

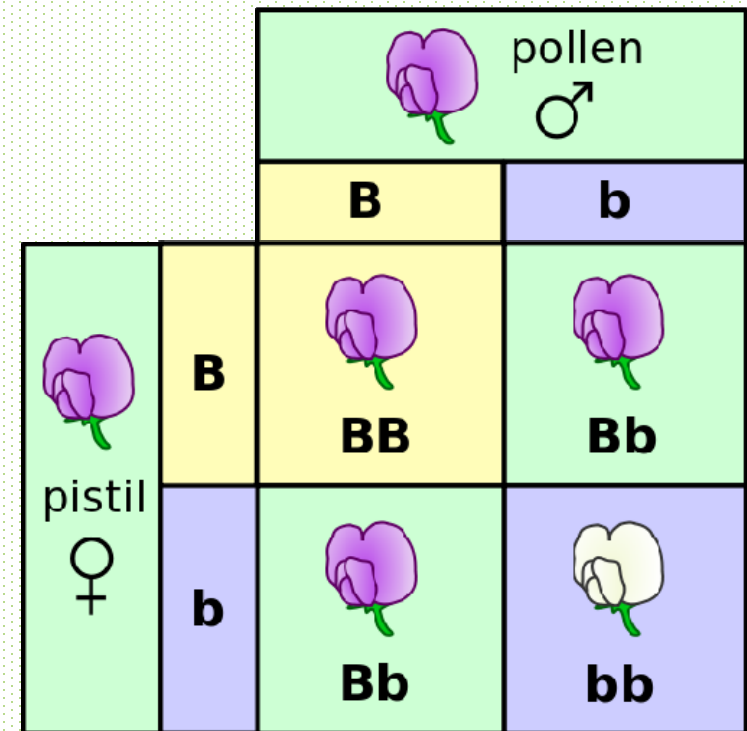
Graph Based Automated Analysis for Plant Root Phenotyping

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What is plant phenotyping?

Phenotype

The set of observable characteristics resulting from the interaction of its genotype with the environment.



What is root phenotyping and why is it important?

To **understand** and to **establish relationships** between developmental stages between seedling and adult traits in the future.



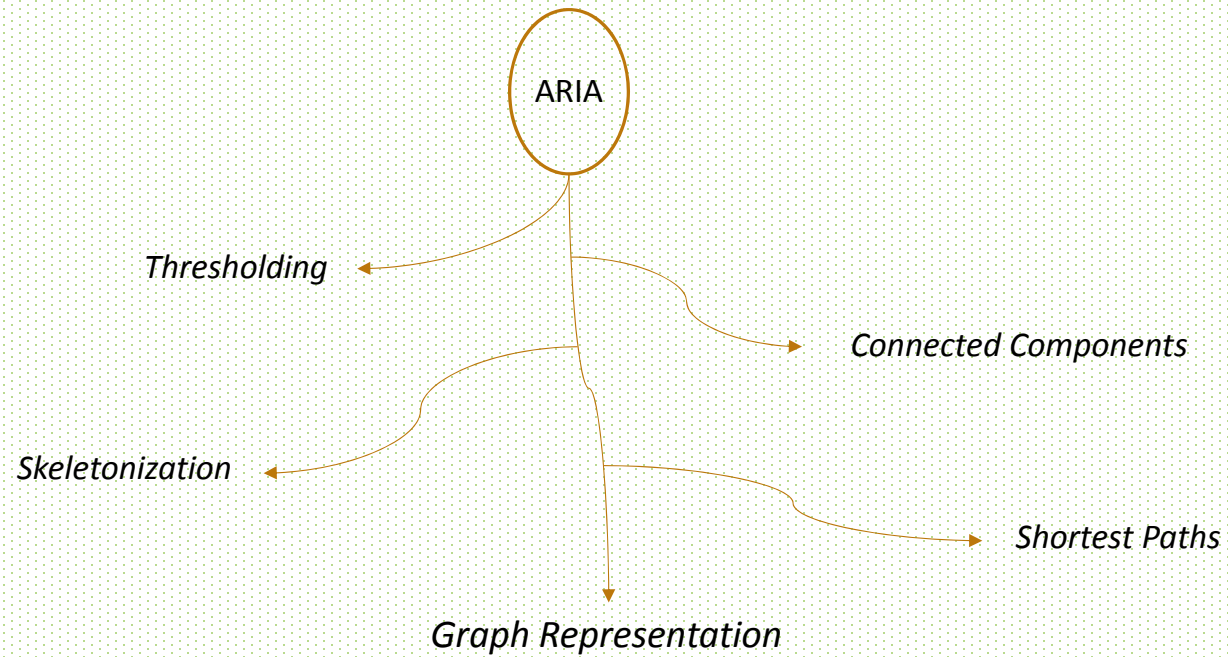
Source: <http://www.campverdepromotions.org/wp-content/uploads/2013>

Current Methods of Root Phenotyping and their implications.



Method	Implications
Roots are dug out, washed and spread out to be measured using a ruler or measuring tape.	<ol style="list-style-type: none">1. Plant is damaged.2. Extremely time-consuming.3. Highly inaccurate and high possibility of error.

Automated Root Image Analysis ARIA



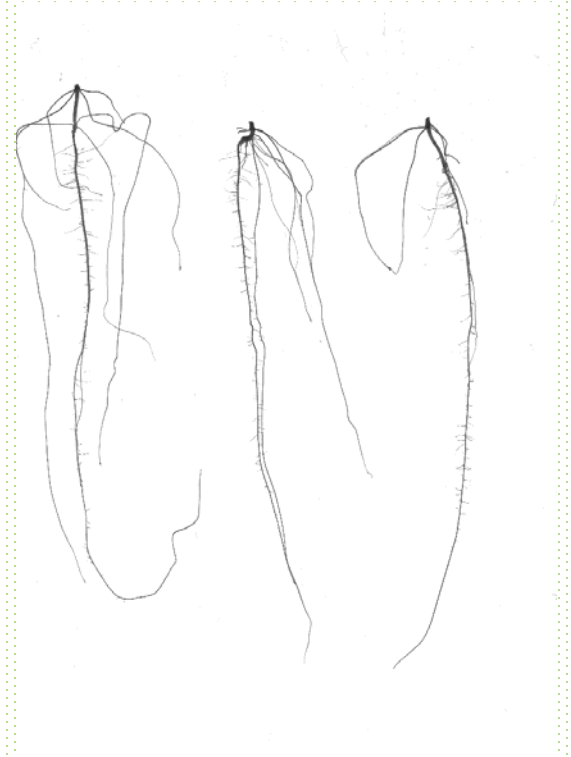
Slide 5

MN3 Trying to make a diagram of roots to show a chart. (emphasis on trying)
Marcus Naik, 4/6/2014

How are root images obtained?



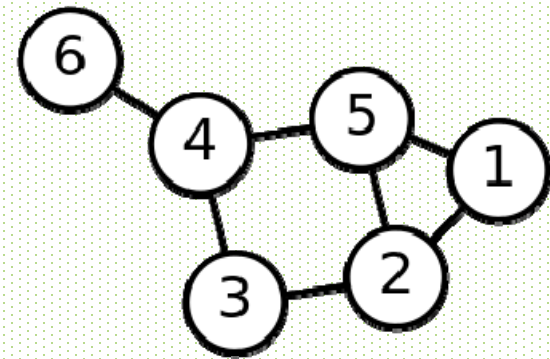
Source: <http://pcinpk.com/wp-content/uploads/2013/12/>



What is “Graph Based Analysis”?

Graph

A representation of a set of objects (vertices) where some pairs are connected by links (edges).



Source: Wikimedia Commons

Slide 7

MN1 Explain that images are converted into graphs by identifying vertices and connecting them by edges.

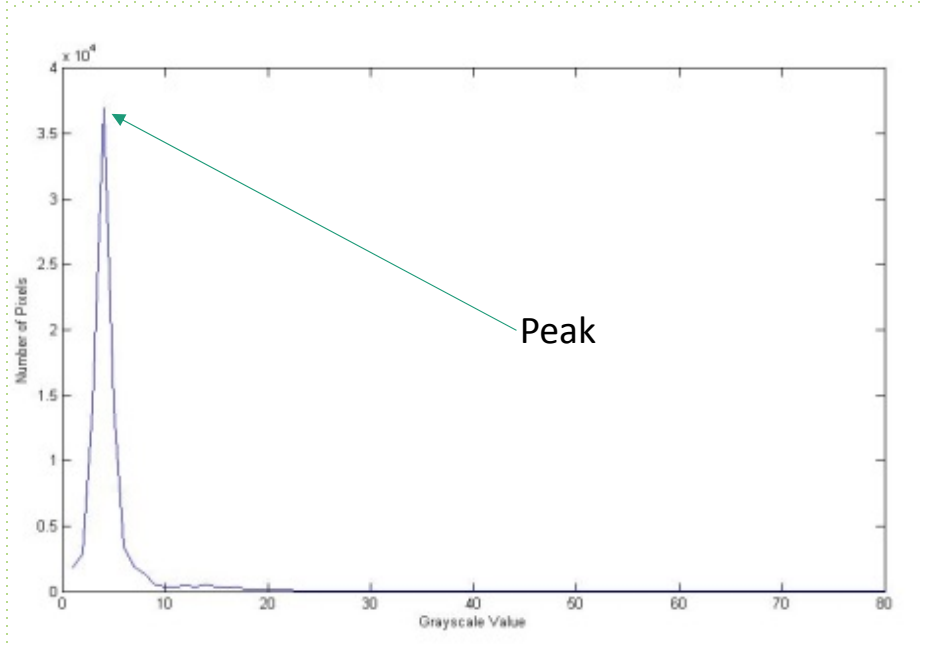
Marcus Naik, 4/6/2014

MN2 Use an example, eg: GPS

Marcus Naik, 4/6/2014

What are these methods?

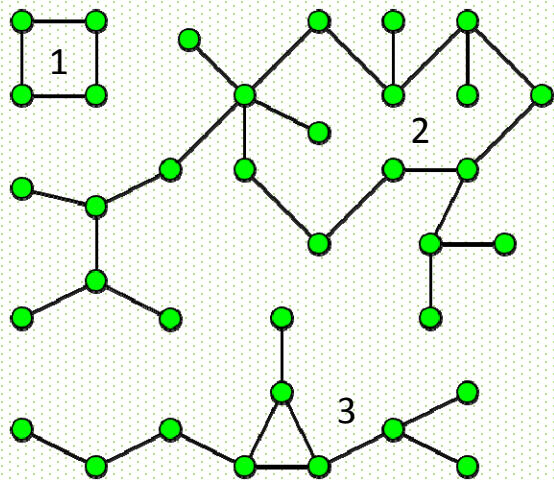
Thresholding MN5



Slide 8

MN5 A form of image segmentation. To isolate the root from the image.
Marcus Naik, 4/6/2014

Connected Components



Three connected components

BW =

0	0	0	0	0	0	0	0	0
0	1	1	0	0	1	1	1	0
0	1	1	0	0	0	1	1	0
0	1	1	0	0	0	0	0	0
0	0	0	1	1	0	0	0	0
0	0	0	1	1	0	0	0	0
0	0	0	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0

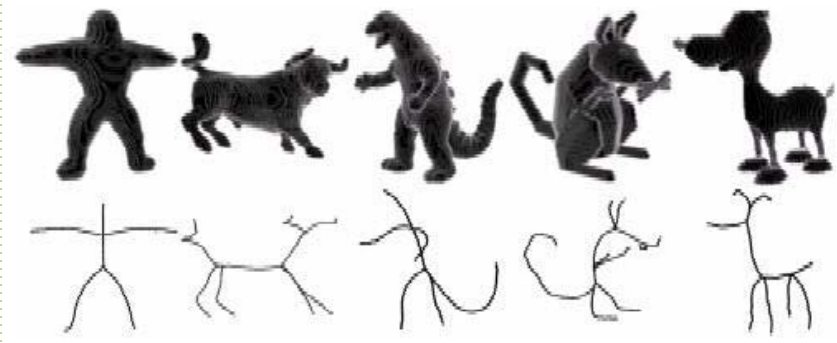
Connected Components to remove noise

Slide 9

MN6 A subgraph in which any two vertices are connected to each other by paths, and which is connected to no additional vertices in the supergraph.

Marcus Naik, 4/6/2014

Skeletonization

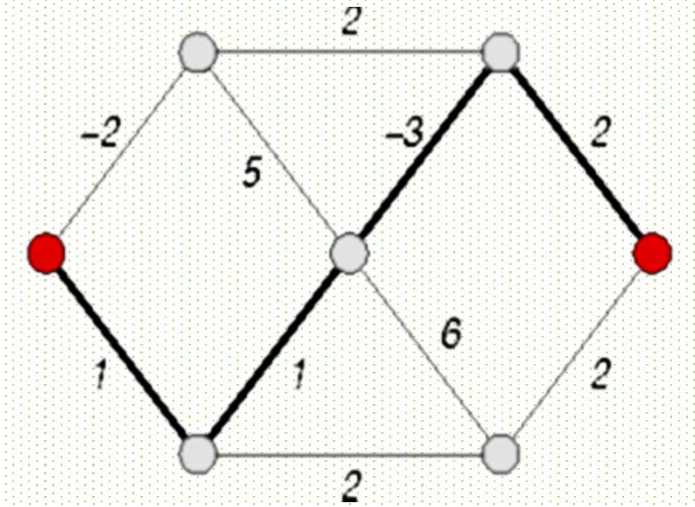
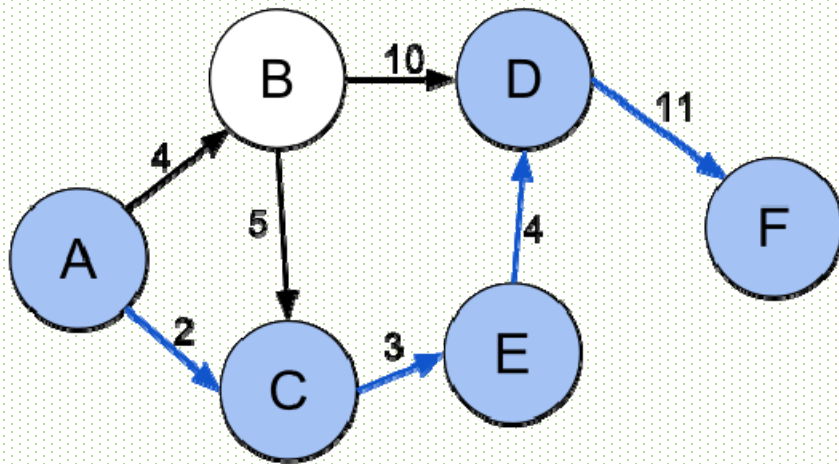


<http://coewww.rutgers.edu/www2/vizlab/images/skel.jpg>

Slide 10

MN6 Pixels on the outer boundaries of the object are removed without allowing the object to break. The remaining pixels make up the image skeleton
Marcus Naik, 4/6/2014

Shortest Path

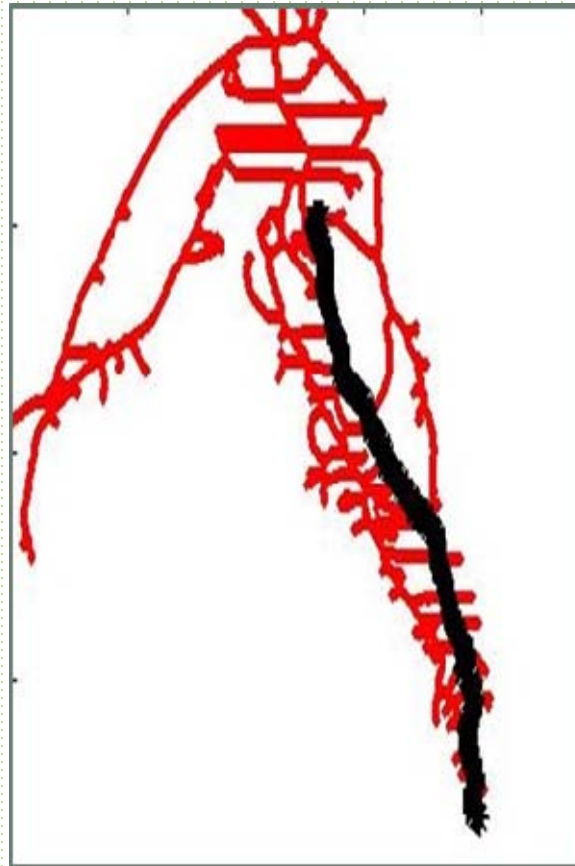


Slide 11

MN6 The longest graph is chosen, then the shortest path through the graph is chosen. That is how the primary root is identified.

Marcus Naik, 4/6/2014

Graph Representation



Slide 12

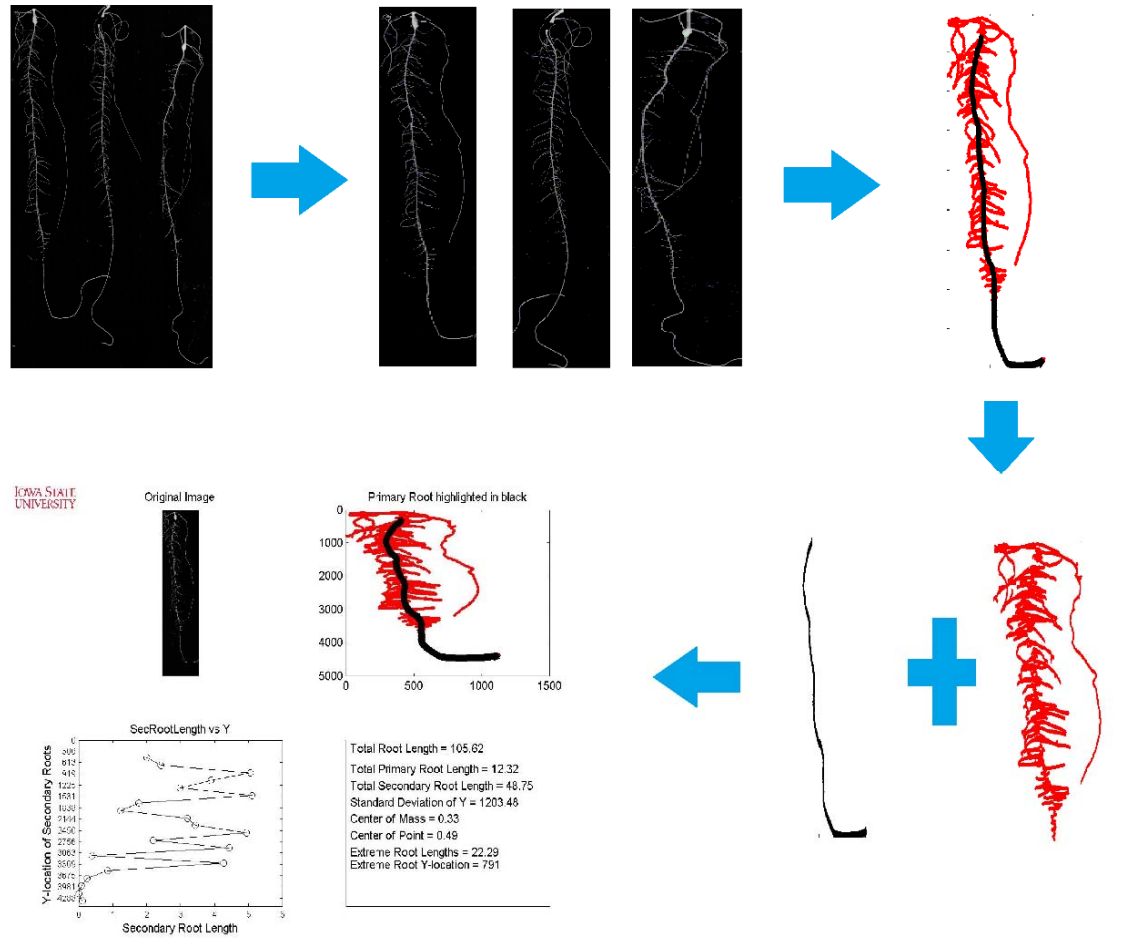
MN6 The primary root is plot onto a graph after being identified. The secondary roots are obtained by subtracting the primary root from the original image.

Marcus Naik, 4/6/2014

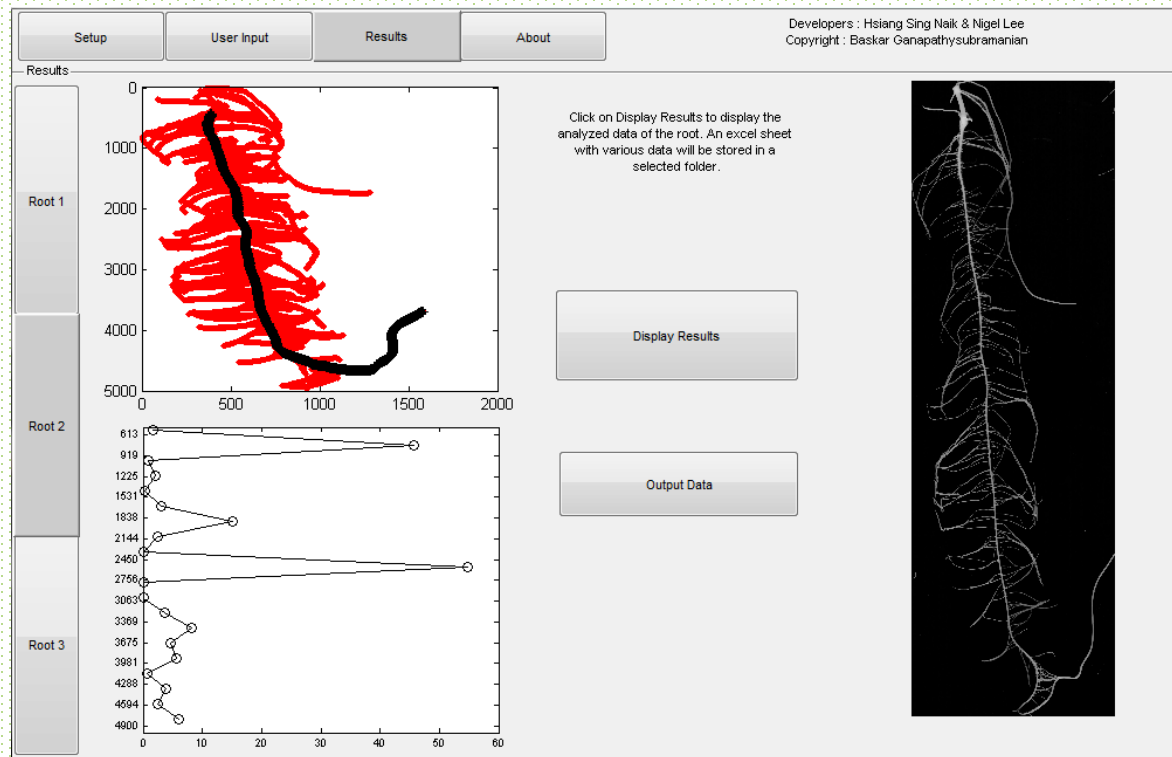
Traits Measured

1. Total Root length
2. Primary Root Length
3. Secondary Root Length
4. Center of Mass
5. Center of Point
6. Center of Mass (Top)
7. Center of Mass (Mid)
8. Center of Mass (Bottom)
9. Center of Point (Top)
10. Center of Point (Mid)
11. Center of Point (Bottom)
13. Perimeter
14. Depth
15. Width
16. Width\Depth ratio
17. Median
18. Total Number of Roots
19. Convex area
20. Network Area
21. Solidity
22. Bushiness
23. Length Distribution
24. Diameter
25. Volume
26. Surface Area
27. Maximum Number of Roots

Summary of Operation

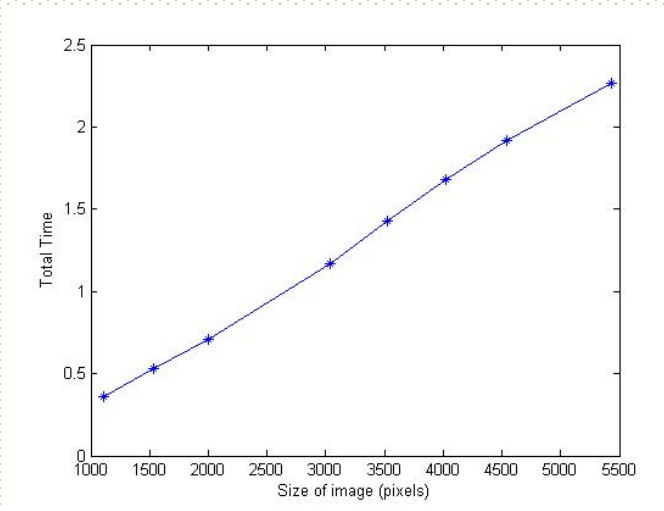


Graphical User Interface



Why is ARIA superior to current methods?

ARIA	Current Methods
Data obtained between 2 to 10 seconds.	Data obtained between 10 to 30 minutes.
Highly accurate measurements, up to 0.01mm.	Accurate to 0.8mm (1/32 inch.), depending on instrument used.



SUMMARY

- Importance of phenotyping, and more specifically root phenotyping.
- Current Methods of Root Phenotyping
- Automated Root Image Analysis (ARIA) and its mathematical concepts for accurate and dependable measurements.
- ARIA is superior to current methods.

ACKNOWLEDGEMENTS

- **Root Images**

- Jordan Pace
- Thomas Lubberstedt

- **Advisor**

- Baskar Ganapathysubramanian

Questions
And/or
Comments?