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 $f : \mathbb{R}^2 \to \mathbb{R}$ 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
But …

- Where, how many?
- Is it possible to reduce the number without sacrificing 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

<table>
<thead>
<tr>
<th>leaf type</th>
<th>method</th>
<th>boundary points</th>
<th>total points</th>
<th>points for accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>frangipani</td>
<td>PLM</td>
<td>17</td>
<td>10473</td>
<td>55 131 323</td>
</tr>
<tr>
<td></td>
<td>CTM</td>
<td>17</td>
<td>10473</td>
<td>62 185 327</td>
</tr>
<tr>
<td>flame tree</td>
<td>PLM</td>
<td>61</td>
<td>5706</td>
<td>127 306 587</td>
</tr>
<tr>
<td></td>
<td>CTM</td>
<td>61</td>
<td>5706</td>
<td>142 331 607</td>
</tr>
</tbody>
</table>
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!)