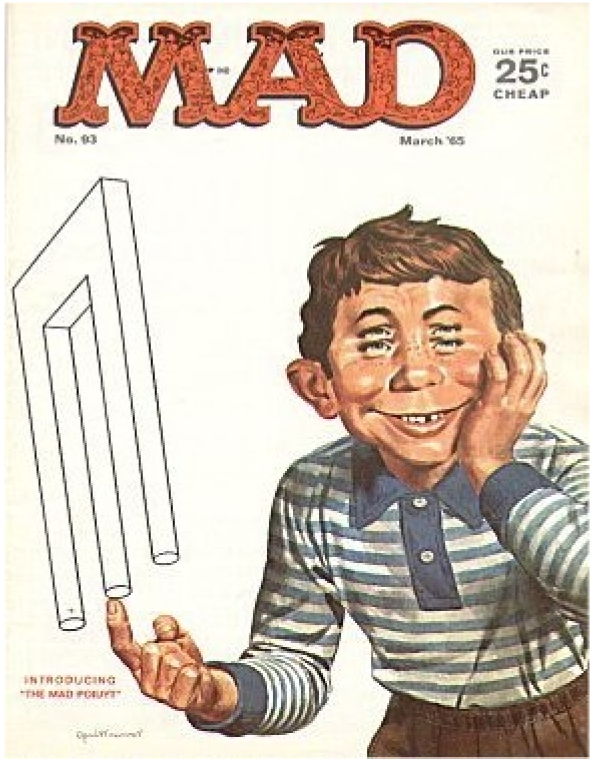
What is the Problem?

A ***fundamentally difficult one***, i.e. ultimately, how to simulate the human vision system including our ***reasoning based on image perception***



The Problem with Machine Vision

- To date, there is no ***complete theoretical model*** for simulating the processes that take place when a human interprets an image generated by the eye

- Machine vision is an elusive subject area in which automatic inspection systems are advanced without having a fully ***operational theoretical framework*** as a guide

- The subject is therefore ***'littered' with different approaches, methods and algorithms*** that are not necessarily part of any common theme

Some Basic Questions in Computer Vision

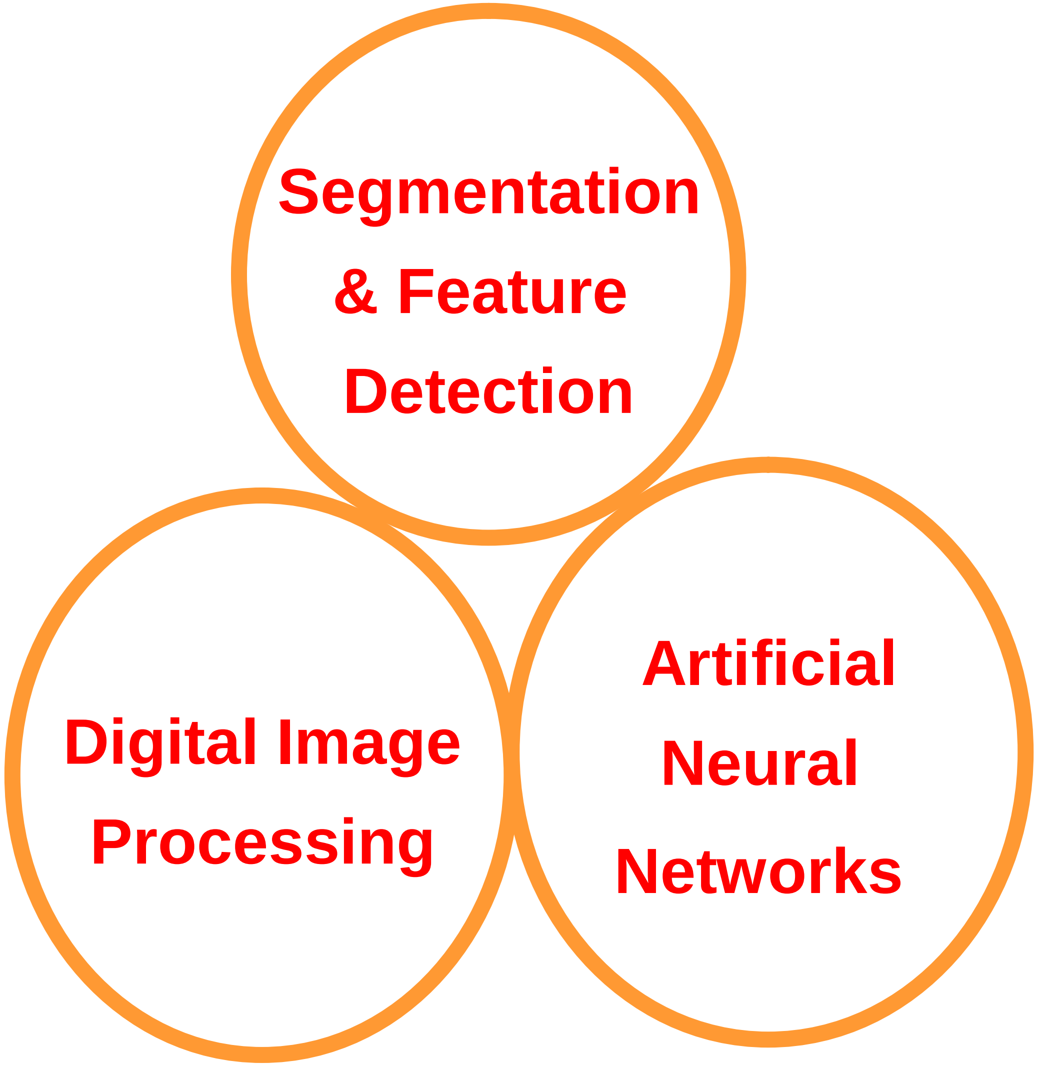
- What are the goals and constraints?

- What type of algorithm or set of algorithms is required to effect vision?

- What are the implications for the process given the types of hardware that might be available?

- What are the levels of representation required to achieve vision?

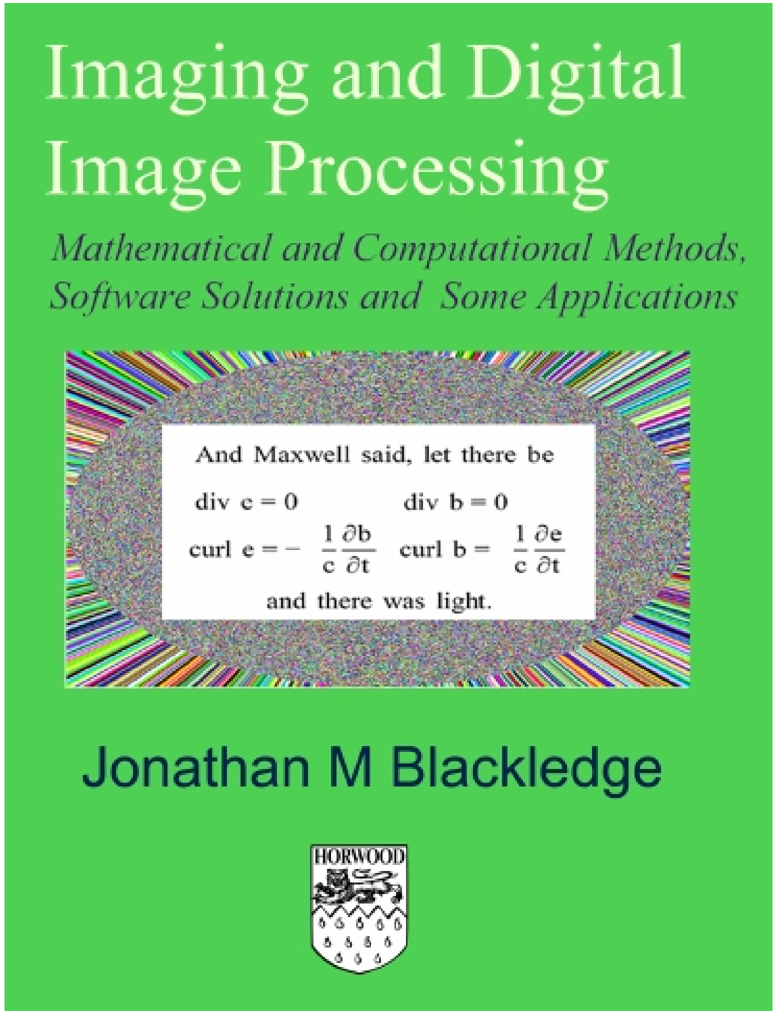
Related Subject Areas

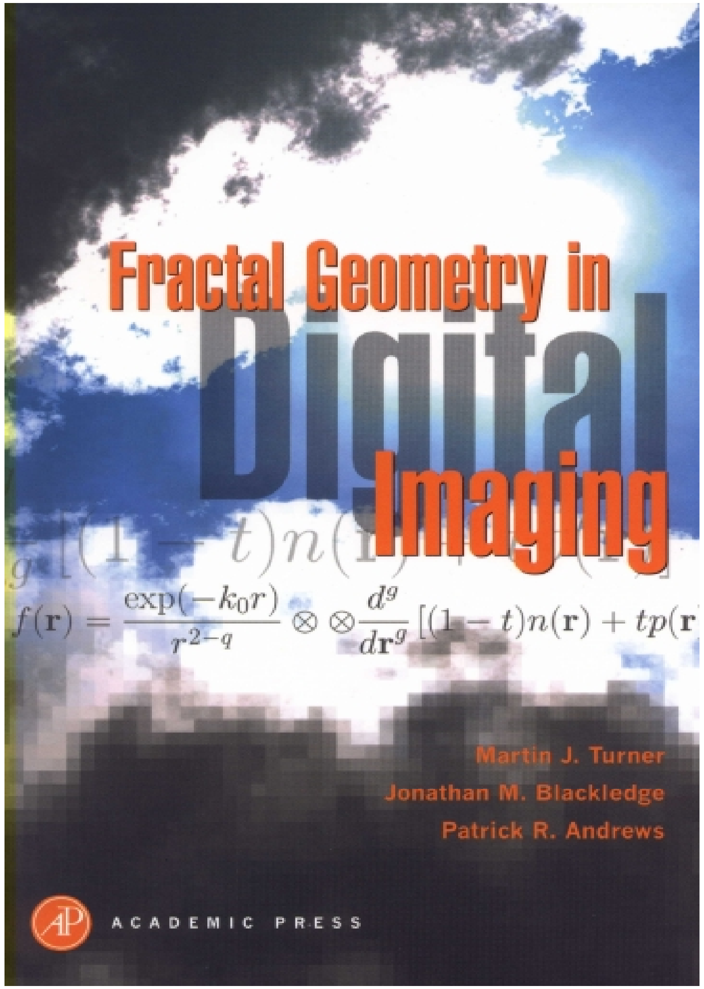


Related issues include:

- ***Feature Correlation***
- ***Edge Detection***
- ***Geometry***
- ***Topology***
- ***Genetic Algorithms***
- ***Image Compression***

Principal Publications





http://eleceng.dit.ie/papers/103.pdf

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- Introduction and Overview
- Correlation Based Pattern Recognition
- Example Pre-processing Methods:
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  - Image Statistics
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- The Marr-Hildreth Algorithm
- Radon Transform Based Computer Vision and the Hough Transform
- Summary
- Q & A + Interval (10 Minutes)

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- A Short Introduction to Fractal Geometry

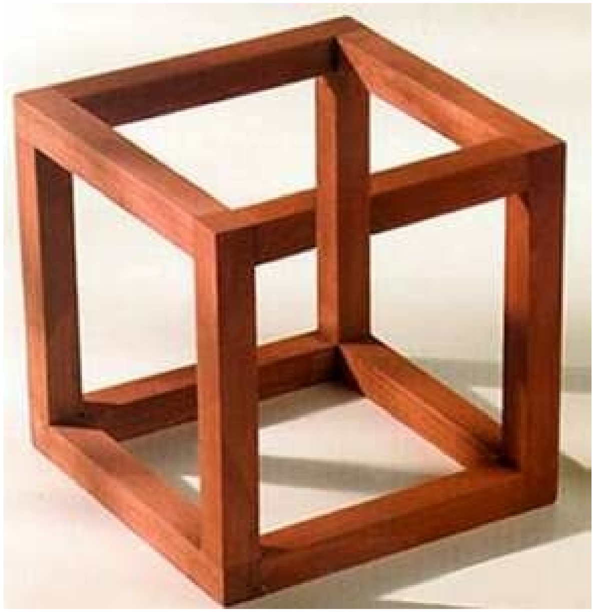
- Computer Vision using Fractal Geometry

- Example Applications in Image Analysis:
  - Growth of Micro-organisms
  - Quality Control of Rolled Steel
  - Cytopathology
  - A Skin Cancer Screening System

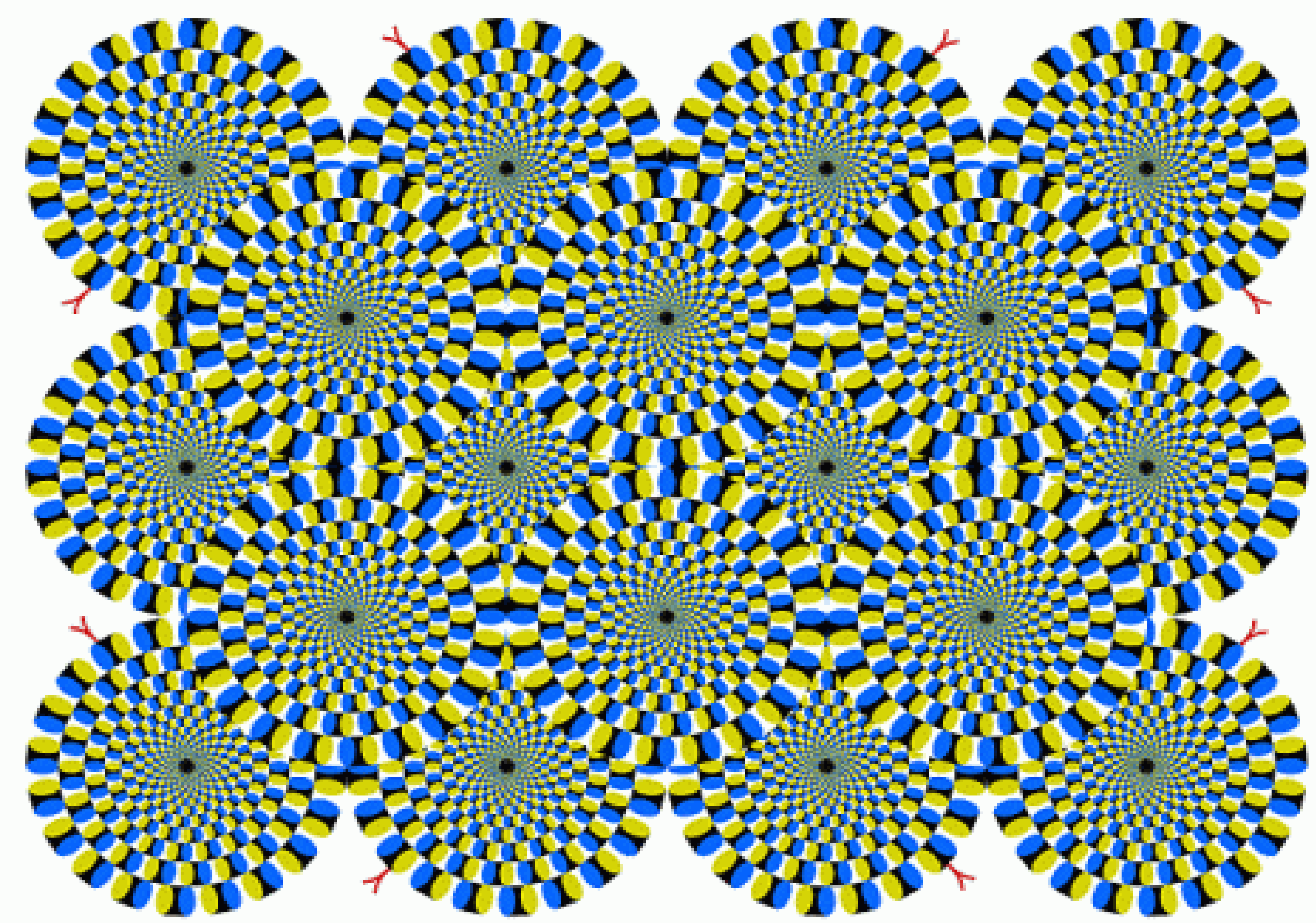
- Summary

- Q & A

Introduction:
Making Sense of Images



Optical Illusions



Seeing Objects in the Clouds

The Sun and Vision:

Why do we see in the Visible Spectrum ?

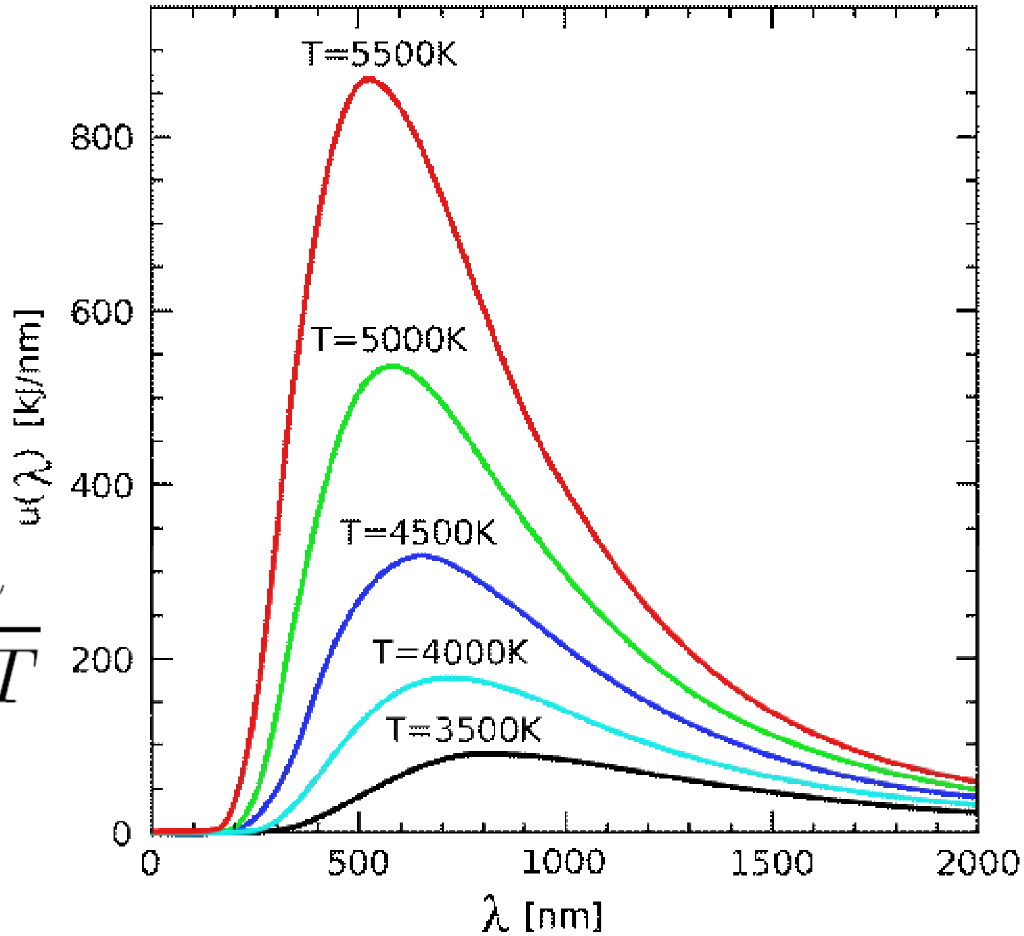
Planck radiation law expressed in Energy per unit range of wavelength is

$$E_\lambda = \frac{8\pi ch}{\lambda^5[\exp(ch/\lambda kT) - 1]}$$

$$\frac{\partial E_\lambda}{\partial \lambda} = 0$$

$$\left(1 - \frac{x}{5}\right) e^x = 1 \quad x = \frac{ch}{\lambda kT}$$

$$\frac{ch}{\lambda_m kT} = 4.9651$$



Vision and the Rayleigh Scattering Effect

$$u_s(\hat{\mathbf{n}}_s, \hat{\mathbf{n}}_i, k) = \frac{k^2}{4\pi r_s}\exp(ikr_s)\int_V \exp[-ik(\hat{\mathbf{n}}_s - \hat{\mathbf{n}}_i)\cdot\mathbf{r}]\gamma(\mathbf{r})d^3\mathbf{r}$$

For a spherically uniform scatterer

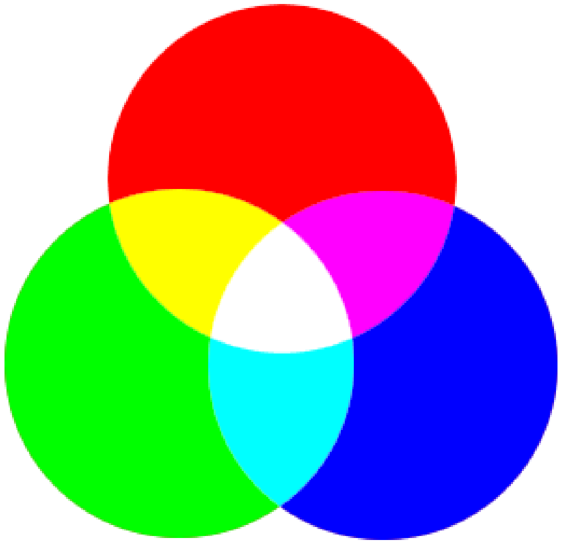
$$A(\theta) = \frac{2\pi k\gamma}{\sin(\theta/2)}\int_0^R \sin[2kr\sin(\theta/2)]rdr$$

$$\sin[2kr\sin(\theta/2)] \simeq 2kr\sin(\theta/2), \quad 0 \leq r \leq R \quad kR << 1$$

$$A(\theta) \simeq 4\pi k^2\gamma\int_0^R r^2 dr = k^2\gamma V \qquad |A(\theta)|^2 \propto \frac{1}{\lambda^4}$$

Why is the Sun Yellow ?

- The sun radiates most energy in ***Green***
- Green is in the middle of the visual spectrum
- The atmosphere filters out ***Blue*** light
- The sun therefore appears to be ***Yellow***



Scattering in the Visible Spectrum

- Scattering of EM waves in the visible spectrum provides images of objects where the edges are well defined.

Information ~ Wavelength

- In the infrared region, edges are not so well defined because:

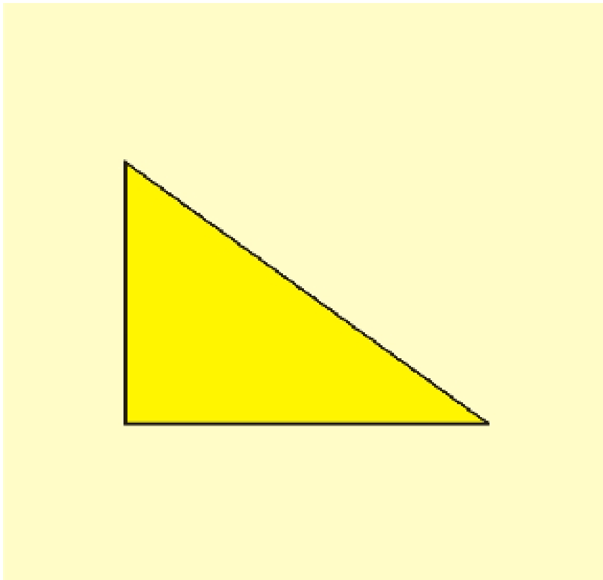
  - infrared radiation scatters from larger scale structures

  - the emission of infrared radiation from a body tends to dominate, the process of thermal diffusion being more significant than infrared scattering

A Philosophical Question

- What would a species just as intelligent ourselves see if it evolved on a suitable planet orbiting a hotter (or cooler) sun ?

- Would it have developed Pythagoras' Theorem if its visual perception was based in the Infrared ?



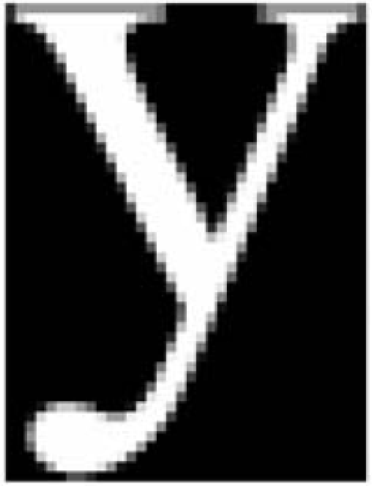
Pattern Recognition using the Correlation Function

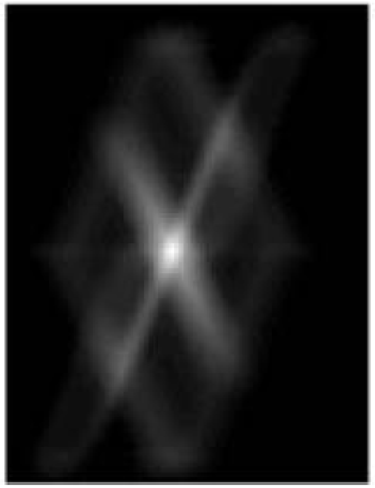
- Construct a template based on a replica of the feature in an image that requires identification and correlate the template data with the image

$$c_{ij} = t_{ij} \odot \odot f_{ij} \equiv \sum_n \sum_m t_{(i+n)(j+m)} f_{nm}$$

- The correlation image or surface will contain a maximum value (a 'peak' or 'point') at the positions in the image which matches the template

Example of Pattern Recognition by Digital Correlation





The Auto-Covariance Function

$$C_{ij} = \sum_n \sum_m [f_{nm} - \langle f_{ij} \rangle][t_{(i+n)(j+m)} - \langle t_{ij} \rangle]$$

- The ***correlation function*** and the ***covariance function*** are two important metrics used in pattern recognition

- The problem is to decide what ***feature(s) of an image*** to extract in order to generate a template that is robust and relatively insensitive to noise

- The template is typically constructed by processing the image first in order to isolate features that may be based on ***pixel similarity, discontinuity, and statistical measures***

Limiting Conditions

- The orientation of the pattern must be the same as that of the template: ***Fourier-Mellin Transform***

- The scale of the pattern must be the same: ***Wavelet (multi-resolution) image analysis***

- The template should be a good representation of the pattern

- In practice, this is not always possible and several image processing methods are required to implement this method of pattern recognition in practice

Example Pre-Processing Methods: *The Homomorphic Filter*

- Basic Model: $f(x,y) = i(x,y)r(x,y)$

Image = Illumination x Reflectance

- Assume that reflectance component consists of high frequency (scattering) information that needs to be recovered for pattern recognition algorithm

$$\ln f(x,y) = \ln i(x,y) + \ln r(x,y)$$

$$r(x,y) \simeq \exp\left(\mathrm{HPF}[\ln f(x,y)]\right)$$

- **HPF** – High Pass Filter

Histogram Equalization 1

$$P(v_k) = \frac{n_k}{N}$$

Problem: Find a transform such that

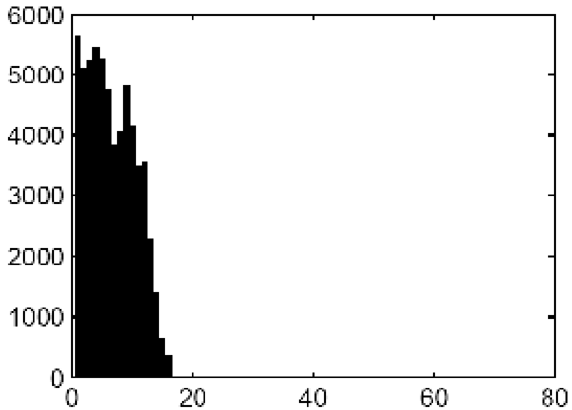
$$v_k^{\mathrm{out}} = \hat{T}[v_k^{\mathrm{in}}]$$

$$P(v_k^{\mathrm{out}}) = \begin{cases} 1, & \forall k > 1; \\ 0, & k = 0. \end{cases}$$

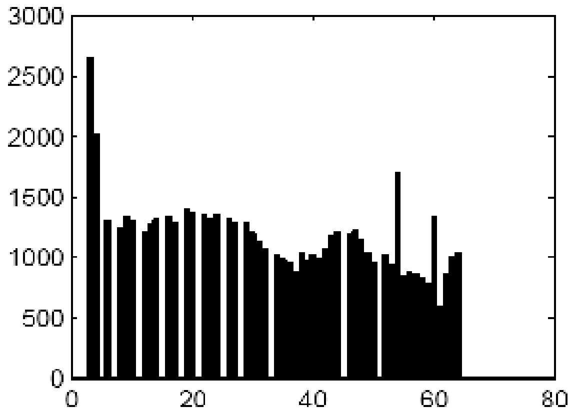
Histogram Equalization 2

Solution:

$$v_k^{\mathrm{out}} = C(v_k^{\mathrm{in}})$$



$$C(v_k^{\mathrm{in}}) = \sum_{i=0}^{k} P(v_i^{\mathrm{in}})$$



Noise Reduction Algorithms

- Typically undertaken in ***Real*** or ***Fourier*** space, e.g. moving average filter or low pass filter respectively.

- For linear convolution/correlation type filters the convolution/correlation theorem holds and each real space filter has a Fourier based equivalent.

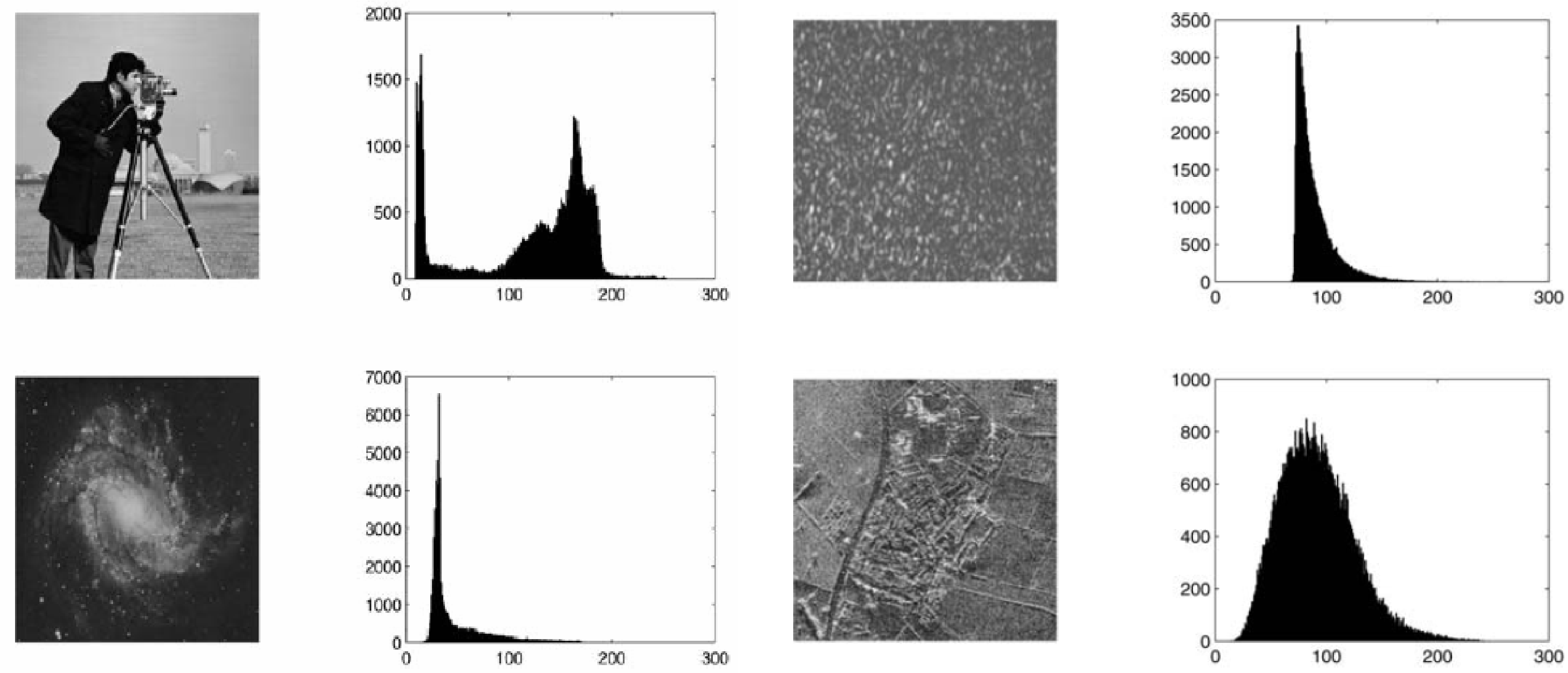
- Many other moving window filters for which the convolution/correlation theorem does not hold, ***e.g. the Median filter***

Median Filter

- Moving window is applied to the image and the median computed at each window position
- Of particular value for salt-and-pepper noise – ***noise spikes***

Image Statistics

Incoherent images have an unlimited range of statistical distributions whereas coherent images are of a negative exponential type, e.g. ***Rayleigh distributed***



Statistical Image Segmentation

Statistical Moments & m-order Entropy

For an image f_{ij} that is segmented using a moving window W

$$\mu_{ij}^{n} = [\langle (f_{i-k,j-l} - \mu_{ij})^{n} \rangle]^{\frac{1}{n}}$$

where

$$\mu_{ij} = \langle f_{kl} \rangle_{ij} = \frac{1}{N} \sum_{k,l \in W} f_{i-k,j-l}$$

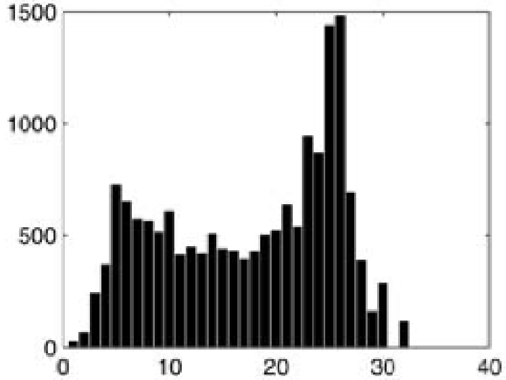
Order-m entropy can also be calculated by extending the formula. By defining $P_m(x_1, x_2, \ldots, x_m)$ as the probability of seeing the sequence of m pixels $x_1, x_2, \ldots, x_m$ we have

$$E_m = -\sum_{x_1, x_2, \ldots, x_m = 0}^{N-1} P_m(x_1, x_2, \ldots, x_m) \log_2 \frac{1}{P_m(x_1, x_2, \ldots, x_m)}.$$

Binarization

$$\text{if } v_{ij}^{\text{in}} > \text{threshold}$$
$$v_{ij}^{\text{out}} = 1$$
$$\text{else}$$
$$v_{ij}^{\text{out}} = 0$$

Problem: How to choose the threshold



Solution:
For bi-modal images
find min between the two modes

Edge Detection

- One of the most important expects of the human visual system is the way in which it appears to make use of the outlines or ***edges of objects*** for recognition and the ***perception of distance and orientation.***
- This has led to a theory for the ***human visual system*** which is based on the idea that the visual cortex contains a complex of ***feature detectors*** that are tuned to edges and segments of various widths and orientations.
- For this reason, the detection of the edges in an image can play an important role in pattern recognition.

What is Edge Detection ?

- Edge detection is basically a method of segmenting an image into ***regions of discontinuity***; it allows the observer to identify those features of an image where there is a more or less abrupt change in grey level indicating the end of one region in the image and the beginning of another

- Like other methods of image analysis, edge detection is ***sensitive to noise*** and for this reason, detected edges can occur in places where the transition between regions is not abrupt enough or else edges can be detected in regions of an image that are uniform

Approaches to Edge Detection

- First order edge detection

$$\nabla f(x,y) = \hat{\mathbf{x}}\frac{\partial}{\partial x}f(x,y) + \hat{\mathbf{y}}\frac{\partial}{\partial y}f(x,y)$$

$$|\nabla f| = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}$$

- Second order edge detection

$$\nabla^2 f(x,y) = \frac{\partial^2}{\partial x^2}f(x,y) + \frac{\partial^2}{\partial y^2}f(x,y)$$

If $\nabla^2 f_{\text{in}} \geq 0$ then
$f_{\text{out}} = 1$
else
$f_{\text{out}} = -1$

Digital Gradients 1

- Forward Differencing: $D_x f_{ij} = f_{(i+1)j} - f_{ij}$

$$D_y f_{ij} = f_{i(j+1)} - f_{ij}.$$

- Equivalent to digital convolution with a ***mask***

$$D_x f_{ij} = D_x \otimes f_{ij}, \qquad D_x = \begin{pmatrix} -1 & 1 \end{pmatrix}$$

$$D_y f_{ij} = D_y \otimes f_{ij} \qquad D_y = \begin{pmatrix} -1 \\ 1 \end{pmatrix}.$$

Digital Gradients 2

- Centre Differencing

$$D_x = \frac{1}{2}\begin{pmatrix} -1 & 0 & 1 \end{pmatrix}$$

$$D_y = \frac{1}{2}\begin{pmatrix} -1 \\ 0 \\ 1 \end{pmatrix} \equiv \frac{1}{2}\begin{pmatrix} -1 & 0 & 1 \end{pmatrix}^T$$

- ***Magnitude*** of gradient $G = |D_x| + |D_y|.$

- ***Angle*** of gradient $\theta(G) = \tan^{-1}\left(\frac{D_y}{D_x}\right).$

Edge Detectors

- There are a range of edge detectors (i.e. different masks) which attempt to:

  - provide continuous edges

  - have robustness to noise

- Examples include:

  Prewitt, Sobel, Compass and Canny

- All are ***FIR-type filters***

Example of an Edge Detector:

The Sobel Detector

$$D_x = \frac{1}{8}\begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix}$$

$$D_y = \frac{1}{8}\begin{pmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{pmatrix}$$

Figure 16.3: An image of Isaac Newton (top-left), D_x (top-centre), D_y (top-right), $G = | D_x | + | D_y |$ (bottom-left), $\tan^{-1}(D_y/D_x)$ (bottom-centre) and G after binarization with threshold $= 0.2$ (bottom-right).

The Marr-Hildreth Algorithm

On the theory of edge detection, Proceedings of The Royal Society, London, B 207: 127-217, 1980

- One of the first approaches in pattern recognition to be based on a model for the human visual system.

- The basic idea is that our ability to recognize and interpret different objects in an image scene is based on matching the edges of the scene over different frequency scales

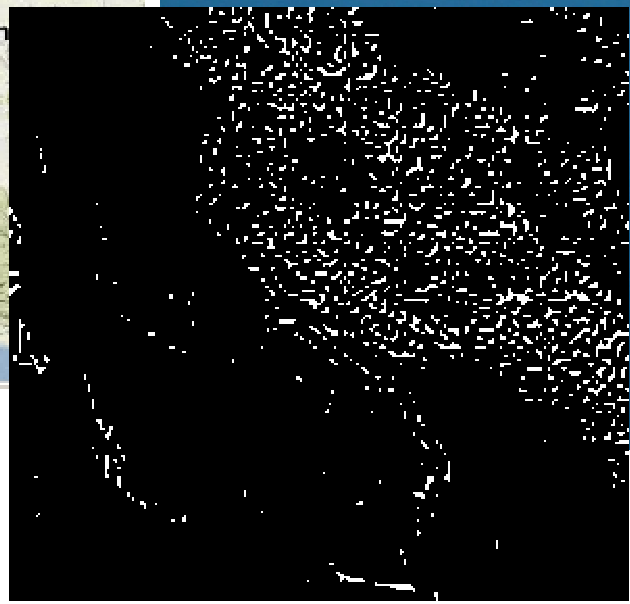
Locate the zero crossings associated the function

$$g_{ij} \otimes \otimes \nabla^2 f_{ij}$$

where g_{ij} is a Gaussian lowpass filter for different values of the filter's standard deviation.

The Importance of Edges:

A Story from the Gulf War 1990/91



Radon Transform Based Computer Vision

Based on application of the ***Radon Transform*** and ***Inverse Radon Transform***

Radon transform

$$P(z,\theta) = \hat{R}O(x,y) = \int\int O(x,y)\delta(z - x\cos\theta - y\sin\theta)dxdy$$

Inverse Radon transform

$$O(x,y) = \hat{R}^{-1}P(z,\theta) = \frac{1}{2\pi^2}\int\int \frac{1}{x\cos\theta + y\sin\theta - z}\frac{\partial}{\partial z}P(z,\theta)dzd\theta$$

The Hough Transform

- Although conceived independently, the Hough transform is a special case of the Radon transform: the ***Radon Transform of a point***

$$O(x,y) = \delta(x - x_0)\delta(y - y_0)$$

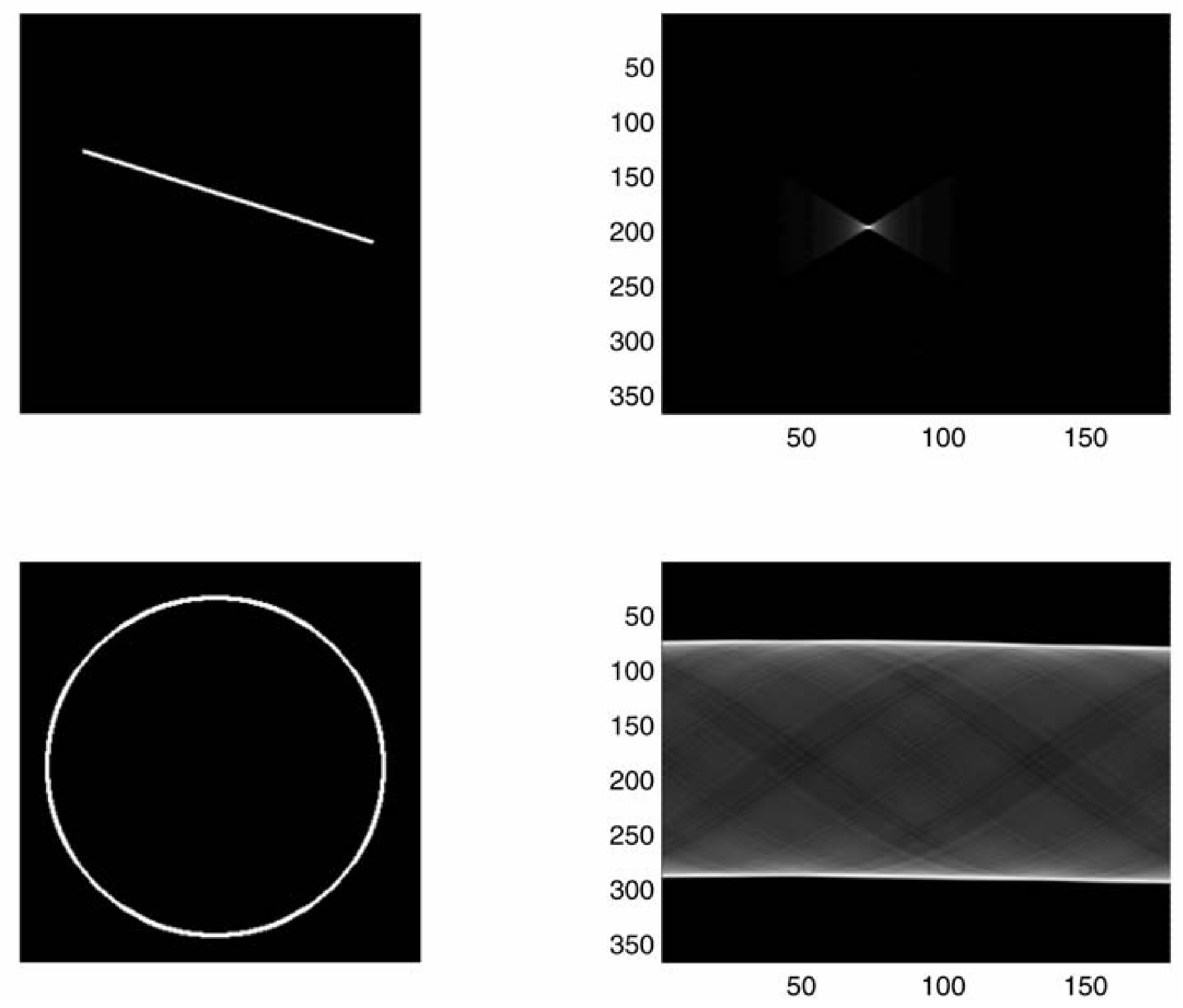
$$P(z,\theta) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \delta(x - x_0)\delta(y - y_0)\delta(z - x\cos\theta - y\sin\theta)dxdy$$

$$= \delta(z - x_0\cos\theta - y_0\sin\theta)$$

- Describes a curve in ***Radon space*** with the characteristic equation

$$z = x_0\cos\theta + y_0\sin\theta$$

Example of the Radon Transform



Summary

- Pattern recognition is based on a range of image processing methods designed to extract different ***features in the image scene***, e.g. edges
- There is no complete theoretical model for a vision system and the subject of pattern recognition and computer vision are dominated by a range of ***paradigms, algorithms, methods and models*** that are not connected other than in terms of a common goal which is usually applications dependent

In the Following Lecture…

We shall consider the role of ***Fractal Geometry*** in image analysis and pattern recognition, i.e.

Fractal Computer Vision

with applications in

Medical Imaging

Questions

+

Interval (10 Minutes)

http://konwersatorium.pw.edu.pl/wyklady/2010_VLZ7_06_wyklad.pdf

Part II: Contents

Part II: Fractal Computer Vision

- A Short Introduction to Fractal Geometry
- Computer Vision using Fractal Geometry
- Example Applications:
  - Growth of Micro-organisms
  - Quality Control of Rolled Steel
  - Cytopathology
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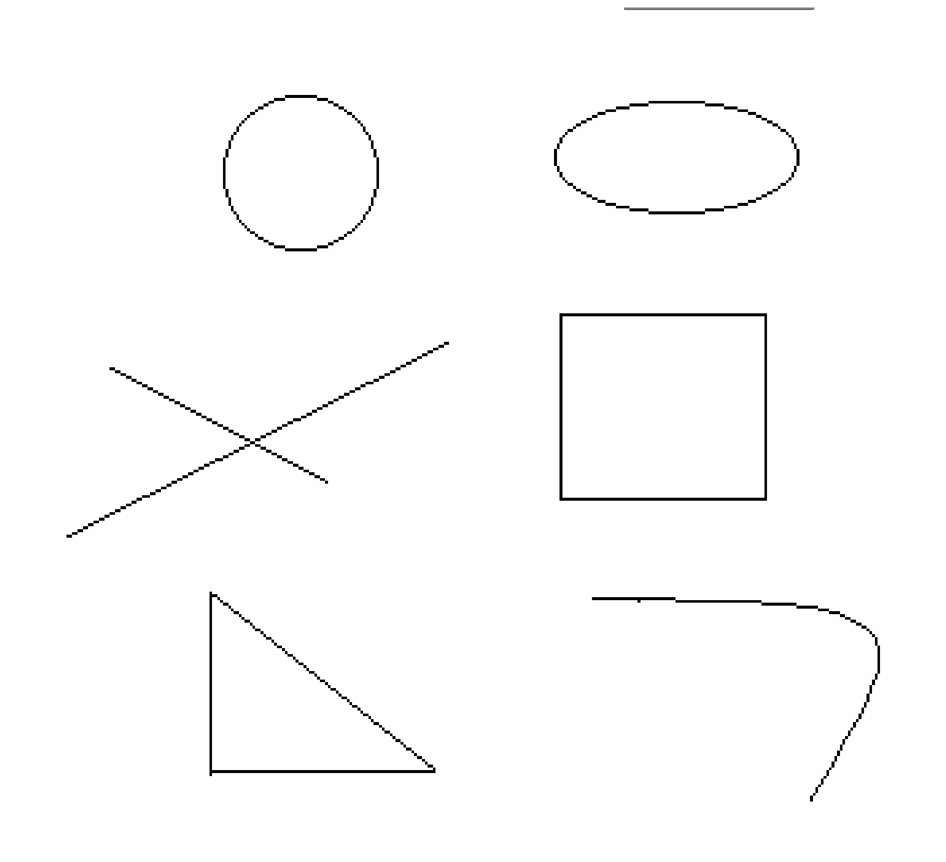
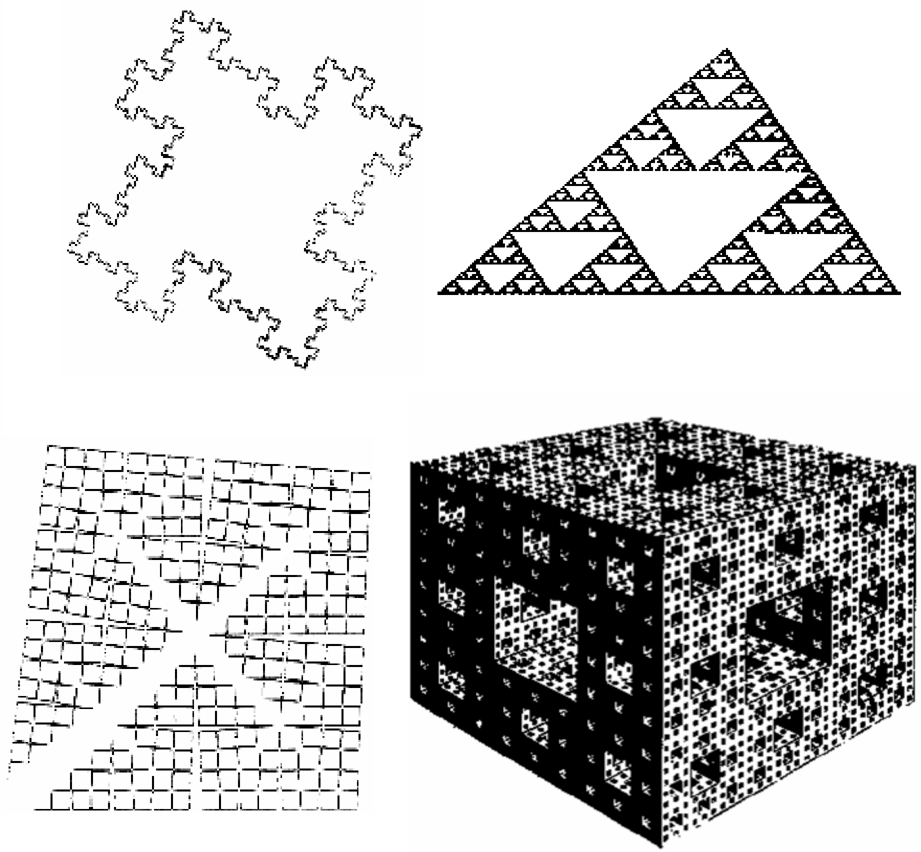
A Short Introduction to
Fractal Geometry

Euclidean objects



Fractal objects



Euclidean Geometry

- Based on the theorems and results associated with ***simple objects***:

  triangles, squares, circles, lines etc.

- Some abstract concepts,

  e.g. two parallel lines meet at infinity

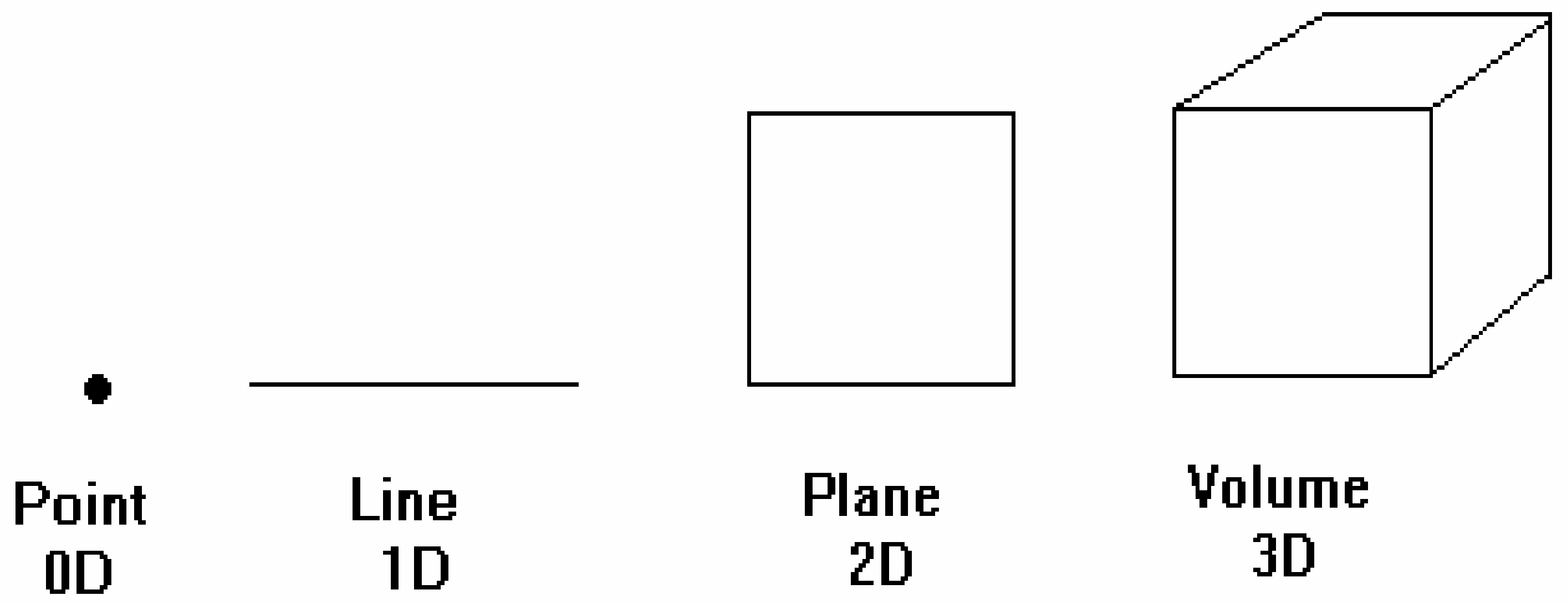
- **Underlying philosophy:** combine primitive objects to construct complex ones - basis of most man-made objects, computational geometry, pattern recognition systems etc.

Fractal Geometry

- Based on the theorems and results associated with complex objects with repeating patterns that are ***scale invariant***
- Some abstract concepts,

  e.g. repeating patterns continue to infinity
- **Underlying philosophy:** construct object by finding simple underlying structure and then repeat this structure again and again - basis of natural objects and systems.

Points, Lines, Planes, Volumes and Common (Integer) Dimensions



Dimension

- We are all used to the concept of dimensions 1, 2 and 3.

- The 4th dimension or time is also now accepted thanks to Albert Einstein

- Higher dimensions, i.e. 5,6,7,8,… are abstractions but nevertheless of fundamental significance in modern theoretical physics

Dimension and Western Art

- Pre-renaissance art: 2D - flat paintings with distortions in natural perspective
- Renaissance art: 3D - coming to terms with perspective in paintings and taking on three dimensional form – a re-birth of Greek/Roman concepts and philosophy
- Cubist art: trying to express 4D in paintings.
- Computer graphics: attempts being made to represent hyper-space.

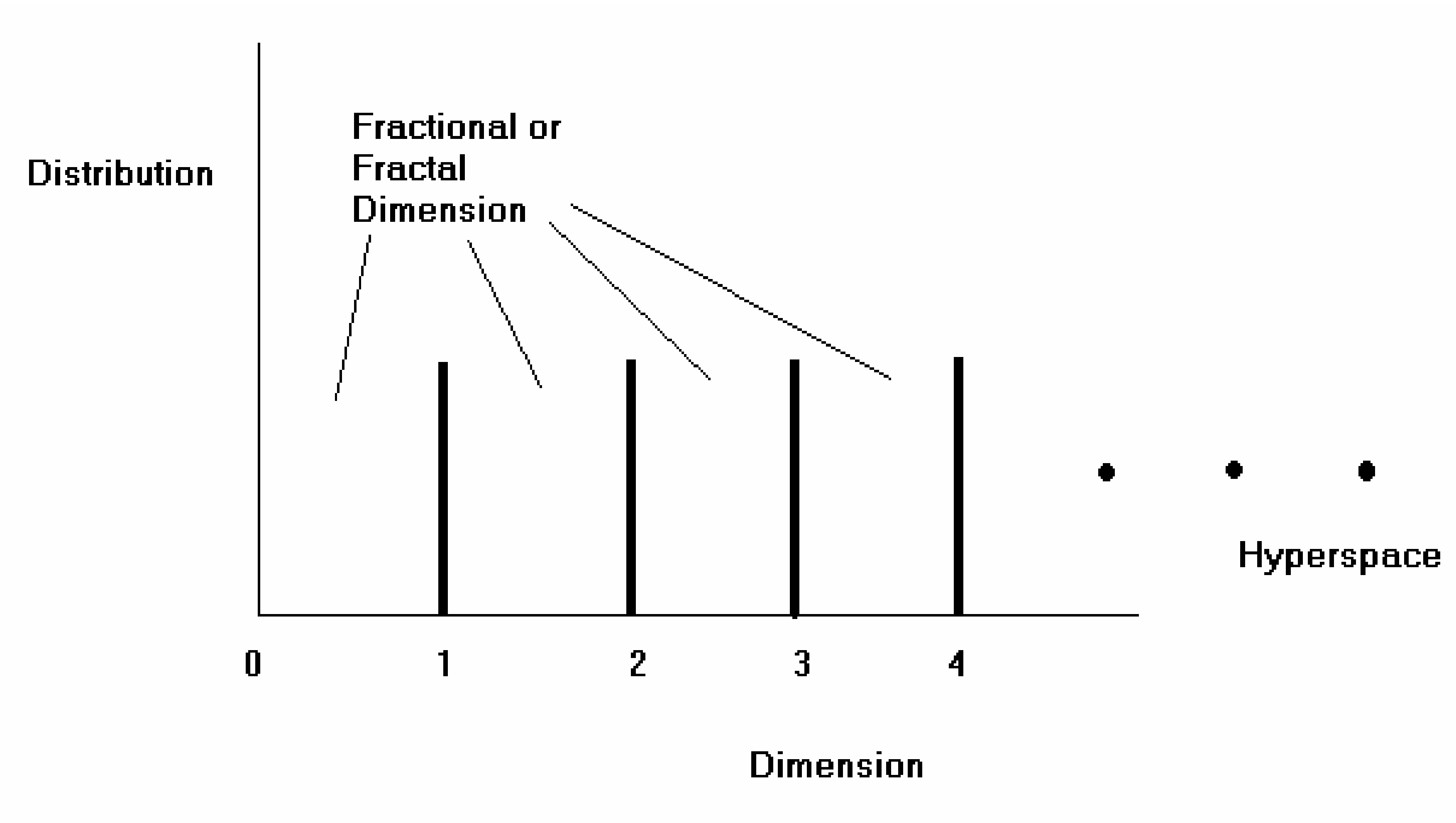
Medievil Art - 2D Flatness

High Renaissance Art - 3D

Cubism:

Trying to Representing 4D

Fractional Dimensions:
Why Should Dimension Always be Integer?



Fundamental Definition of the Fractal Dimension

$$D = -\frac{\log(N)}{\log(r)}$$

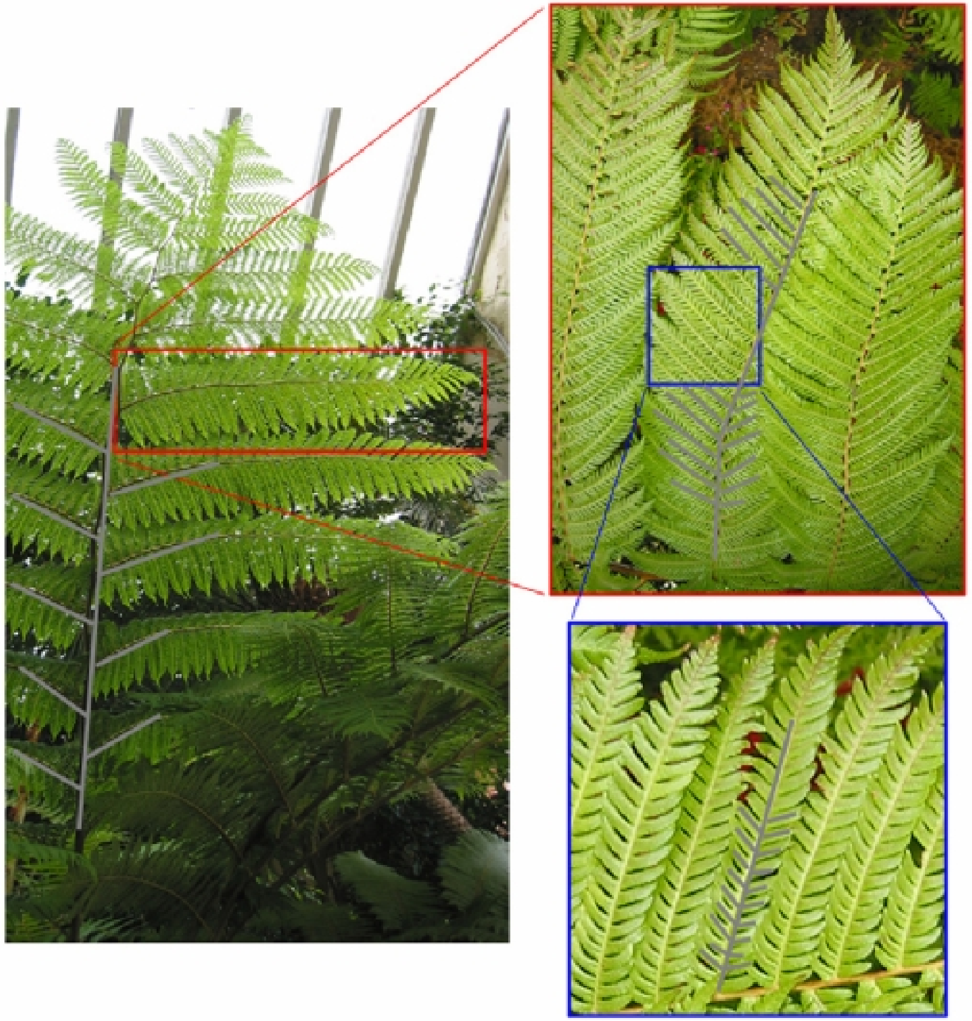
Fractal Types

Fractal type	Fractal Dimension
Fractal Dust	$0 < D < 1$
Fractal Curve	$1 < D < 2$
Fractal Surface	$2 < D < 3$
Fractal Volume	$3 < D < 4$
Fractal Time	$4 < D < 5$
Hyper-fractals	$5 < D < 6$
$\vdots$	$\vdots$

Self-Affine Structures

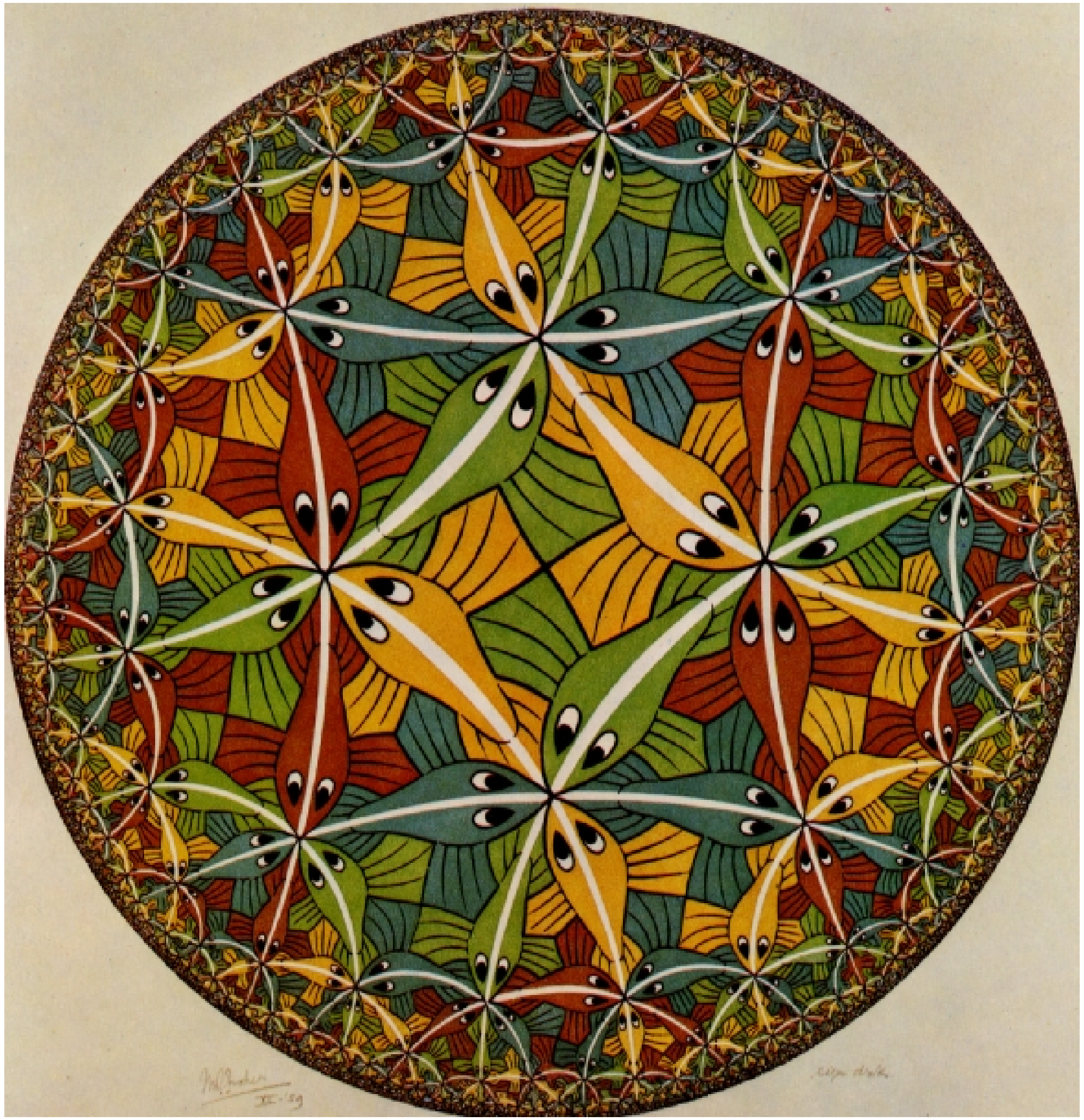
$$\lambda^q f(\mathbf{r}) = f(\lambda \mathbf{r})$$

$$q = 1 - D + \frac{3}{2} D_T$$

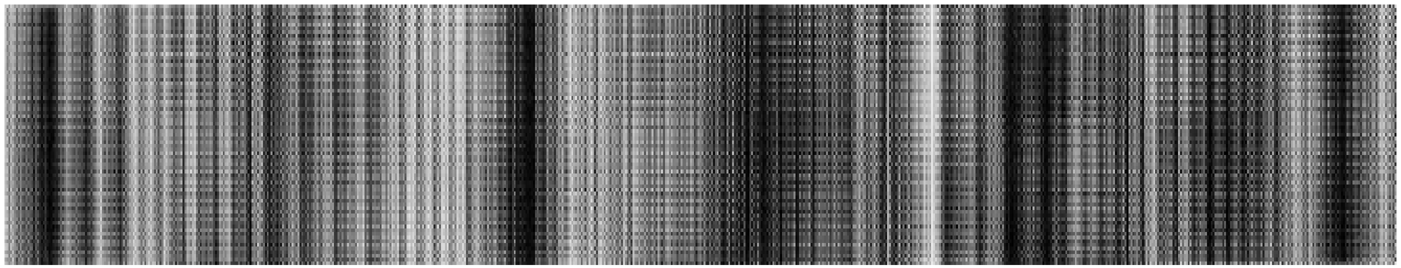


Islamic Art:
Stylised Versions of Self-Repeating Patterns

Self-Similarity by M C Escher



Self-Similarity and J S Bach



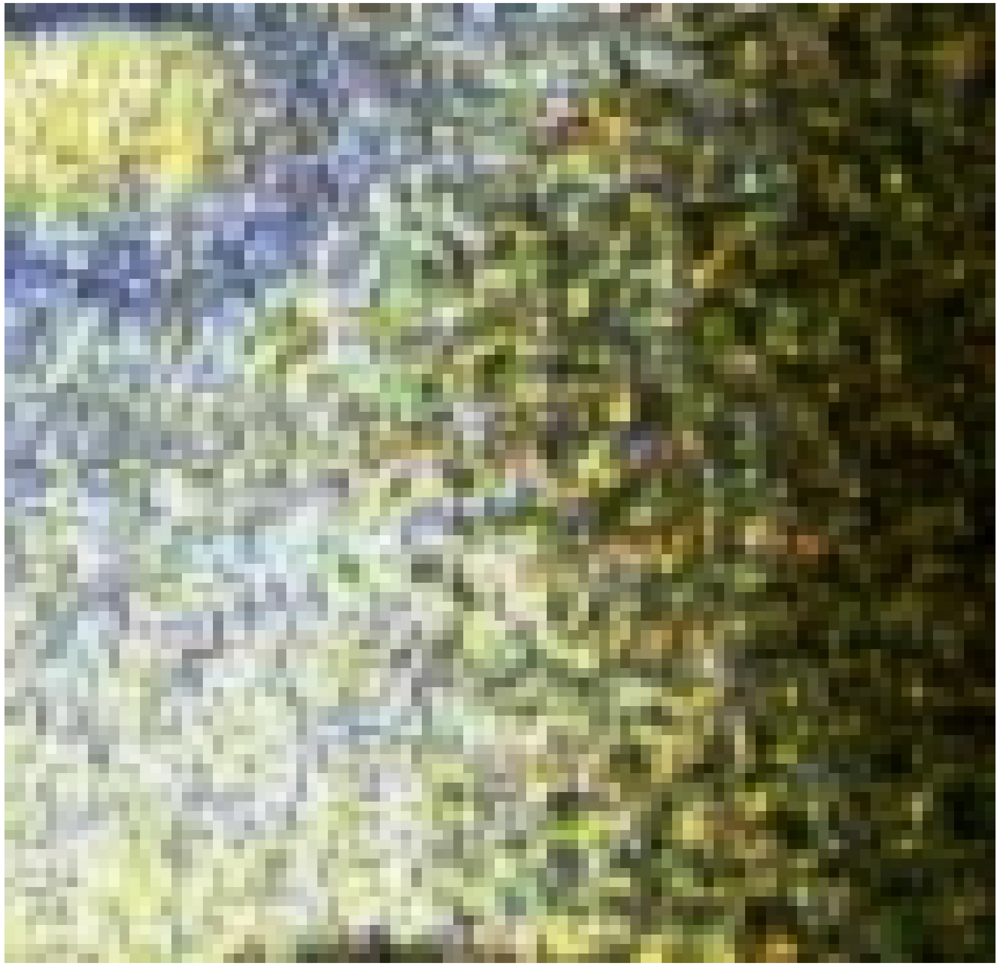
Fractals and Texture

$$\lambda^q \Pr[f(\mathbf{r})] = \Pr[f(\lambda\mathbf{r})] \qquad q = 1 - D + \frac{3}{2}D_T$$

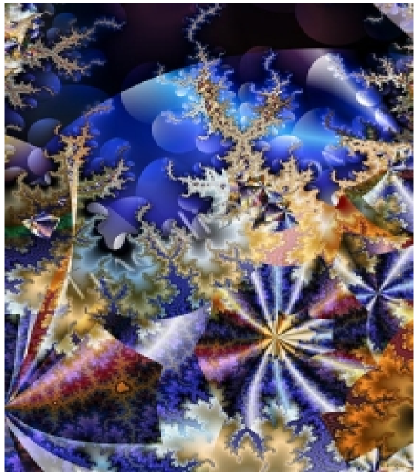
"Much of Fractal Geometry can be considered to be an intrinsic study of texture" *B Mandelbrot*

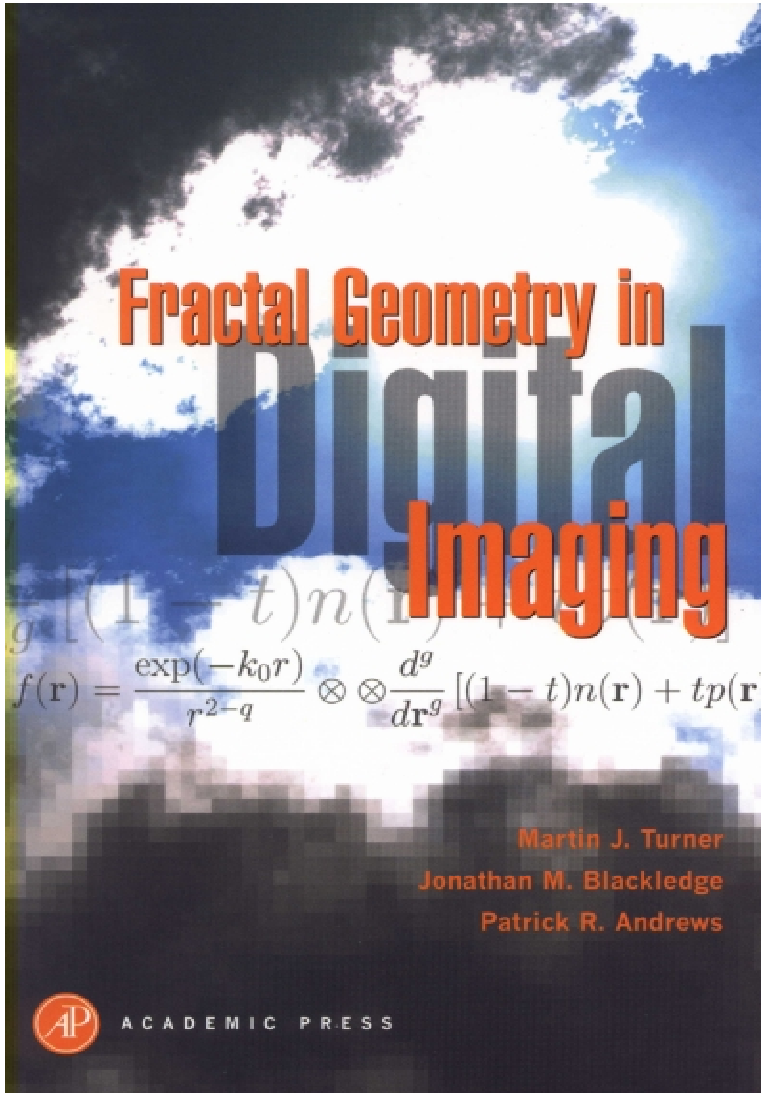
Texture by Claude Monet

Texture by Paul Signac



Fractal Art:
CAD of Natural Objects





Universal law of Critical States

Critical states are governed by the ***universal power law***:

$$\text{System(size)} = \text{constant} \cdot (\text{size})^{-q}$$

where q is a non-integer value.

Scaling Law & Poisson's Equation

- Coulomb's law (and Newton's law of gravity) are based on the ***inverse square law***:

$$\text{Force} \propto \frac{1}{\text{distance}^2}$$

- Result can be expressed as

$$\nabla^2(\text{electric field potential}) = \text{charge density}$$

Scaling Law and the *Fractional Poisson Equation*

- Random fractal self-affine image are characterised by the ***spectral density law***:

$$\text{Spectral density} \propto \frac{1}{(\text{frequency})^q}, \quad 1 < q < 2$$

- Result can be expressed as

$$\nabla^q(\text{fractal surface}) = \text{white noise}$$

Mandelbrot Surfaces

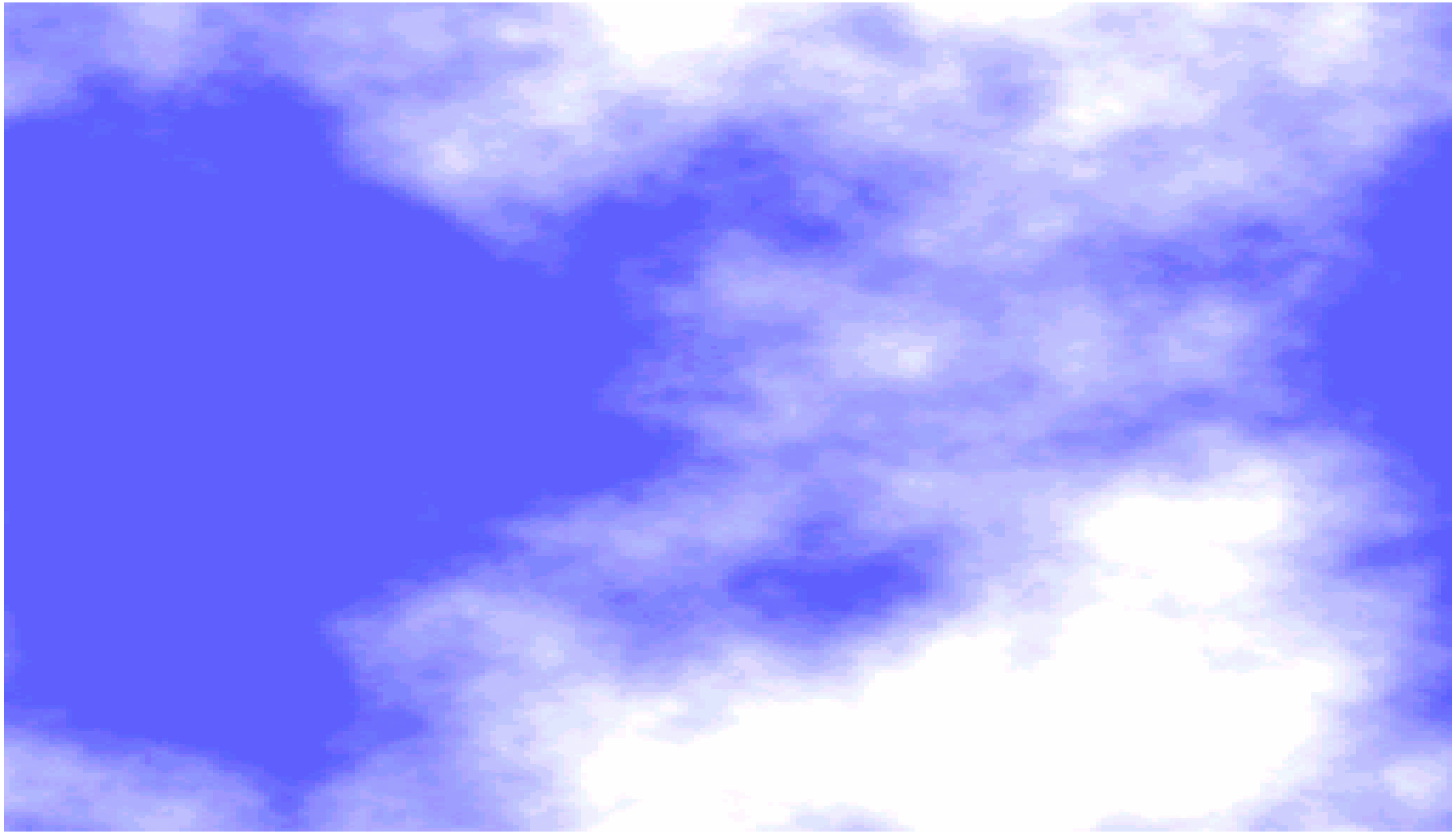
- Can be considered in terms of a solution to the ***Fractional Poisson Equation*** for a ***white noise source***

$$\nabla^q u(\mathbf{r}) = n(\mathbf{r}) \qquad q = 1 - D + \frac{3}{2}D_T$$

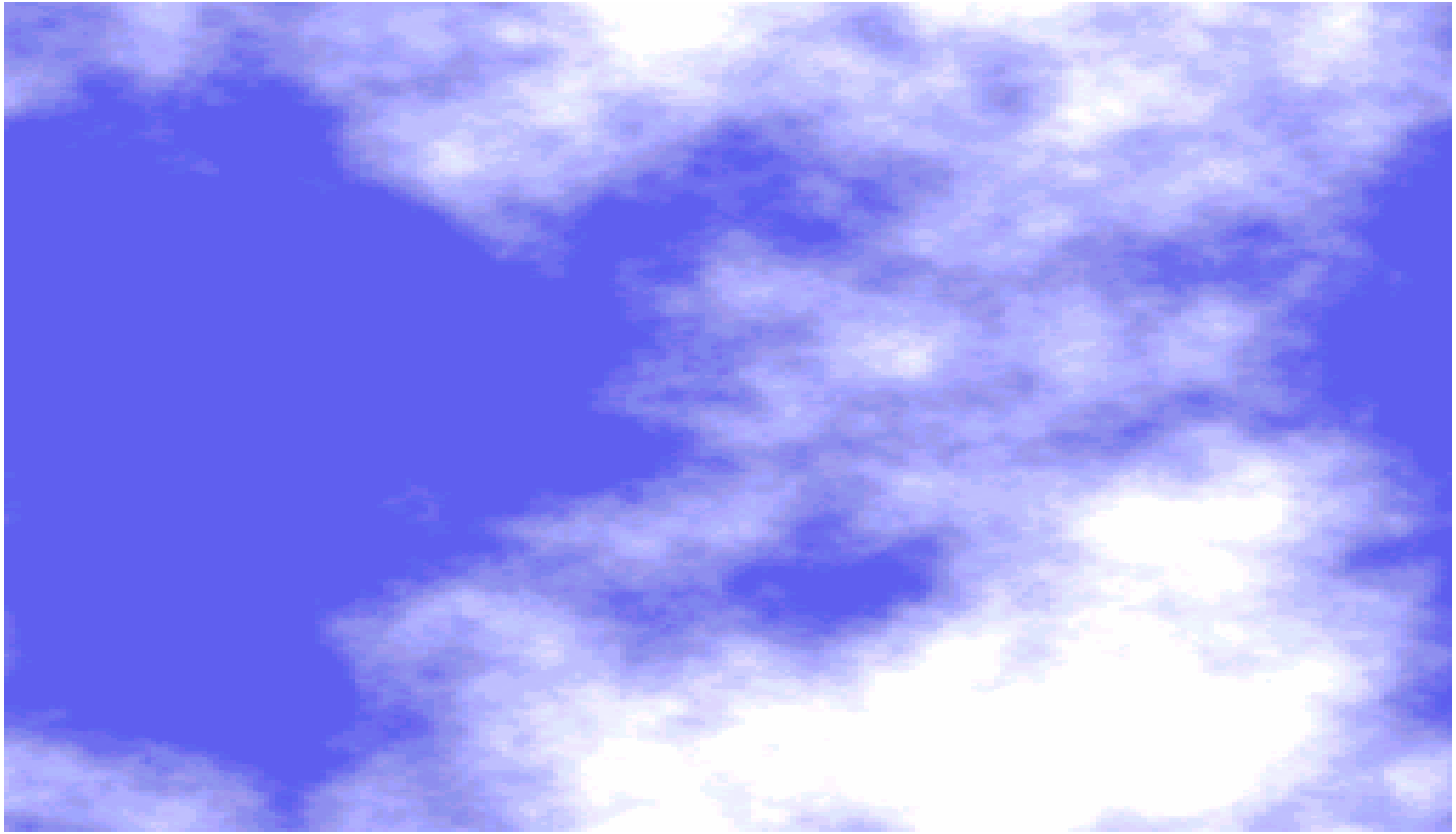
- Use the ***Riesz*** definition of a fractional Laplacian

$$\nabla^q \equiv \frac{1}{2\pi}\int_{-\infty}^{\infty} d^n\mathbf{k}(ik)^q \exp(i\mathbf{k}\cdot\mathbf{r}), \quad k \equiv |\,\mathbf{k}\,|$$

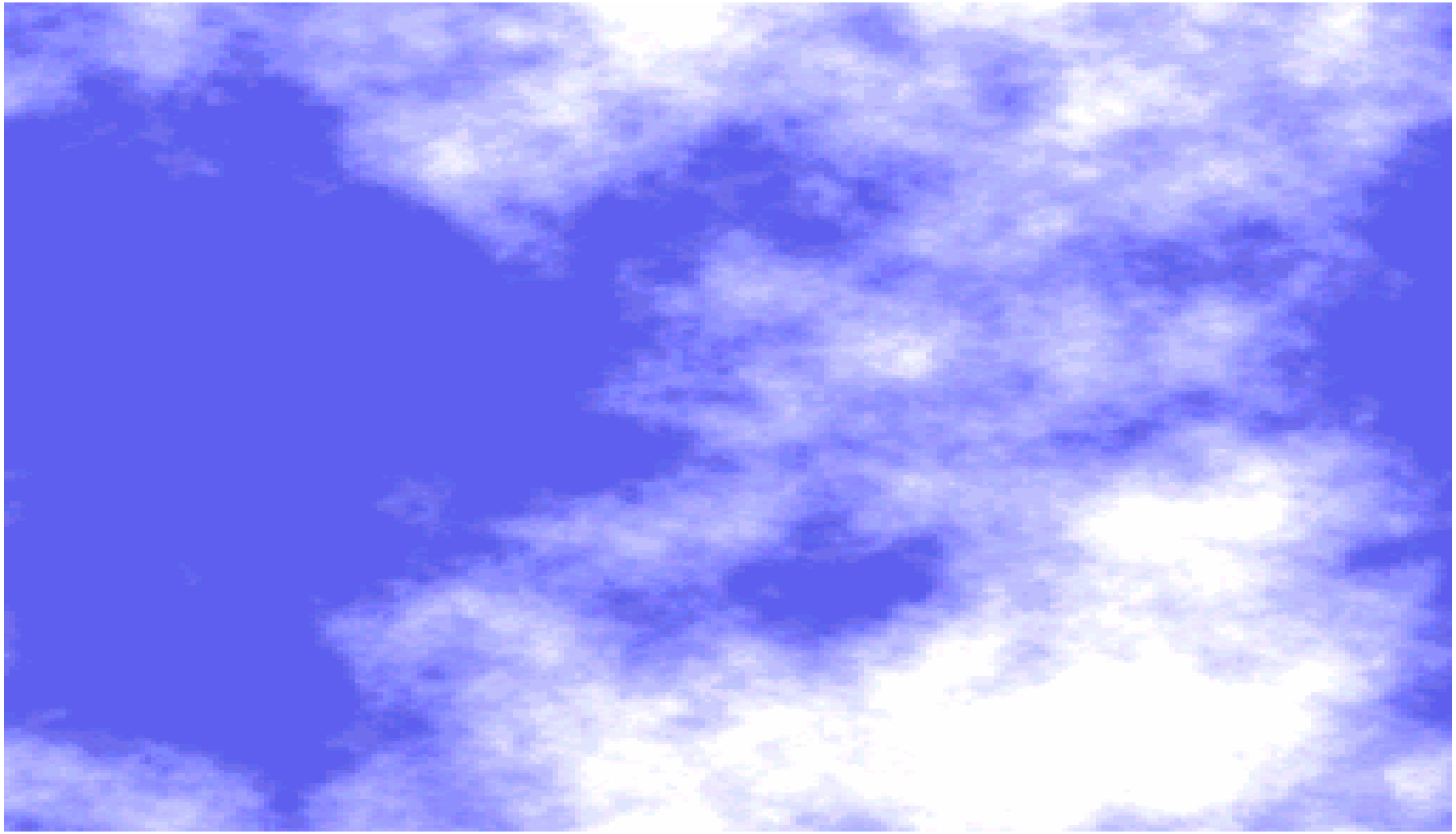
Fractal Clouds: D=2.1



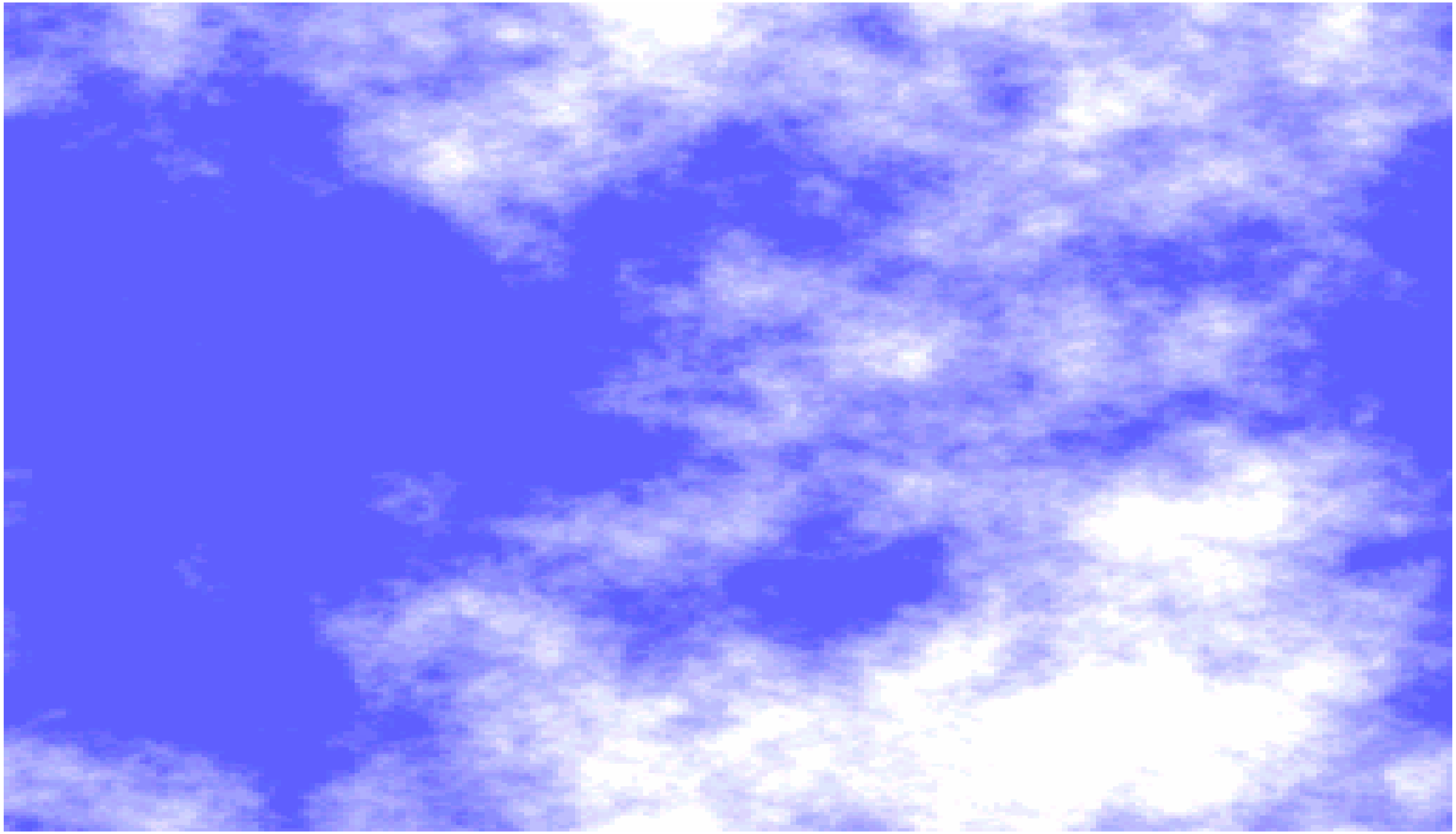
Fractal Clouds: D=2.2



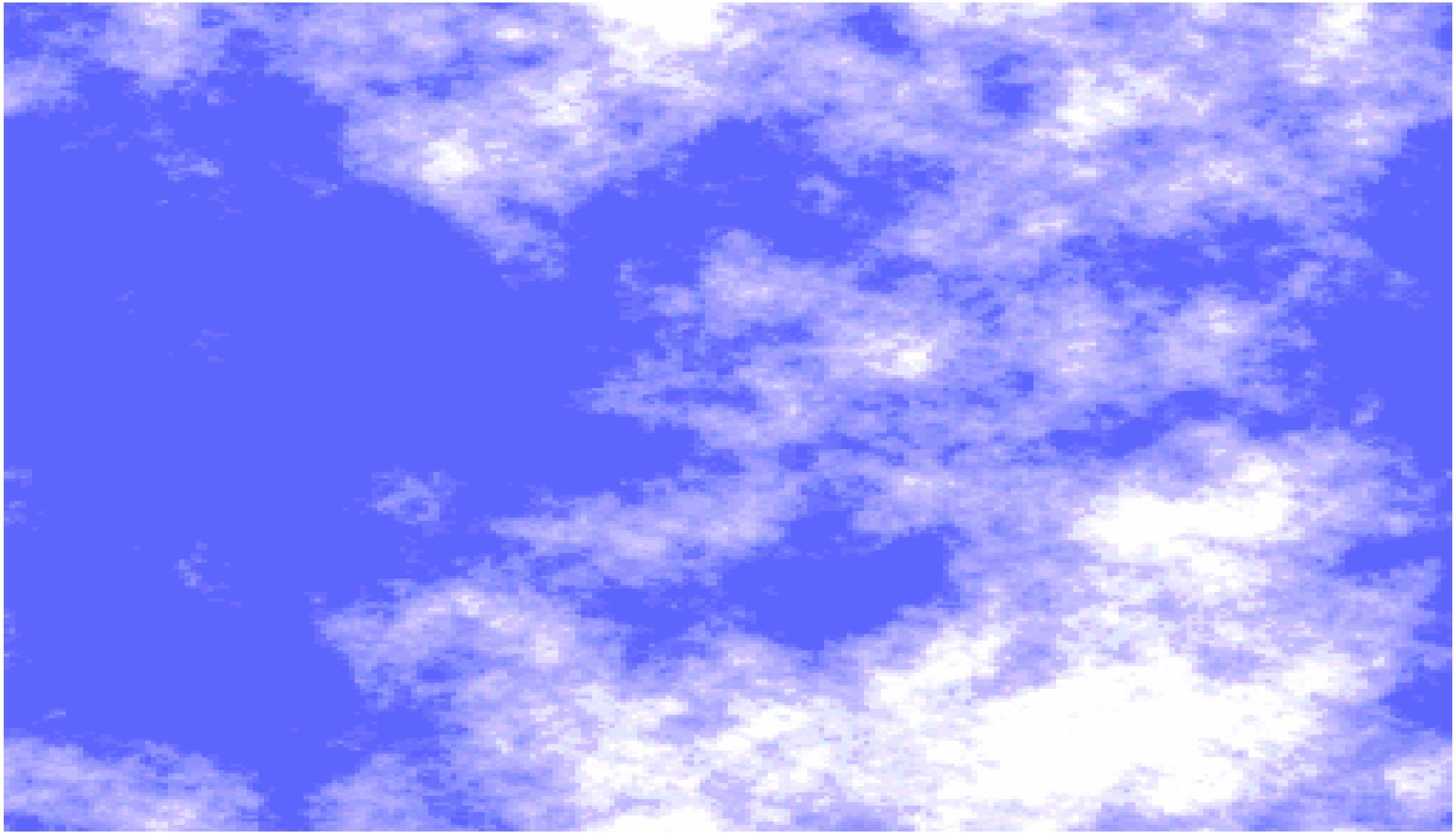
Fractal Clouds: D=2.3



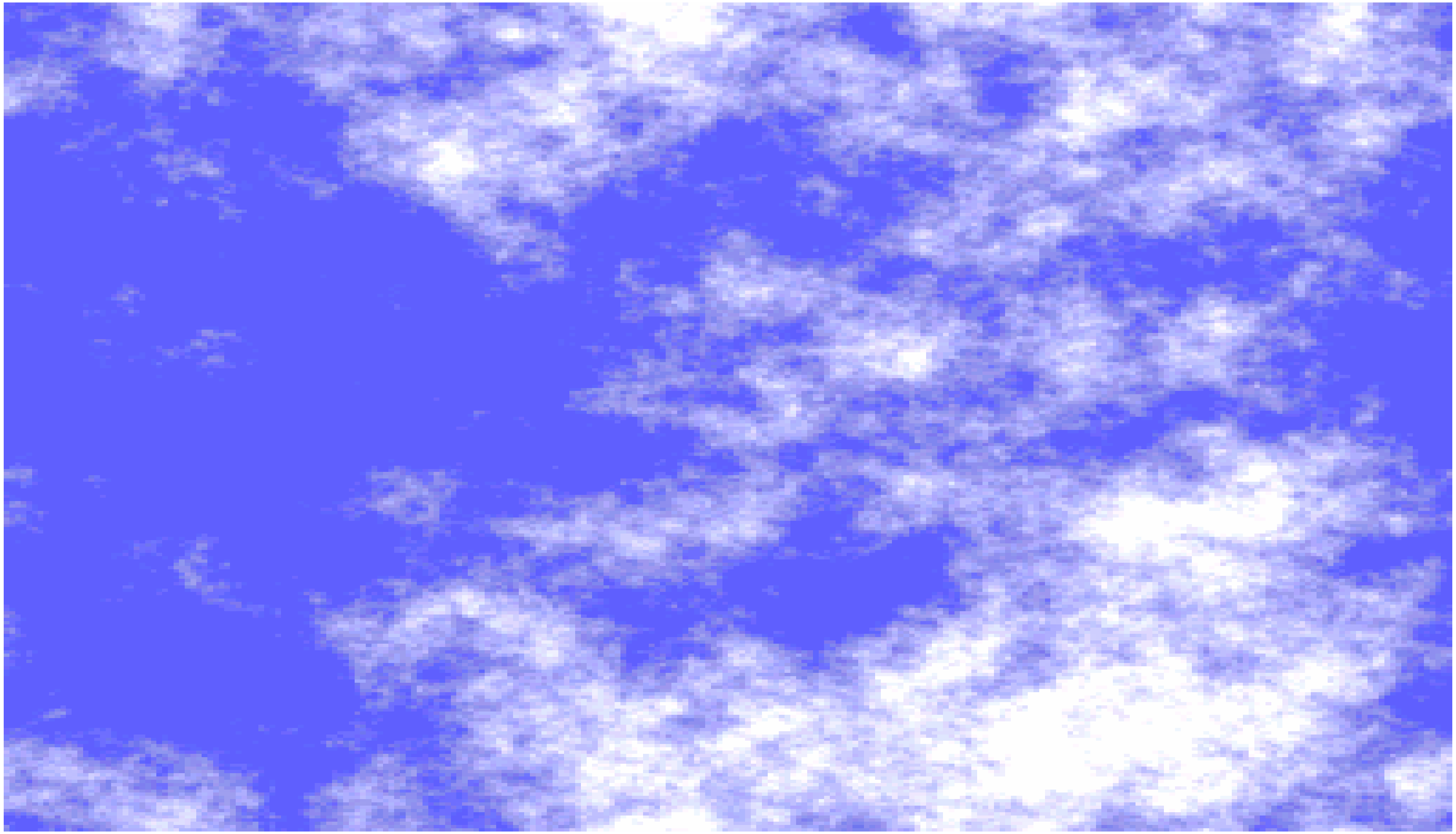
Fractal Clouds: D=2.4



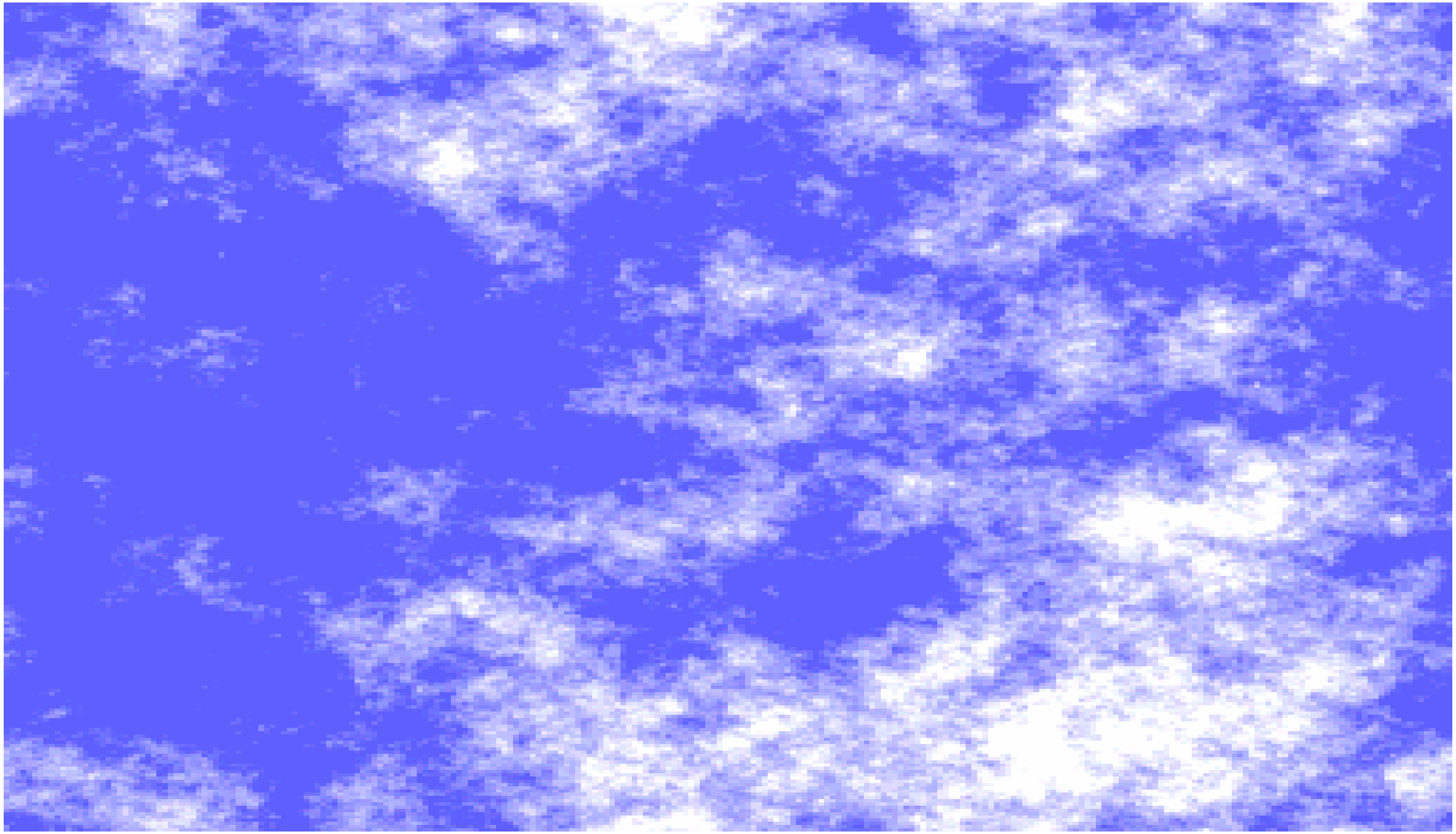
Fractal Clouds: D=2.5



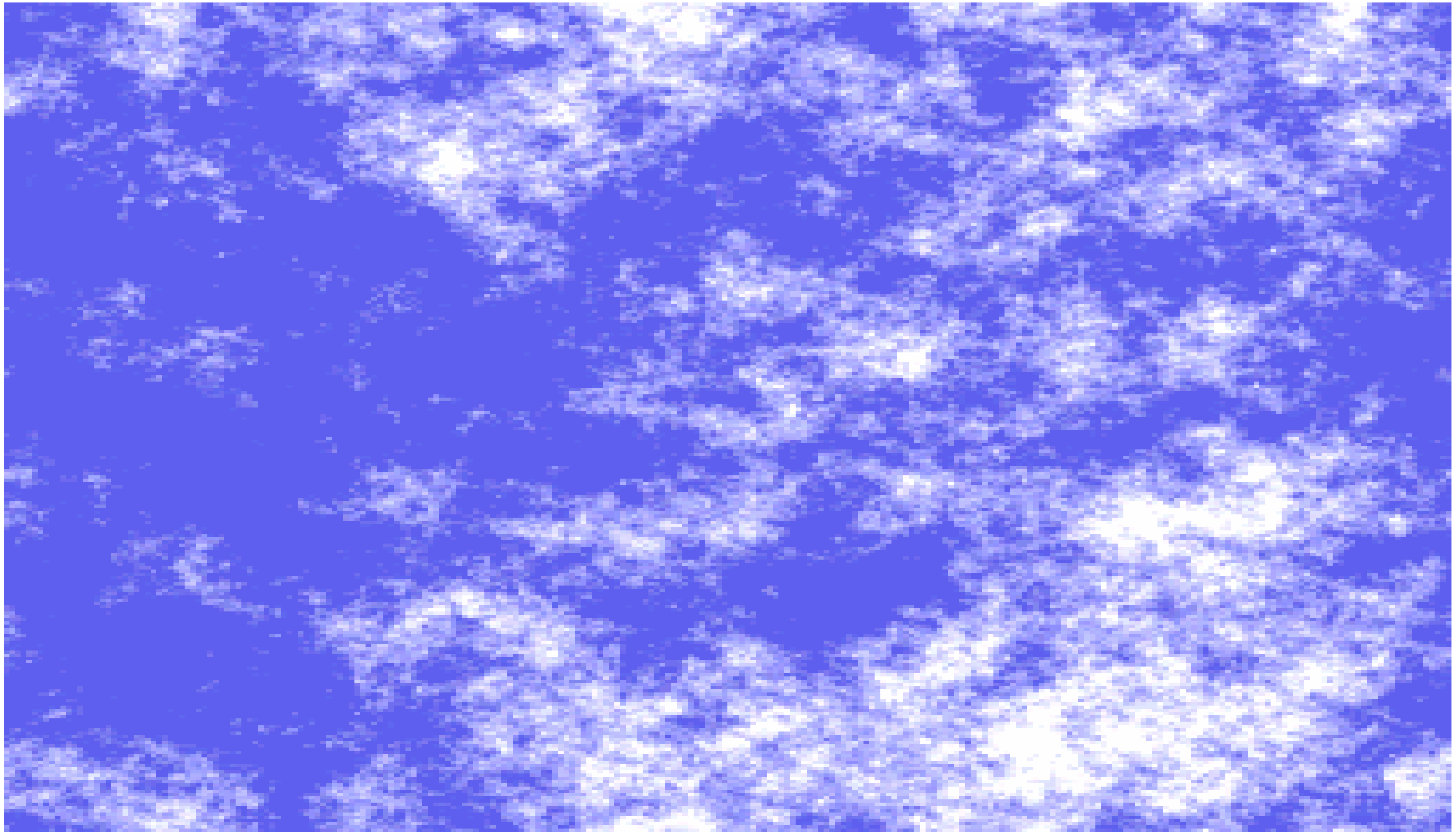
Fractal Clouds: D=2.6



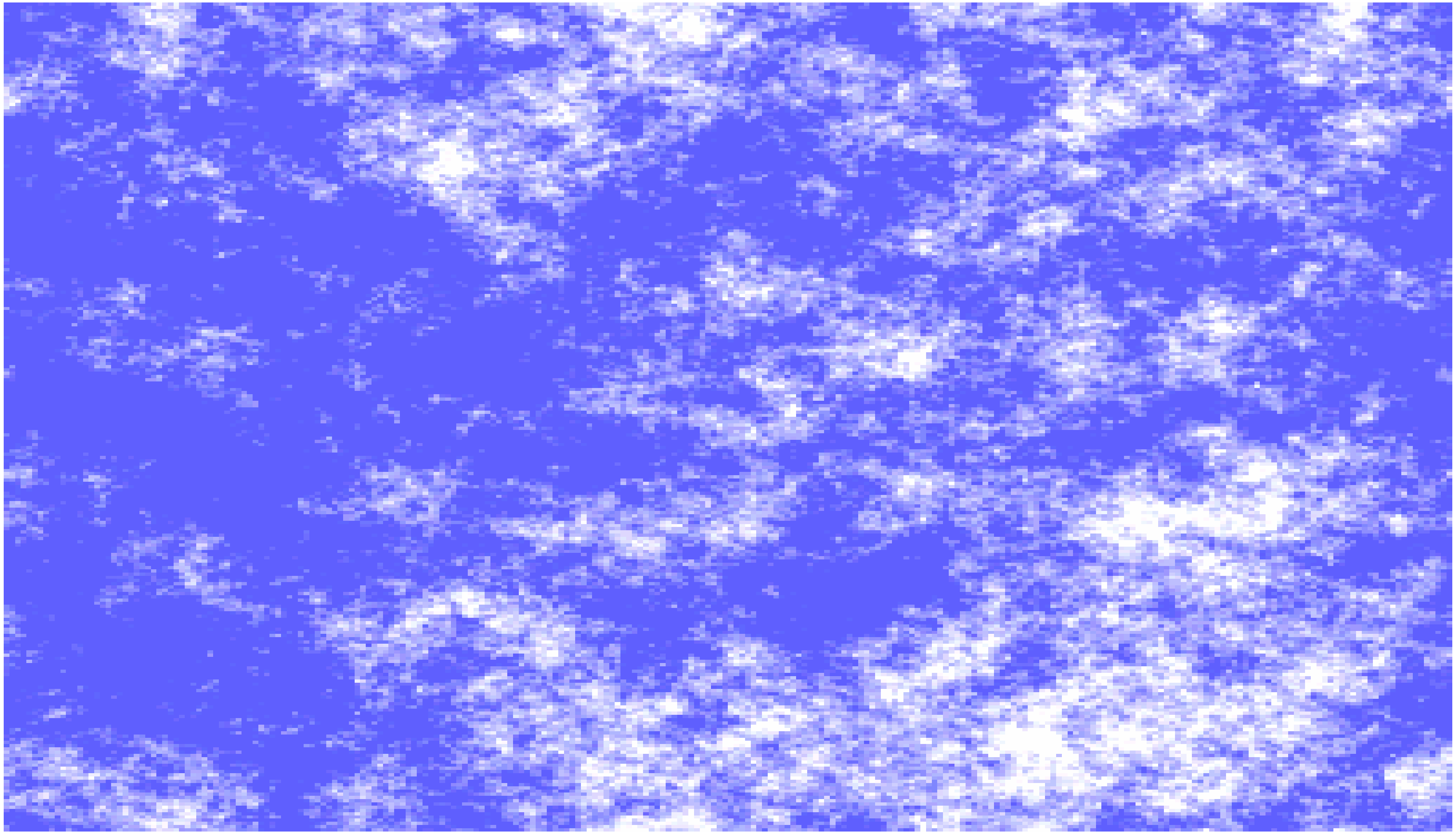
Fractal Clouds: D=2.7



Fractal Clouds: D=2.8



Fractal Clouds: D=2.9



Tailoring the Mandelbrot Surface

$$\nabla^q u(\mathbf{r}) = (1-t)n(\mathbf{r}) + tf(\mathbf{r}), \quad t \in (0,1)$$

$$\|n(\mathbf{r})\|_\infty = 1 \text{ and } \|f(\mathbf{r})\|_\infty = 1$$

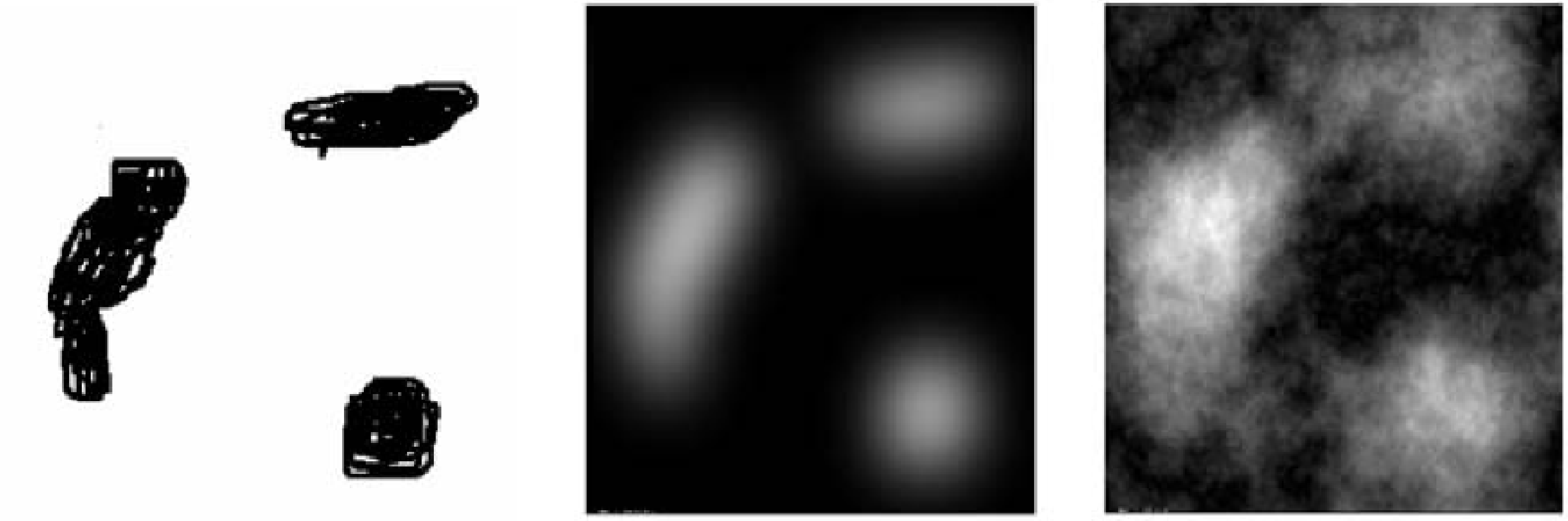


Figure 18.20: Control surface (left) based on hand sketched surface patches, the result of applying a Gaussian low-pass filter to the control surface (centre) and the fractal surface (left) for $q = 1.35$ and $t = 0.3$.

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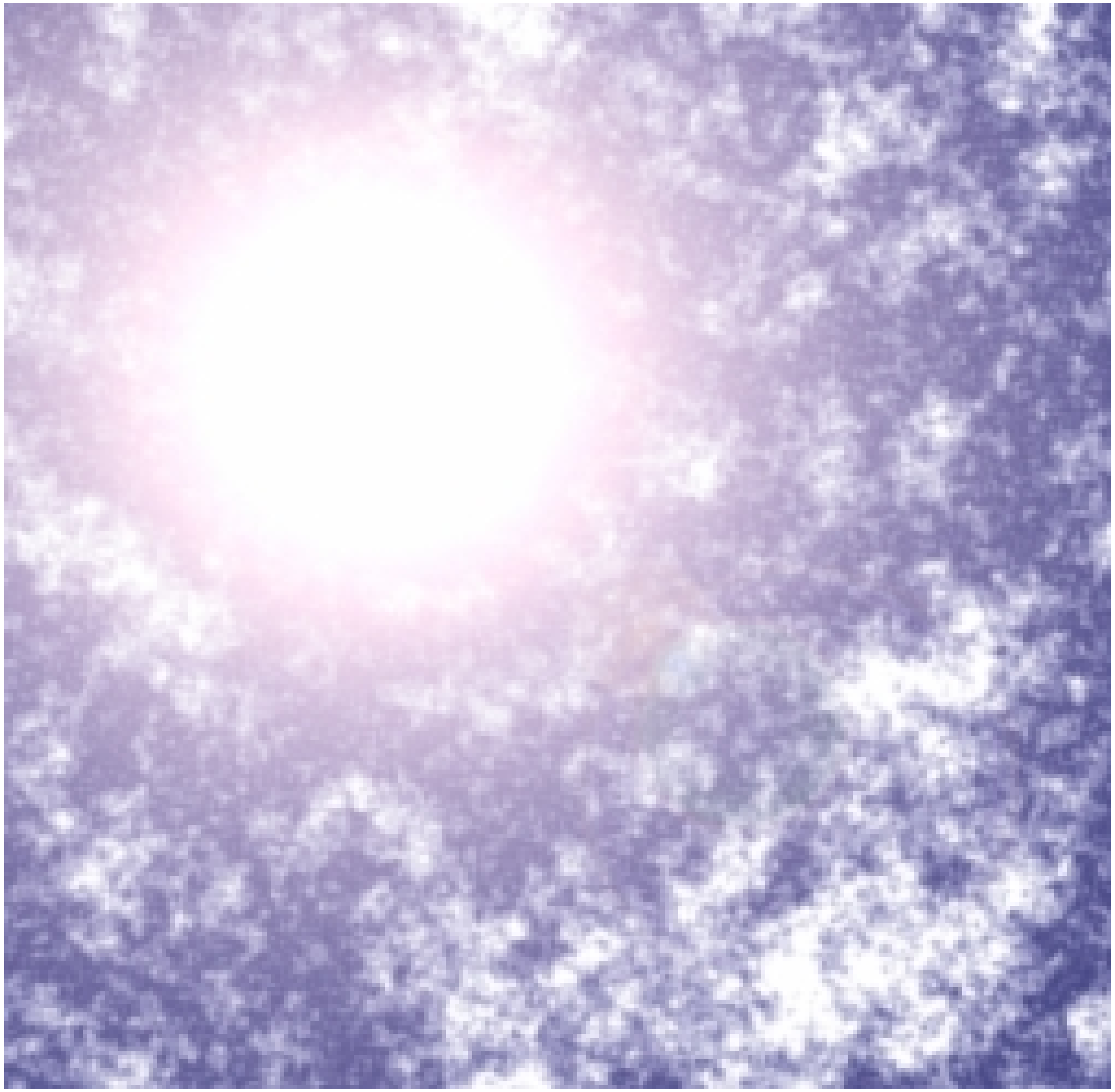
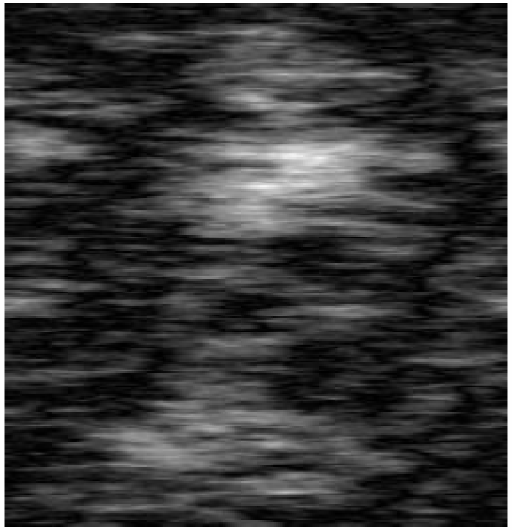
Sun in the Sky D=2.65

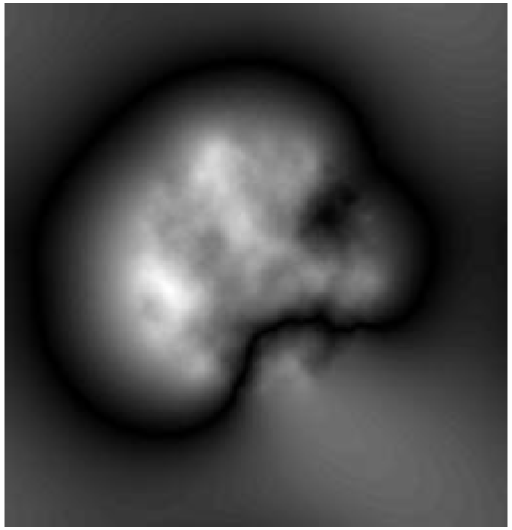


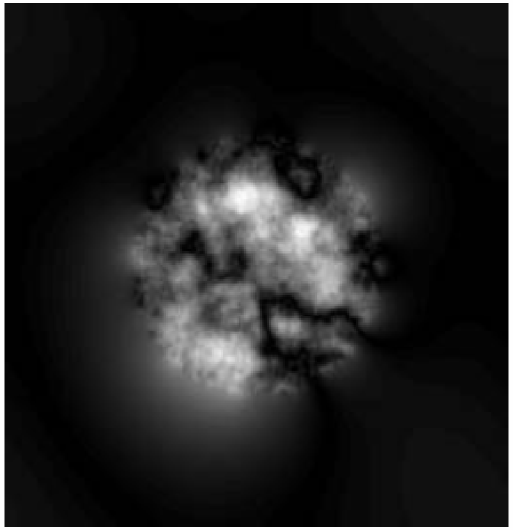
Fractal Flow, Divergent and Rotational Fields

$$\left(\frac{\partial^{q_x}}{\partial x^{q_x}}+\frac{\partial^{q_y}}{\partial y^{q_y}}\right)u(x,y)=n(x,y)$$

$$\nabla^q\times\mathbf{u}(\mathbf{r})=\mathbf{n}(\mathbf{r}),\quad \mathbf{r}\in A$$

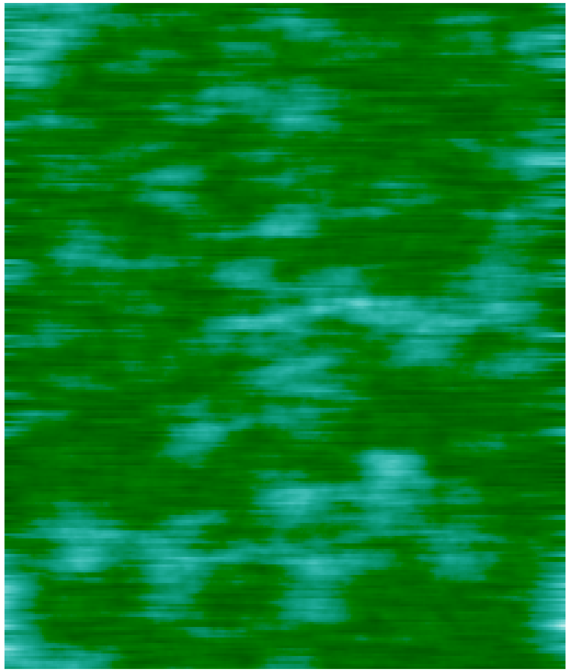






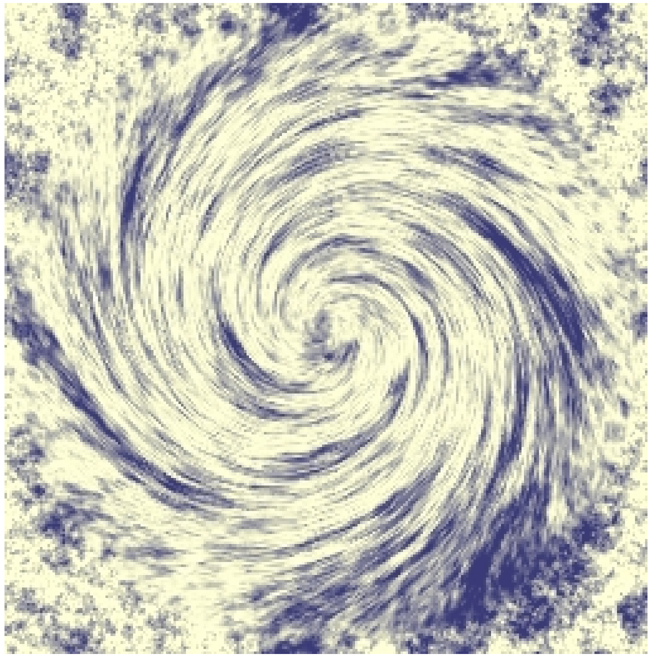
$$\nabla^q\cdot\mathbf{u}(\mathbf{r})=n(\mathbf{r}),\quad \mathbf{r}\in A$$

Examples of Flow, Divergent and Rotational Fractal Fields



Flow

Divergent



Rotational

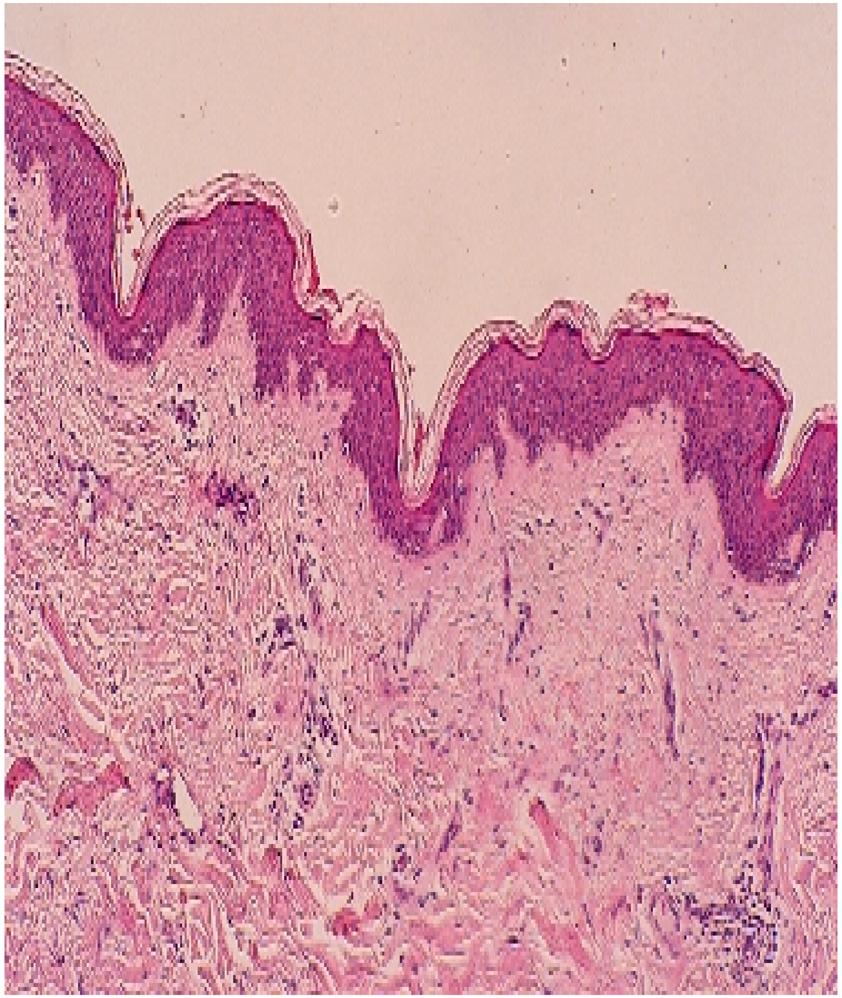
Self-Similarity and the Imagination

- **Copernicus:** Planets orbit the sun
- **Kepler:** Moons orbit the planets
- **Bohr:** Electrons orbit the nucleus (except for a Quantum Mechanic who know better !!!)
- **Rees:** Galaxies orbit super-massive black holes

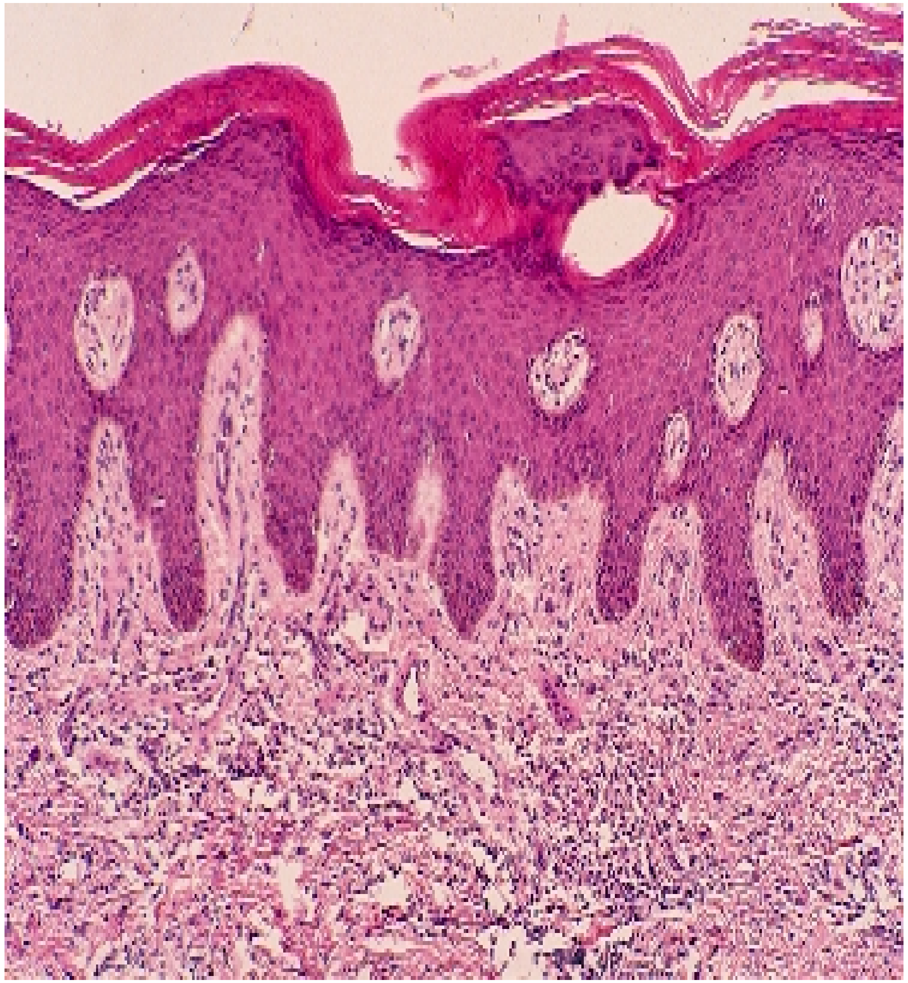
Same idea (in terms of images of the physical system) but at different scales.

Texture and Medicine

Normal Skin



Chronic Dermatitis



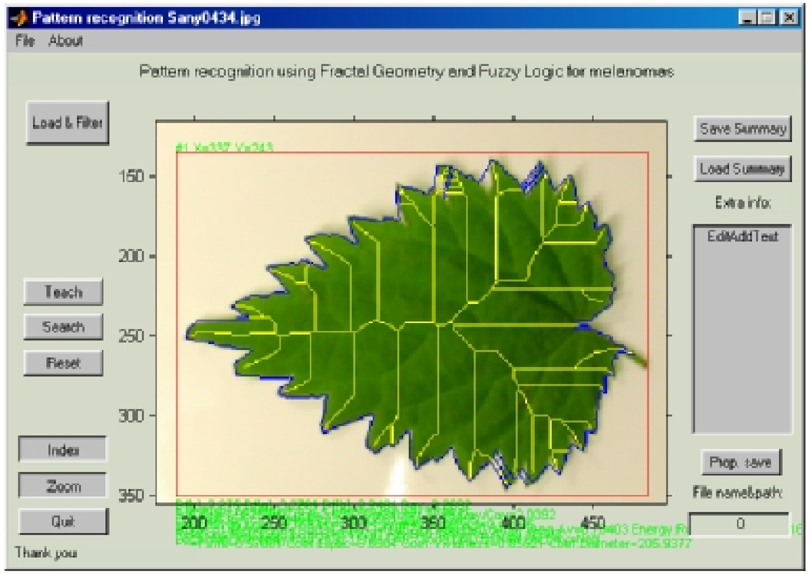
Computer Vision using Fractal Geometry: Texture Analysis

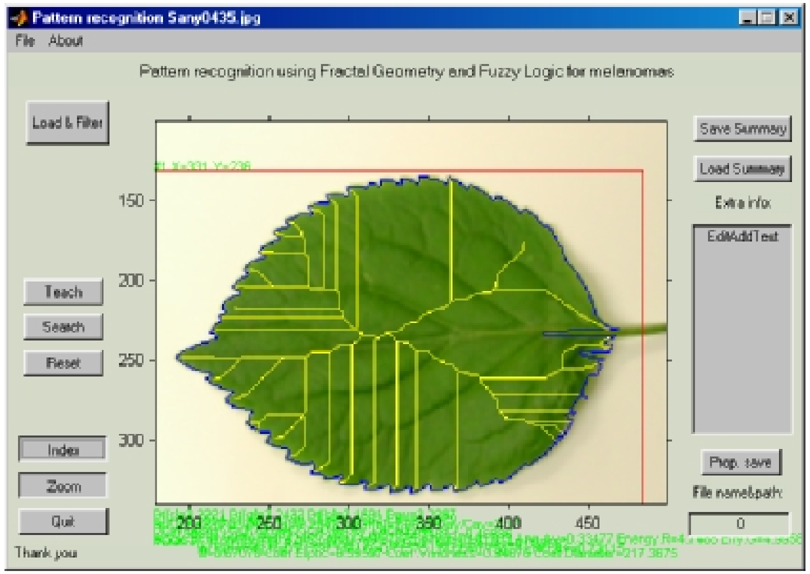
Include Elements of the Feature Vector that are based on Fractal Geometric Parameters of an ‘object’ or ‘target’, e.g.

- Fractal Dimension
- Correlation Dimension
- Lacunarity

associated with boundary and/or surface properties that are applications dependent

Example of a Feature: Fractal Dimension of a Boundary

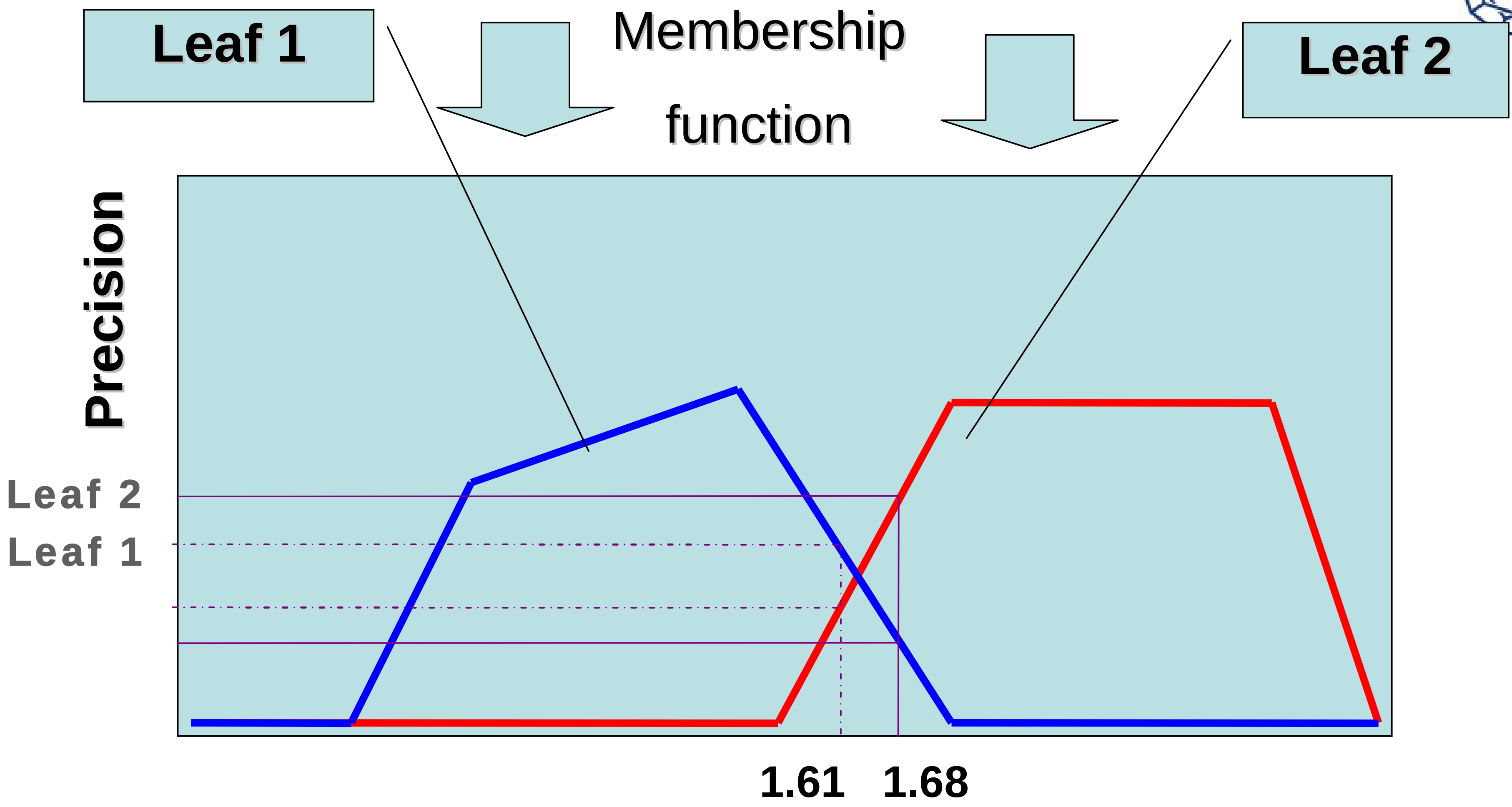




D=1.61

D=1.68

Machine Learning



Fractal Dimension based Fuzzy Logic engine

Illustration of Decision Making: Non-Fuzzy Sets, Two Features

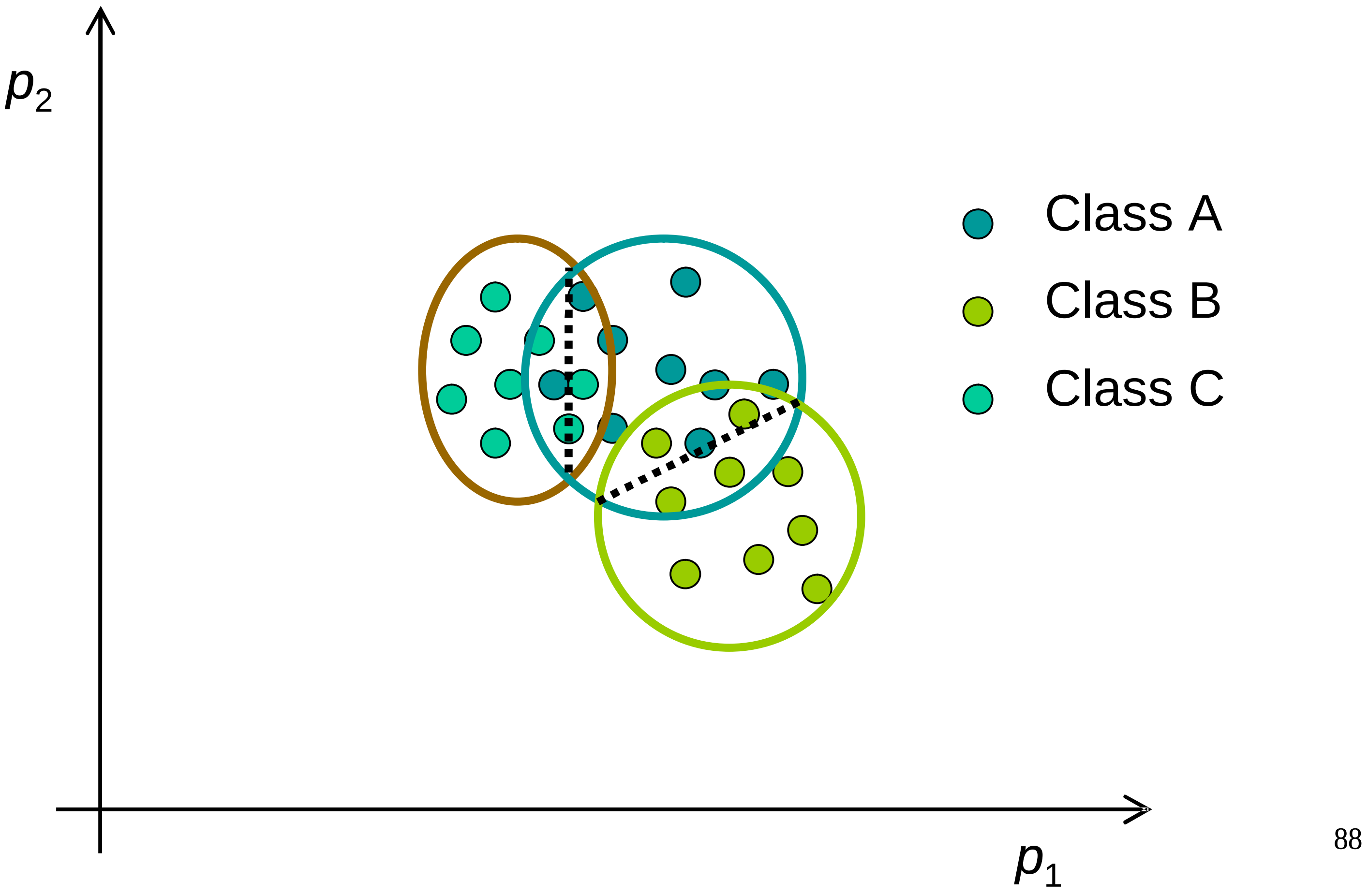
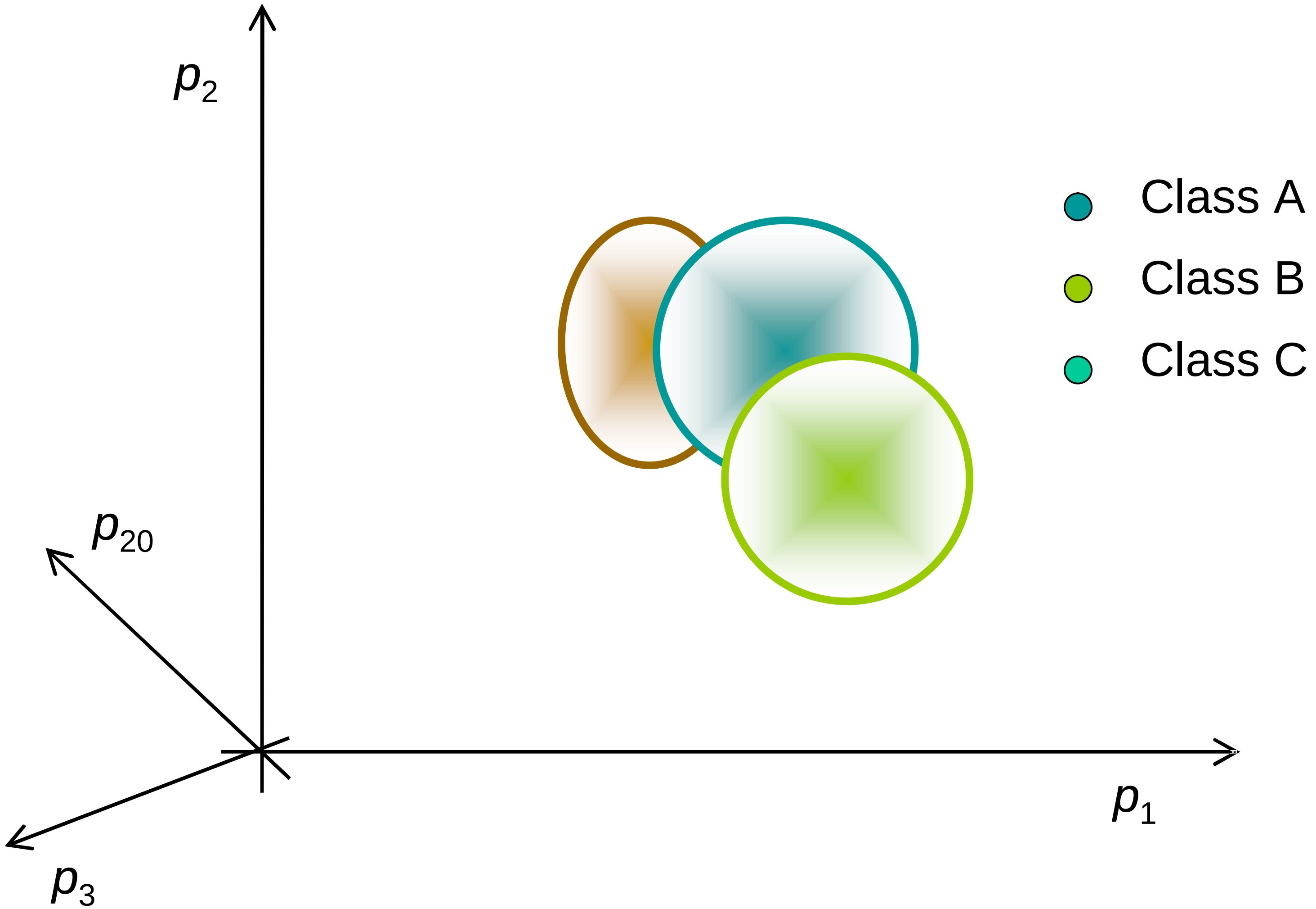
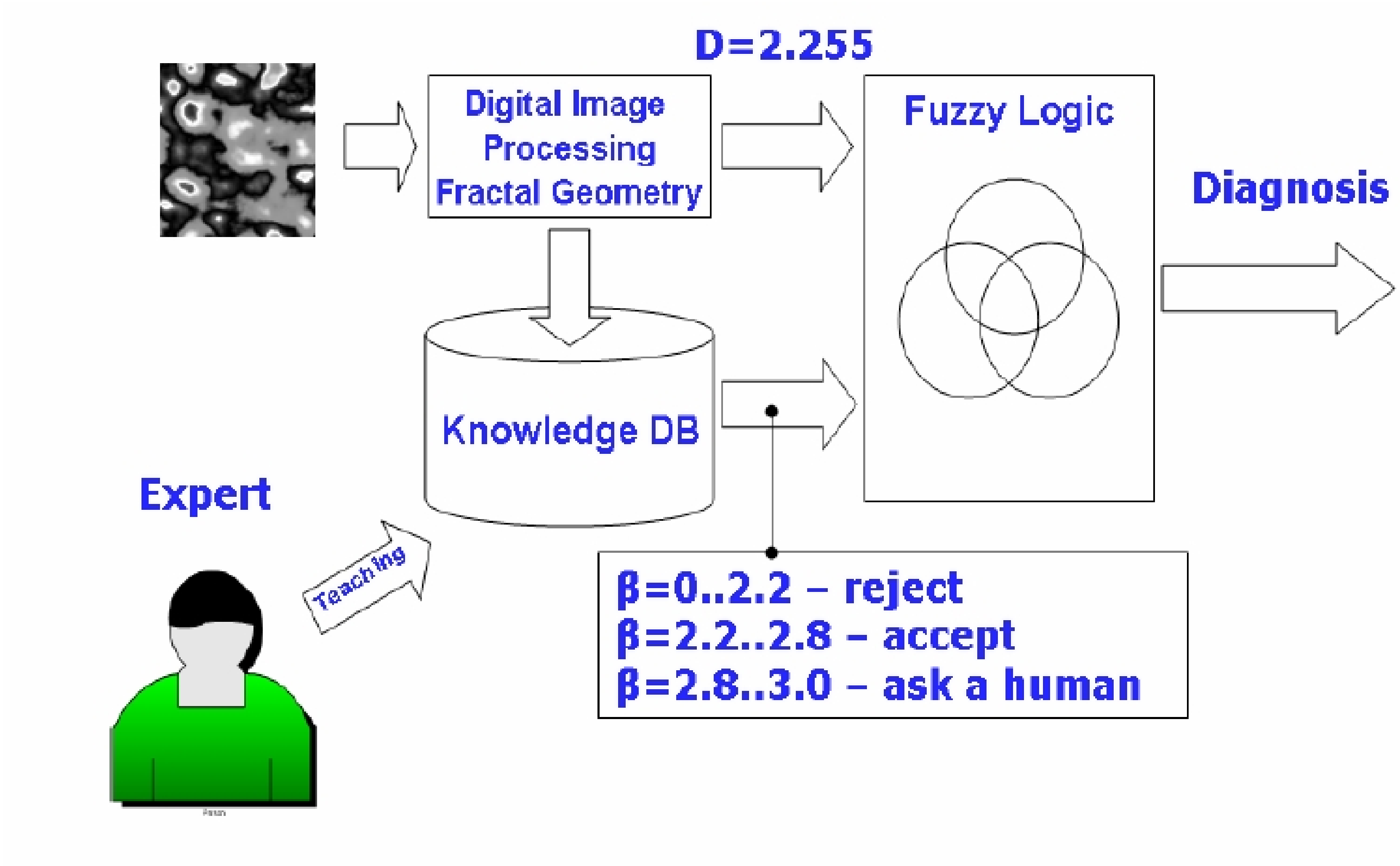


Illustration of Decision Making: Fuzzy Sets, 20 Features



Expert System Development



Example Application of NDE 1: Growth of Microorganisms

Relating Fractal Dimension to Branching Behaviour in Filamentous Microorganisms, D Barry et al, *ISAST Transactions on Electronics and Signal Processing*, Vol. 4, No. 1, 71 - 76, 2009; http://eleceng.dit.ie/papers/138.pdf

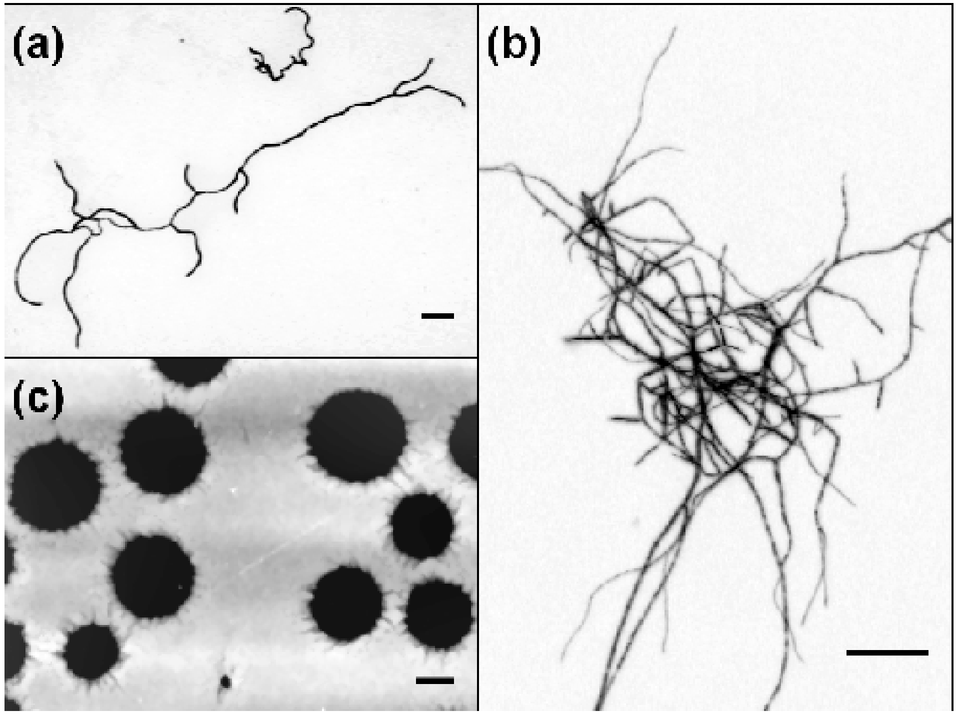


Fig. 1. Typical morphologies found in submerged fermentations of filamentous microorganisms: (a) Freely dispersed mycelia (Bar = 50μm) (b) Mycelial clump (Bar = 100μm) (c) Pellets (Bar = 2.5mm)

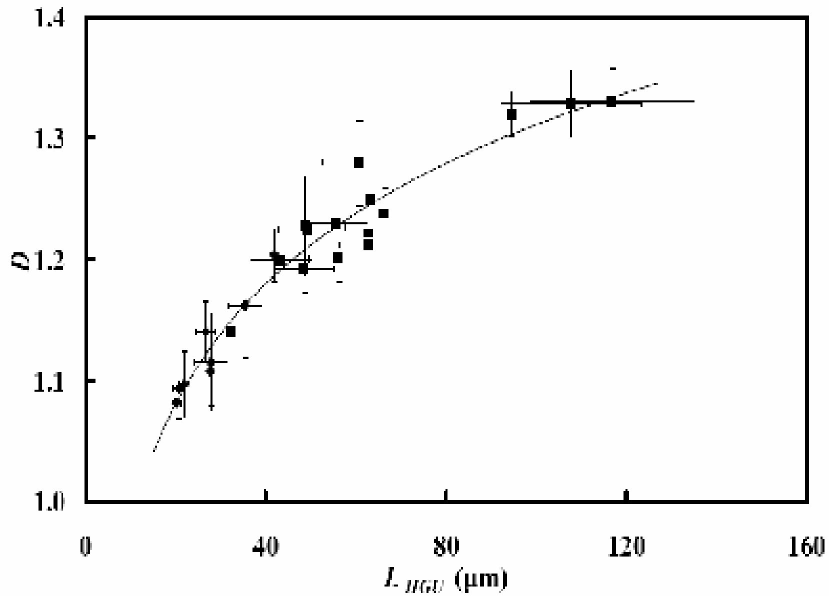
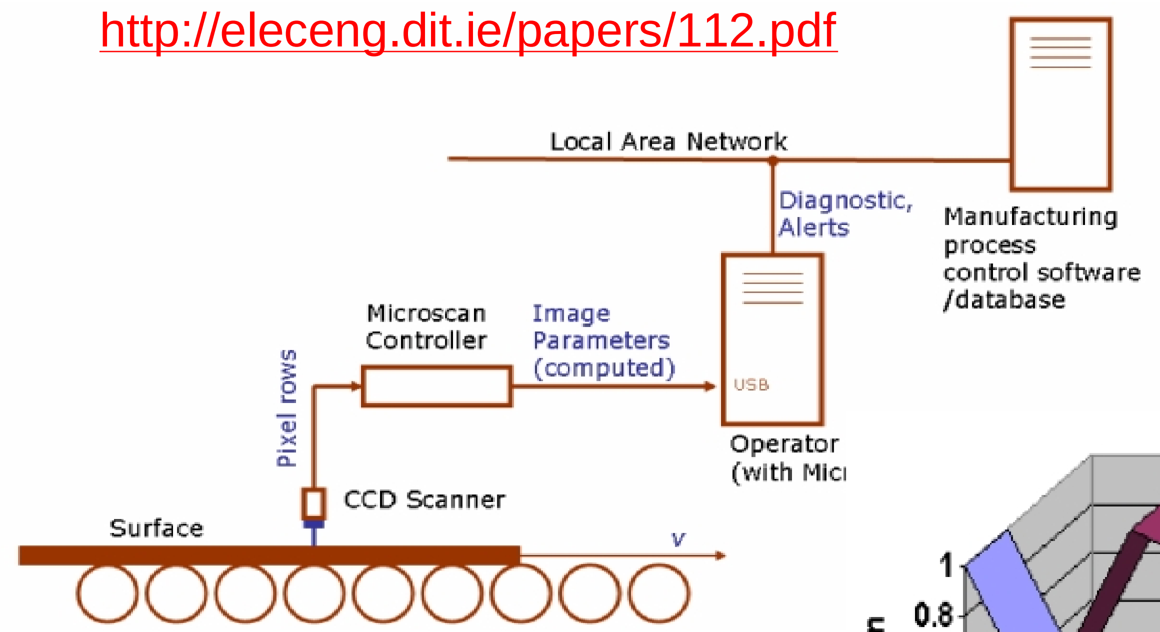


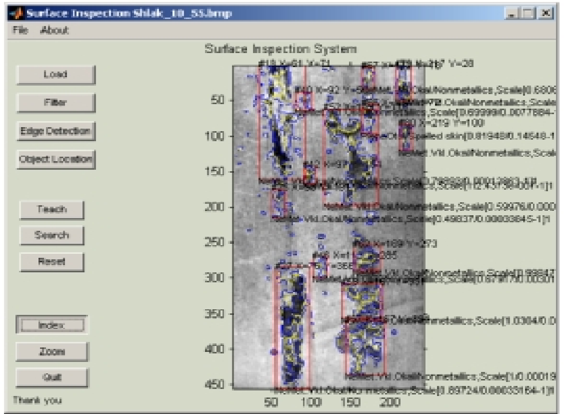
Fig. 5. Relationship between the mean hyphal growth unit (L_{HGU}) and the mean fractal dimension (D) of populations of *Aspergillus oryzae* (■) and *Penicillium chrysogenum* (♦) mycelia, grown under a variety of different conditions (Table I). A logarithmic relationship of the form $D = a\ln(L_{HGU})+b$ exists between the two parameters, where $a = 0.14$ and $b = 0.65$ (—; $R^2 = 0.95$). Error bars represent 95% confidence intervals.

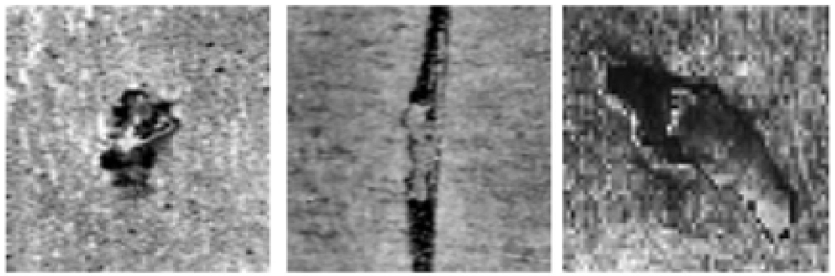
Example Application of NDE 2: Quality Control of Rolled Steel

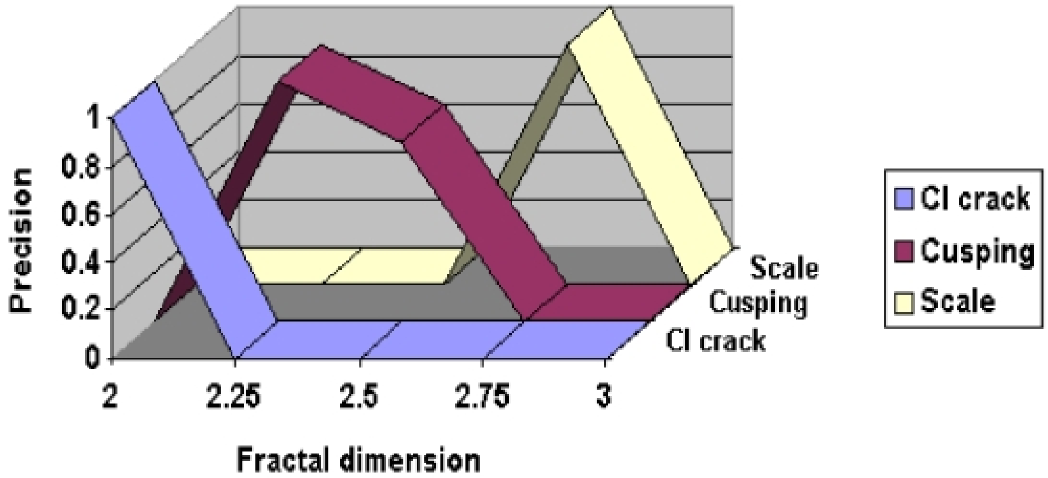
A Surface Inspection Machine Vision System that Includes Fractal Analysis J Blackledge and D Dubovitski, *International Society for Advanced Science and Technology, Journal of Electronic and Signal Processing,* Vol 3, No 2, 76 - 89, 2008

http://eleceng.dit.ie/papers/112.pdf







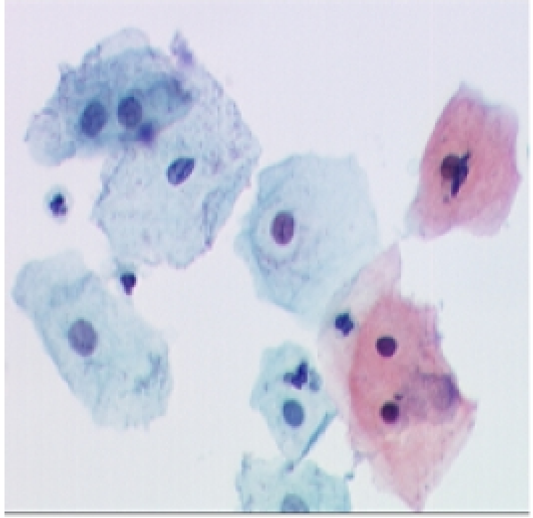


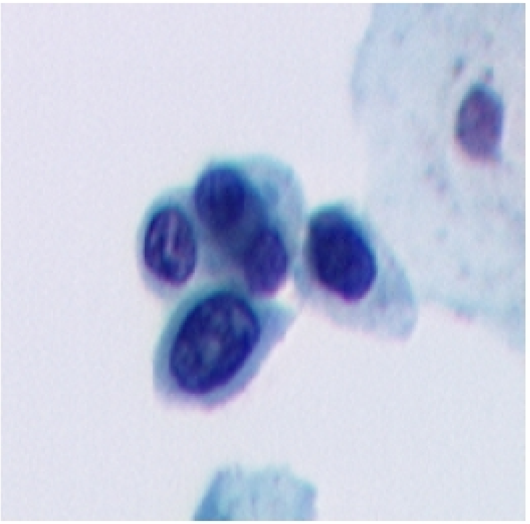
Example Application of NDE 3: Cytopathology

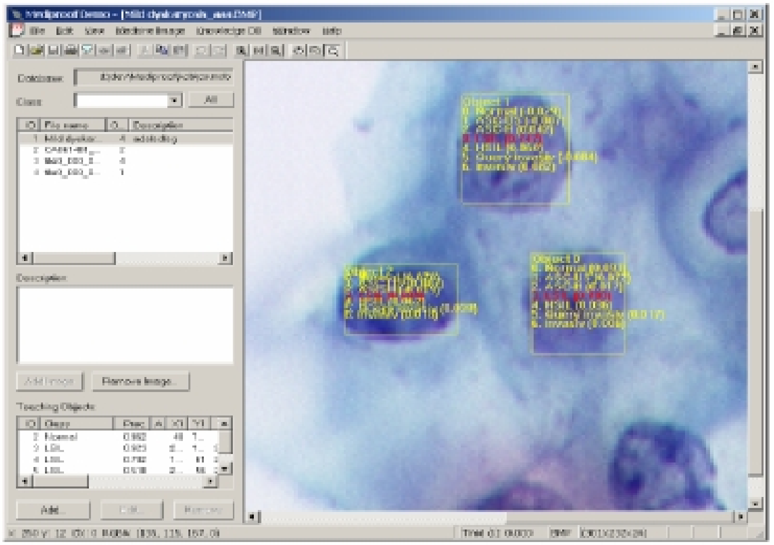
An Optical Machine Vision System for Applications in Cytopathology

J Blackledge and D Dubovitski, *International Society for Advanced Science and Technology, Journal of Electronic and Signal Processing*

To be Published, 2010

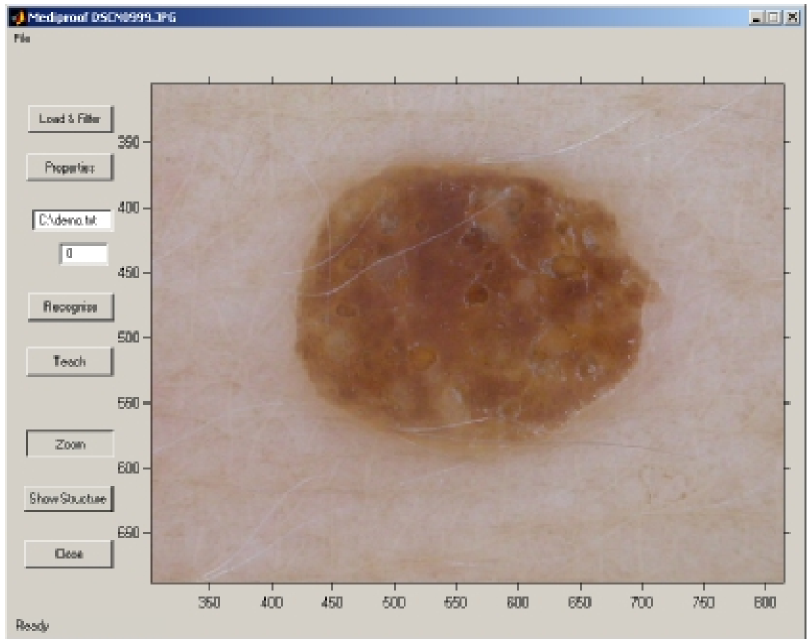






Example Application of NDE 4: A Skin Cancer Screening System

Object Detection and Classification with Applications to Skin Cancer Screening J Blackledge and D Dubovitski, *International Society for Advanced Science and Technology, Journal of Intelligent Systems,* Vol 1, No 1 (ISSN 1797-2329), 34 - 45, 2008; http://eleceng.dit.ie/papers/101.pdf



http://www.oxreco.com/setup.zip

Why Bother?

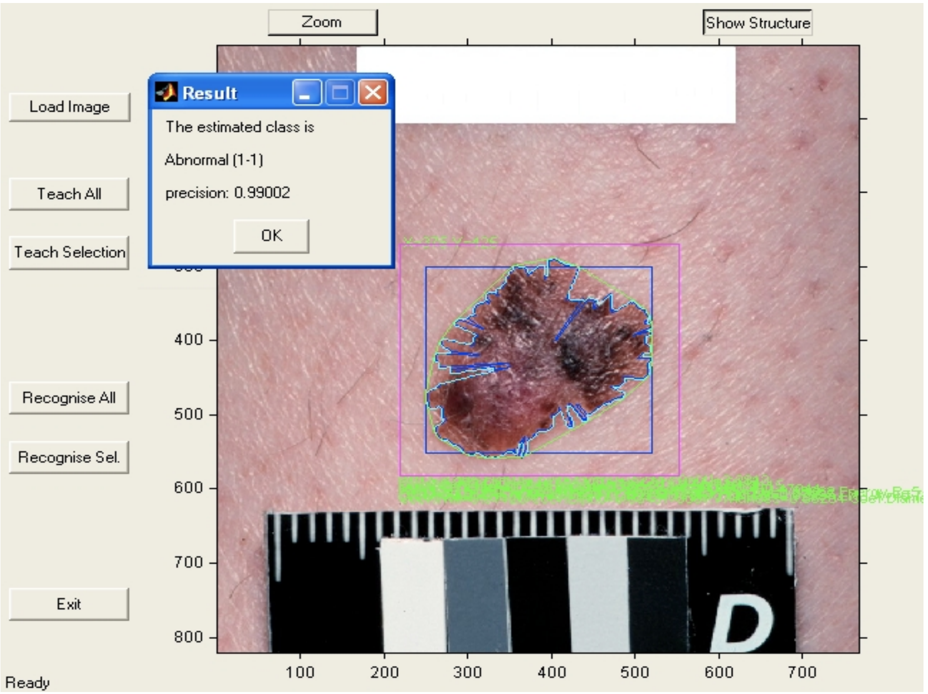
- Over *5,700* new cases each year in the UK
- Manual screening achieves only *35% identification*
- GP’s do not have the *expertise to diagnose skin cancer*
- Cancer specialists improve identification rate to over 65% but are *severely overloaded*

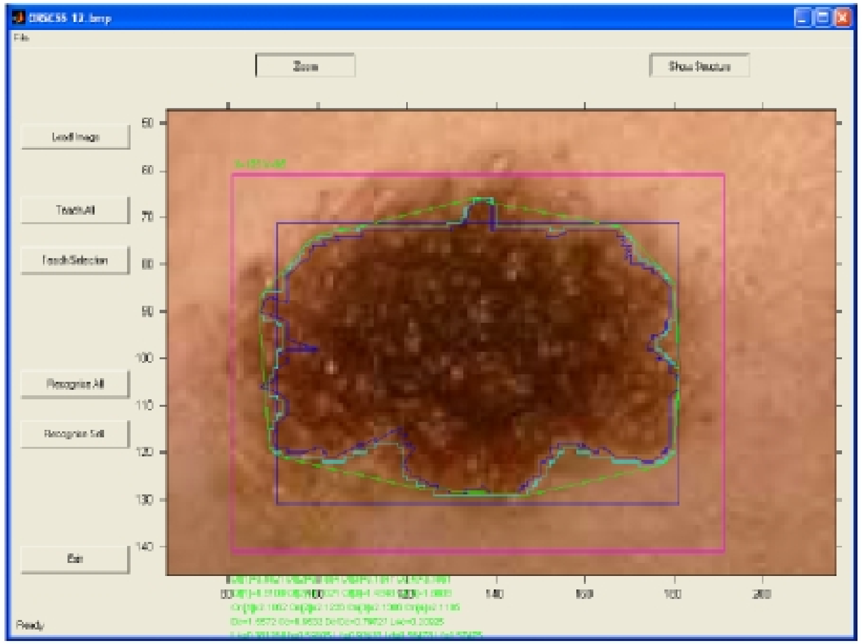
Commercialization

Technology to License

Skin Cancer Screening System

Dublin Institute of Technology (DIT) is seeking companies to license a novel technology that provides a facility for screening te onset of skin cancer using optical images that can be used in a General Practice..





Summary

- Inclusion of ‘Fractal Geometry’ significantly enhances the design of optical computer vision systems for NDE when images are of objects that are textured

- Getting the right ‘mix of parameters’ (i.e. the right mix of Euclidean and Fractal parameters) is ‘as much an art as it is a science’ – applications dependent

- Options in optical computer vision:

  OPTION 1: Raw Data – Artificial Neural Network

  OPTION 2: Processed Data – Fuzzy Logic Engine

  OPTION 2 is preferable using Fractal Geometry for

  texture analysis

Q & A

http://konwersatorium.pw.edu.pl/wyklady/2010_VLZ7_06_wyklad.pdf