Processing Laser Scanner Plant Data to Extract Structural Information

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Data and Plant Structure

Traditional approach:

- digitised points entered in hierarchical pattern
- data collection and classification inseparable

Laser scanner approach:

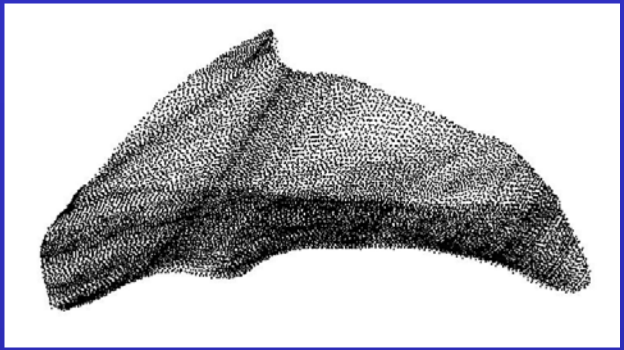
- very large sets of unstructured data points
- structure needs to be extracted from data

Aims

- To use laser scanner data to generate an accurate mathematical model of a plant
- To give advice to plant scientists who are using single-point devices such as sonic digitisers, on where to digitise points for an optimal outcome

Example:
Extracting leaf surface information

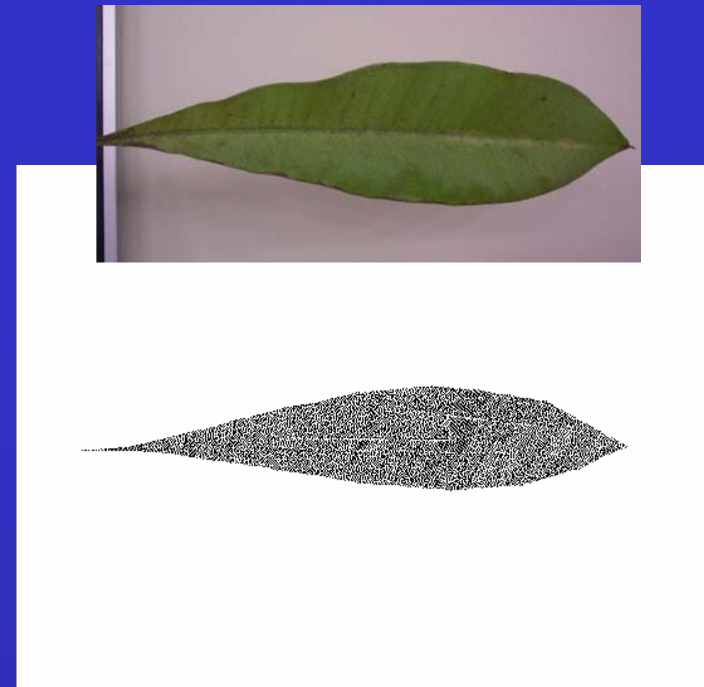
The Laser Scanner (Polhemus FastSCAN)



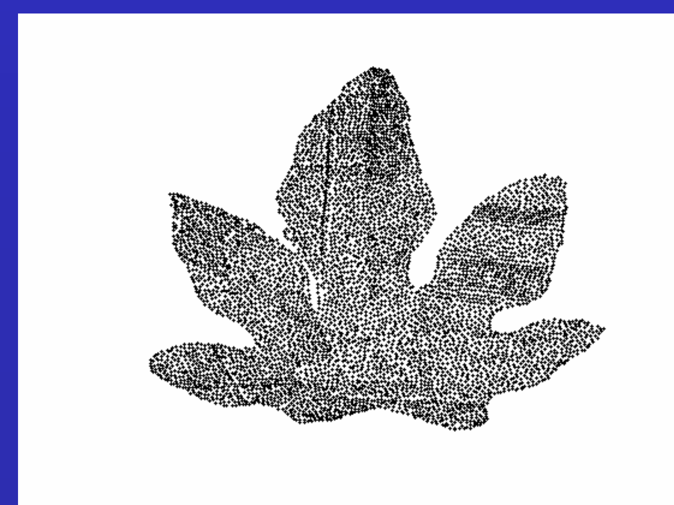
Issues: reflective properties, movement, wind, magnetic interference, daylight, wilting, …

Example leaf types:

Frangipani

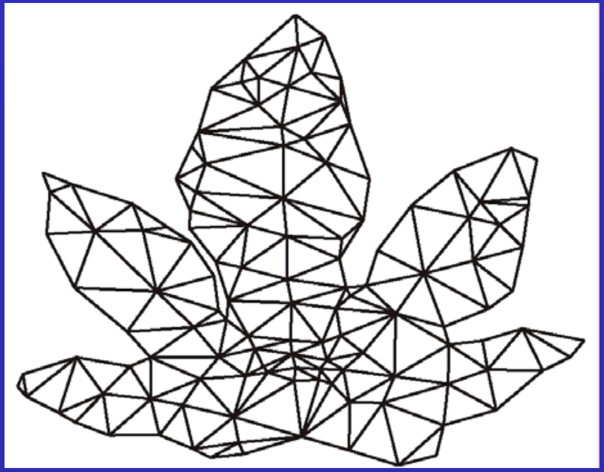


Flame tree



Extracting the structure

- Scattered data
- Surface fitting method (FEM)
- Based on a triangulation of data points (this defines the neighbourhood of points)



Surface fitting

Scattered data interpolation problem:

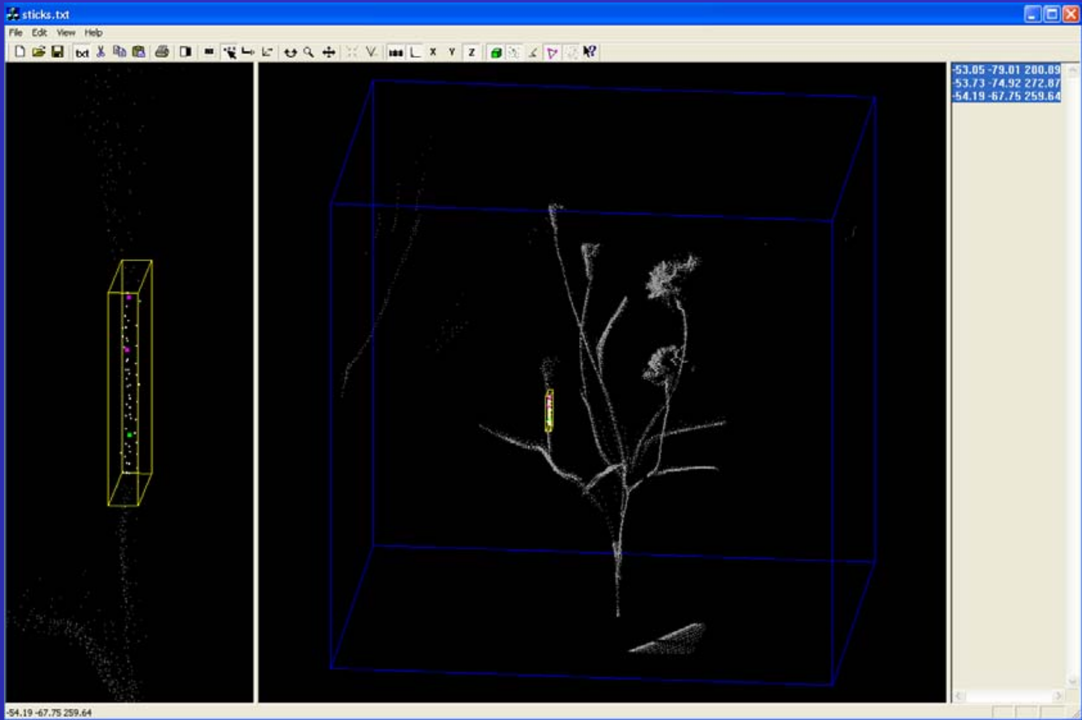
Given n scattered data point triples $(x_i, y_i, z_i),\ i = 1..n,$ find an interpolant $f : R^\wedge 2 \rightarrow R$ satisfying

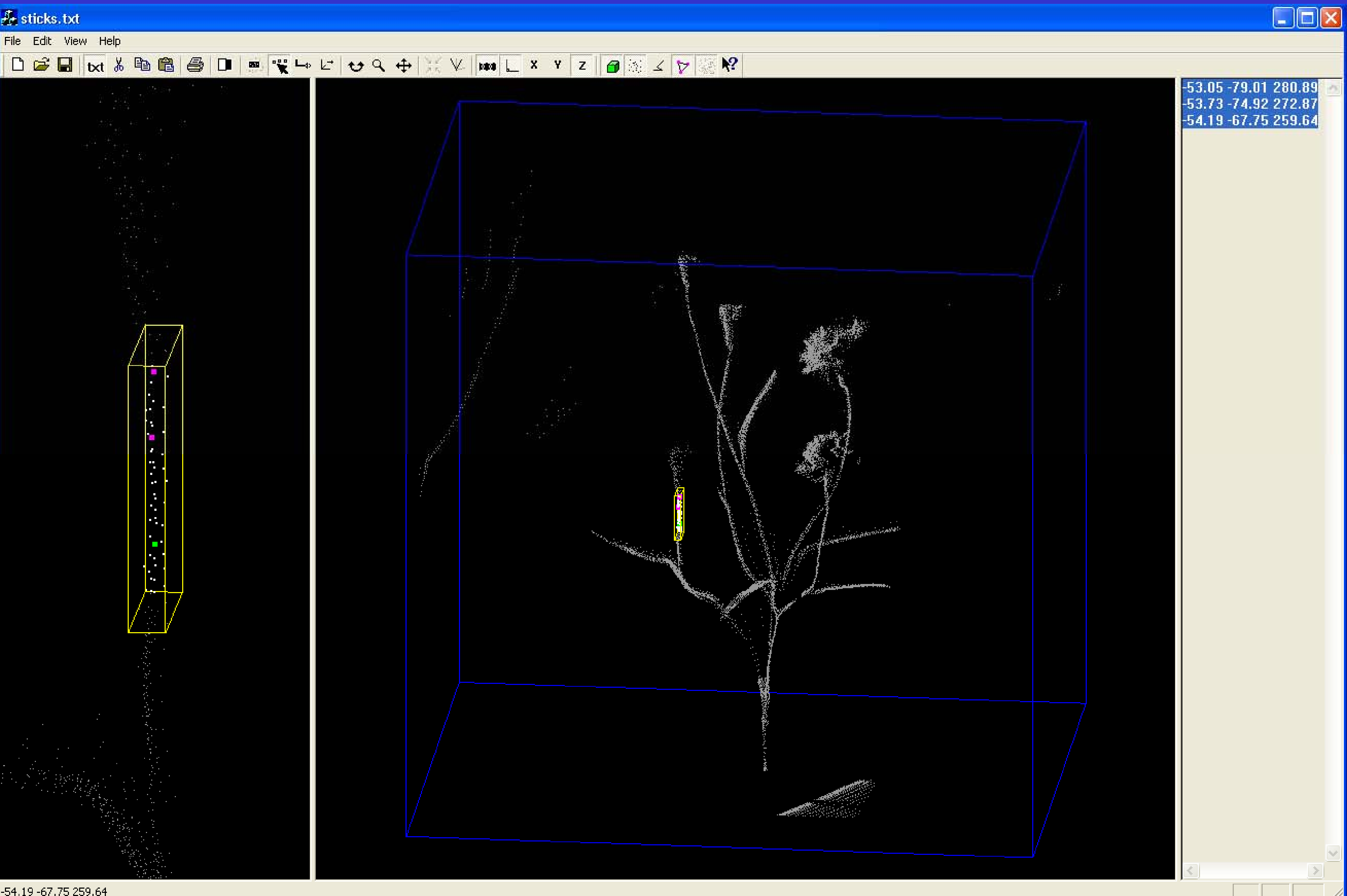
$$f(x_i, y_i) = z_i.$$

n may be small (sonic digitiser) or large (laser scanner)

But …

- Number of points is too large
- Choose by hand with PointPicker
- PICTURE




sticks.txt
File Edit View Help
txt
X Y Z
-53.05 -79.01 280.89
-53.73 -74.92 272.87
-54.19 -67.75 259.64
-54.19 -67.75 259.64

But …

- Where, how many?
- Is it possible to reduce the number without sacrifying too much quality?

Apply adaptive algorithm to determine "significant points" on the leaf surface:

- Begin with an initial set of points
- Fit a surface through these points, measure the accuracy of the fit to all unused data points
- Add those points which are approximated with largest error to the set
- Continue until some error tolerance limit has been reached

Results

Accuracy is measured in terms of a maximum error associated with a fit relative to the maximum variation in z pointwise

leaf type	method	boundary points	total points	points for accuracy 5%	2%	1%
frangipani	PLM	17	10473	55	131	323
	CTM	17	10473	62	185	327
flame tree	PLM	61	5706	127	306	587
	CTM	61	5706	142	331	607

So what do we tell you if you are using a sonic digitiser?

- Collect points along major veins
- Collect points along the boundary, particularly if there is great variation along the edge
- Collect points from peaks and valleys and areas of high curvature
- Spread remaining points evenly
- Number of points dependant on type of surface and application

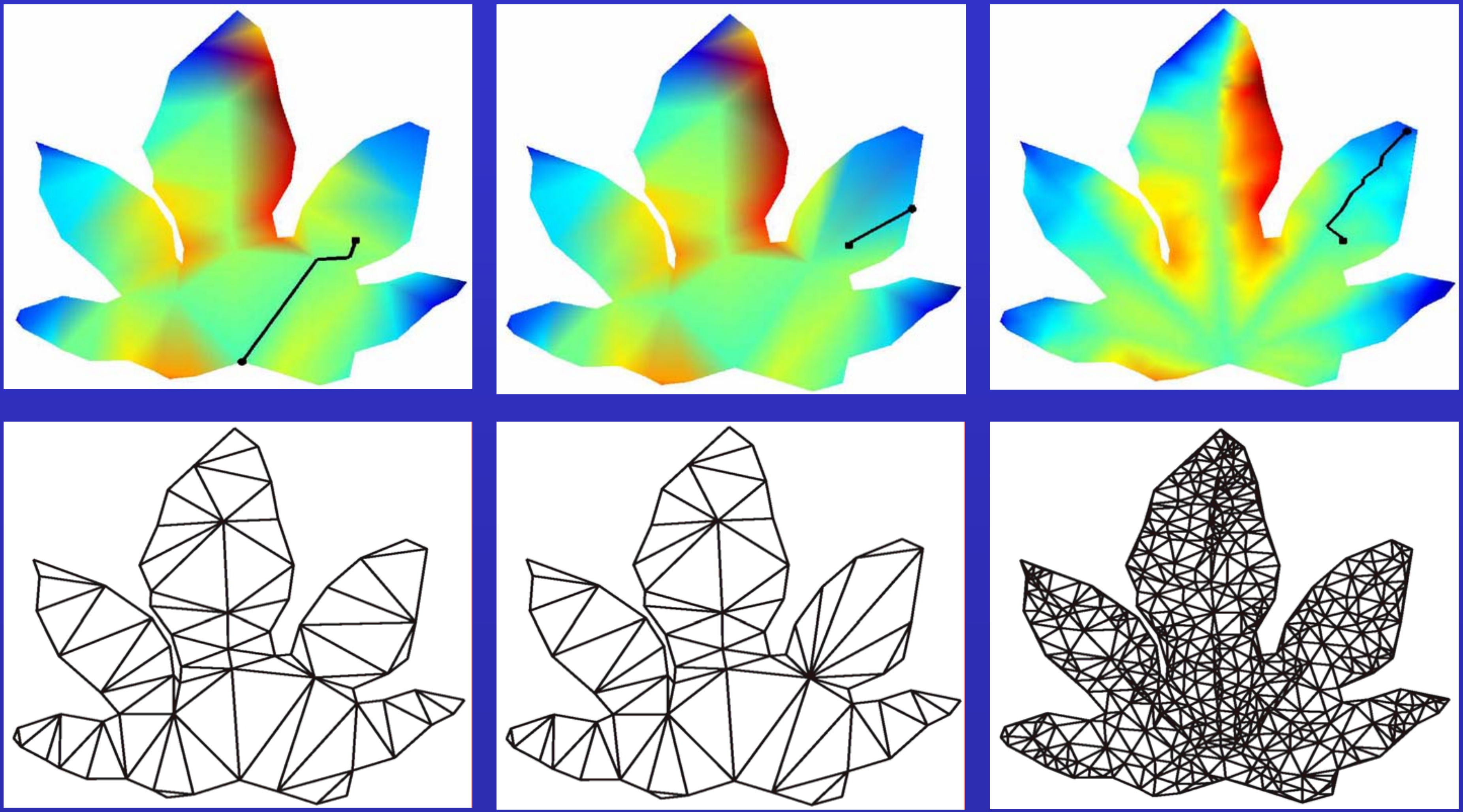
Application example

Droplet running along a leaf surface as part of a simulation of

- spreading of pathogens by a droplet, or
- the distribution of a pesticide on the leaf surface

Simplified conditions:

- Piecewise linear surface
- Negative gradient direction
- The droplet falls off the leaf at the boundary
- The velocity of the droplet is zero as it crosses from one element to the next
- Viscosity of droplet ignored



Future work

- integrate these leaf models in plant models
- average models (paper!), statistical approach
- curled leaves, hidden plant parts, other organs
- dynamic model (growth and functionality)
- compare shading results for these models to those for less detailed models (paper!)