Floradig: a configurable program for capturing plant architecture

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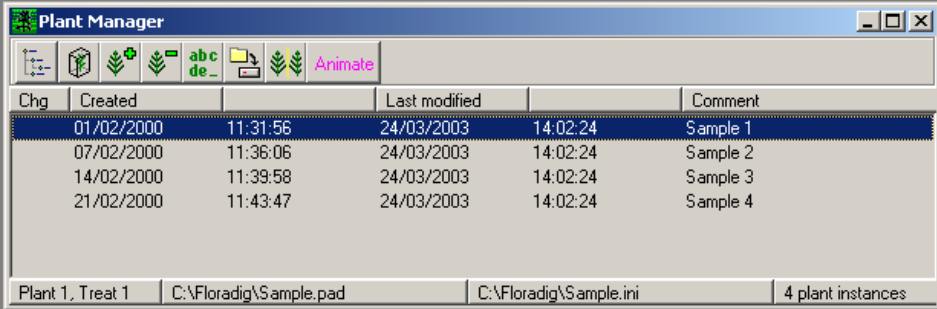
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Floradig is computer software for measuring and recording plant architecture and how it changes over time. It is generic in that it can be configured to collect plant architecture data for any species of plant at any level of detail. It uses a systematic, hierarchical, approach to address the modular nature of plants in which complex architectures are constructed from limited sets of components. In addition, *Floradig* allows records to be made of the positions on plants of associated entities such as insects, infections, damage, and droplets of pesticides. This software demonstration will show how *Floradig* can be configured for different components at various levels of abstraction. The recommended procedure for data entry will be demonstrated, including audible prompting by the program. The use of automated error checking, structural comparisons and animation of data collected over time for ensuring data integrity will be shown. The user can also configure the data to be calculated from the input points and output to a file suitable for import to databases or spreadsheets. A new feature is the ability to produce output in AMAPmod MTG format [1].

The System

The hardware for working with *Floradig* consists of a personal computer (PC) running Microsoft Windows 95, 98 or 2000 and one of a number of compatible 3D digitisers such as a GTCO GP12 sonic digitiser, or a Polhemus FastTrak or IsoTrak magnetic digitiser.

The *Floradig* program allows you to capture change in a plant's architecture by recording snapshots, or **instances**, of 3D structure on a series of dates. It is recommended that all instances of a single plant are accumulated in a single file**,** which increases in size each time the plant is digitised (Figure 1). Following this approach, there will be one data file for each plant in any particular experiment.

Figure 1 Plant Manager Window

Each time a plant is digitised, the geometry of its architecture is recorded as 3D coordinates for a set of **points** in a hierarchical structure (Figure 2). Each point should be at a pre-defined and easily-recognised location on the plant such as at a node or the tip of a leaf. The user provides a **settings file** that contains a list of codes for different components and types and the number of points to be recorded for each. *Floradig* labels the xyz coordinates for each point according to its component type and the component's topological position.
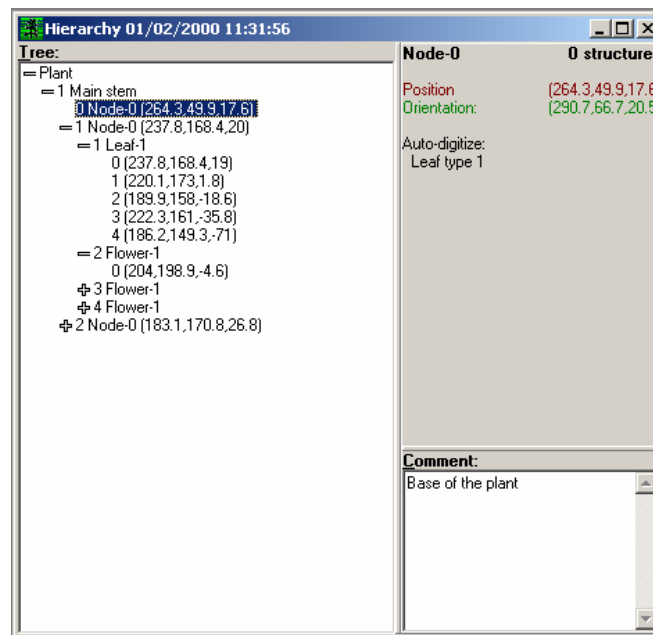
Figure 2 Hierarchy Window

In most cases, digitising proceeds upward from the base of a plant. The series of nodes up the main stem is digitised, followed by the components attached at each node from the bottom up. Branching topology is captured by starting a new series of nodes attached to the parent node of each branch. Components within branches are then added in the same fashion as for the main stem. The components and types within components are selected from a menu using the keyboard. *Floradig* prompts for the number of points to be digitised for the selected component.
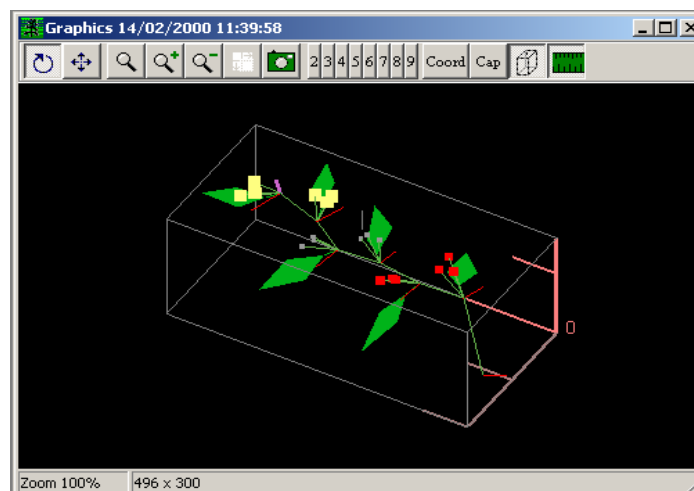

Figure 3 Graphics Window. In this example, flowers are shown as yellow, developing fruit as pale blue, and mature fruit as red.

To help in checking for errors you can activate a 3D graphics reconstruction of the data (Figure 3) that can be rotated and viewed from any angle. Different instances of the same plant can be compared in this way and in text format. Menu commands allow data to be cut and pasted, comments to be recorded, branching topology to be navigated and files to be saved. The 3D coordinate data can be converted into angles and lengths according to instructions in the settings file (*.ini) before being exported in a delimited text format (*.txt) suitable for importing into database, spreadsheet and statistics programs.

Configuring *Floradig*

Floradig is configured to suit a particular study by creating a settings file having an *.ini* extension (**Figure 4**). The settings in the file are arranged in 5 sections: *Session*, *Digitising*, *Graphics, Output*

Control and *Component Definitions*. A text-editing program such as *Notepad* should be used to customise the *Output Control* and *Component Definitions* settings.

The *Component Definitions* section allows you to specify the components and types within components that may be digitised, the number of points to be digitised for each type, what values to calculate and write to file, and what graphics to display. This section of the file consists of an arbitrary number of 3-line definitions. In each line, the first two items give the component name and type separated by spaces. The name must be one of those found in **Table 1** and the corresponding code is the shorthand used to select the component via the keyboard during operation of *Floradig*. The type can be any number from 0 to 9.

```
[Session]
InfoTitle=test
DateFormat=0
TimeFormat=0
TestLengthError=87100890

[Digitizing]
VisitNodeZero=1
UseDefaultComp=0
NodePromptingUp=1
MaxStructuresAtNode=0
DefaultCompType=2
DefaultCompIndex=1
DefaultNodeIndex=0

[Graphics]
Filename=0
PlantID=0
Label=0
Fill=1

[Output Control]
Decimal=2
Minimum Diverg=0.0
Minimum Pitch=0.0
Separator=,

[Component Definitions]
Node 0 Numpoints=3
Node 0 Output Definitions=I "Length"; W "Width"; R "Radial"; P "Axial";
Node 0 Graphics Codes= GC 1 0 0; GS 0 1; GC .4 .7 .3; GW 2;
Node 1 Numpoints=1
Node 1 Output Definitions=I "Length";
Node 1 Graphics Codes=  GC .4 .7 .3; GW 2;
Bud 1 Numpoints=1
Bud 1 Output Definitions=L N 0 "Bud length";
Bud 1 Graphics Codes=GC .8 .4 .8; GS N 0 5;
Leaf 1 Numpoints=5
Leaf 1 Output Definitions= L 1 4 "Leaf Length"; L 2 3 "Leaf Width";
Leaf 1 Output Definitions 2= P N 0 1 "Petiole Angle";L 0 1 "Petiole Length";
Leaf 1 Graphics Codes=GW .2 GC 0 .7 .1; GS 0 1 2; GT 1 2 3; GT 2 3 4;
Flower 1 Numpoints=1
Flower 1 Output Definitions=L N 0 "Flower length";
Flower 1 Graphics Codes=GC .4 .7 .3; GS N 0 1; GC 1 1 0.5; GM 0 15;
```
Figure 3 A Floradig settings file, Sample.ini

Name	Node	Bud	Leaf	Flower	Fruit	Insect	U 1	U 2	U 3	U 4	U 5
Code	N	B	L	F	R	I	X	Y	Z	S	T

Table 1 Component Names and Codes

The first line of each definition sets the number of 3D points to be digitised for that component type. There is no limit to the number of points. When digitising, you must remember to enter the points in the order you decided on for each component type. In **Figure 5**, for example, if you enter points in the order 0, 1, 2, 4, 3, a later assumption that the length of the lamina may be calculated from the second and fifth points to be digitised will be wrong.
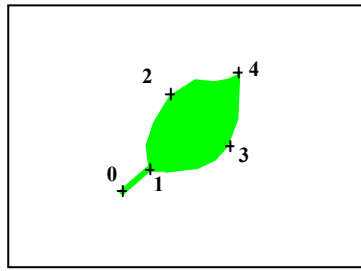
Figure 5 Example of component point positioning by sequence

Nodes are a special case. If you use two for a node, *Floradig* will automatically accept the first point as the position of the node and will prompt for an "**orientation**" for the second point. This is a point on an imaginary line at right angles to the axis of the stem, passing from the centre of the stem out through the node-point. It enables calculation of phyllotactic angles between successive nodes and the distance of the orientation-point from the node-point is of no account. If you use three points *Floradig* will prompt for a stem-width-point on the opposite side of the stem from the point for the node.

The second group of lines of each Component Definition has the keyword "Output Definitions=" followed by a semi colon separated list of definitions specifying what values to calculate and write to an export file. The information in the list takes the form:

        <InfoCode> <Index list> "Optional Label";

where **<InfoCode>** specifies the calculation to be performed such as length L, or pitch P **<Index list>** contains the point-identifying numbers required for the calculation, and the **optional label** is used to identify the result of calculation in the export file.

Similar codes can be used to specify what is drawn in the graphics window. A complete list of codes and illustrative diagrams is available in the Floradig manual. For example, in **Figure 3,** in the lines

        Leaf 1 Output Definitions= L 1 4 "Leaf Length"; L 2 3 "Leaf Width";
        Leaf 1 Output Definitions 2= P N 0 1 "Petiole Angle";L 0 1 "Petiole Length";

leaf length is calculated as the distance between points 1 and 4, the width as the distance between points 2 and 3, the petiole angle is calculated between the direction of the internode and the vector joining points 0 and 1, and the petiole length is calculated as the distance from point 0 to point 1.

Output

Floradig can output the data specified by the user either as a flat data file or in MTG format. When writing a flat export data file (*.txt) (Figure 6), *Floradig* attaches a label to every item of data. The labels have a multi-level structure that corresponds to the hierarchy of branch-levels in a plant. A colon separates the reference numbers of the structures (**S**) and nodes (**N**) which connect the base of the plant to the node of attachment of a component. The last item in a label defines the component and its type. For example: **S**01**N**02**:S**02**N**01**:S**01**L**00**;** from right to left, **S**01**L**00 defines a **L**eaf, which is **S**tructure 01 at **(S**02**N**01**) N**ode 01 of the second **S**tructure at **(S**01**N**02**) N**ode 2 on the main stem. The sequence numbers for structures and nodes are in two-digit fields to facilitate searching and sorting when the data have been imported into a database or spreadsheet. Such a data file can be read into a database or spreadsheet program, and the structure label will provide the hierarchical information needed for detailed analysis.

```
Plant,Treatment,Date,Structure,Component,Type,Level,Label,Value,Comments
Plant 1, Treat 1,17/02/2000,S00D00:C,I,0,0,PAD-file,,"C:\Digit\Floradig\Demos\Sample.pad"
Plant 1, Treat 1,17/02/2000,S00D00:C,I,0,0,Definition-file,,"C:\Digit\Floradig\Demos\Sample.ini"
Plant 1, Treat 1,17/02/2000,S00D00:C,I,0,0,Plant-comment,,"Measured once per week"
Plant 1, Treat 1,17/02/2000,S00D00:C,I,0,0,Instance-comment,,"Sample 1"
Plant 1, Treat 1,17/05/2000,S01N00;,C,0,1,Comment,,"Main stem"
Plant 1, Treat 1,17/02/2000,S01N00;,C,0,1,Comment,,"Base of the plant"
Plant 1, Treat 1,17/02/2000,S01N01;,N,0,1,Length,121.45
Plant 1, Treat 1,17/02/2000,S01N01;,N,0,1,Phyllo,-83.04
Plant 1, Treat 1,17/02/2000,S01N01;,C,0,1,Comment,,"Node 1"
Plant 1, Treat 1,17/02/2000,S01N01:S01L00;,L,1,2,Leaf Length,83.73
Plant 1, Treat 1,17/02/2000,S01N01:S01L00;,L,1,2,Leaf Width,36.80
Plant 1, Treat 1,17/02/2000,S01N01:S01L00;,L,1,2,Comment,,"First leaf"
Plant 1, Treat 1,17/02/2000,S01N01:S02F00;,F,1,2,Flower length,51.75
Plant 1, Treat 1,17/02/2000,S01N01:S03F00;,F,1,2,Flower length,44.79
Plant 1, Treat 1,17/02/2000,S01N01:S04F00;,F,1,2,Flower length,35.53
Plant 1, Treat 1,17/02/2000,S01N02;,N,0,1,Length,55.17
Plant 1, Treat 1,17/02/2000,S01N02;,N,0,1,Phyllo,-171.13
Plant 1, Treat 1,17/02/2000,S01N02:S01L00;,L,1,2,Leaf Length,86.32
…
```

Figure 6 A *Floradig* export file, Sample_0.txt.

Future Developments

Future enhancements include the capability to input arbitrary numbers of points for an component type, keyboard and menu-based entry of data to associate with a component, and interaction with the data through picking from the graphics window. We have a prototype system to allow point-picking entry from arbitrary point clouds, such as those produced by a laser scanner. We are always interested in hearing users' ideas on how to improve any aspect of the software.

References

[1] Godin, C. and Guedon, Y. (2000) AMAPmod Introduction and Reference Manual, V 1.8, CIRAD, Montpellier

[2] Hanan, J and Room, P (2002) Floradig User Manual, CPAI, University of Queensland, Brisbane.