Non-Destructive Rapid Method for Blend Grade Verification using VNIR Hyperspectral Imaging and Advanced Data Processing Algorithms

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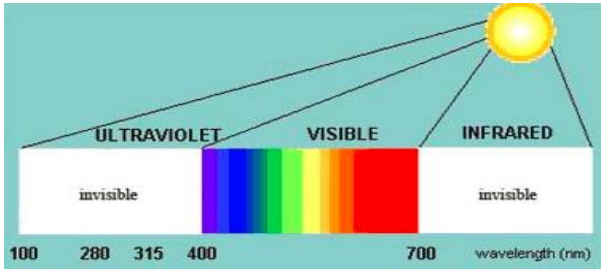
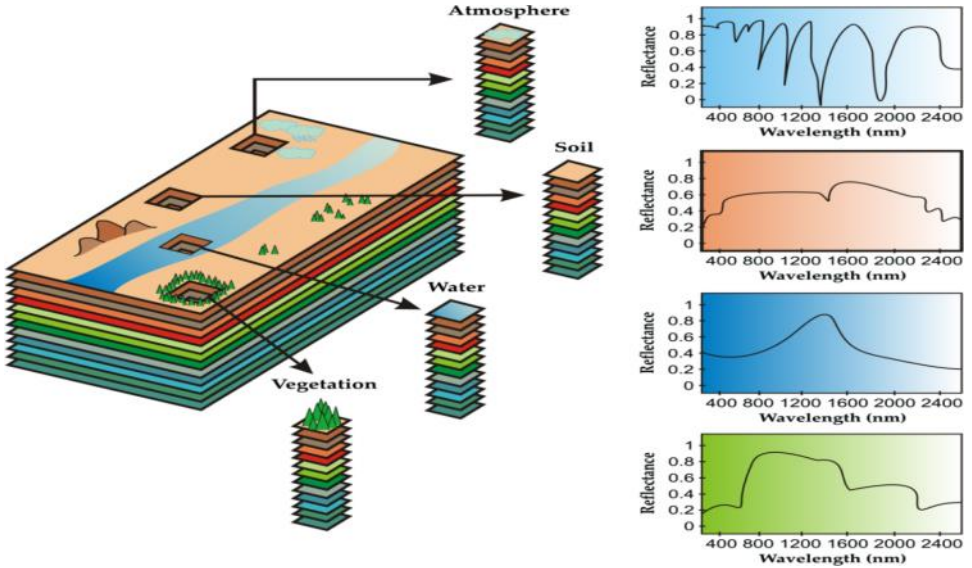
What is Hyperspectral Imaging?

- Combination of spectroscopy and imaging
- Measures spectra for each sample point represented by a pixel
- Identifies materials



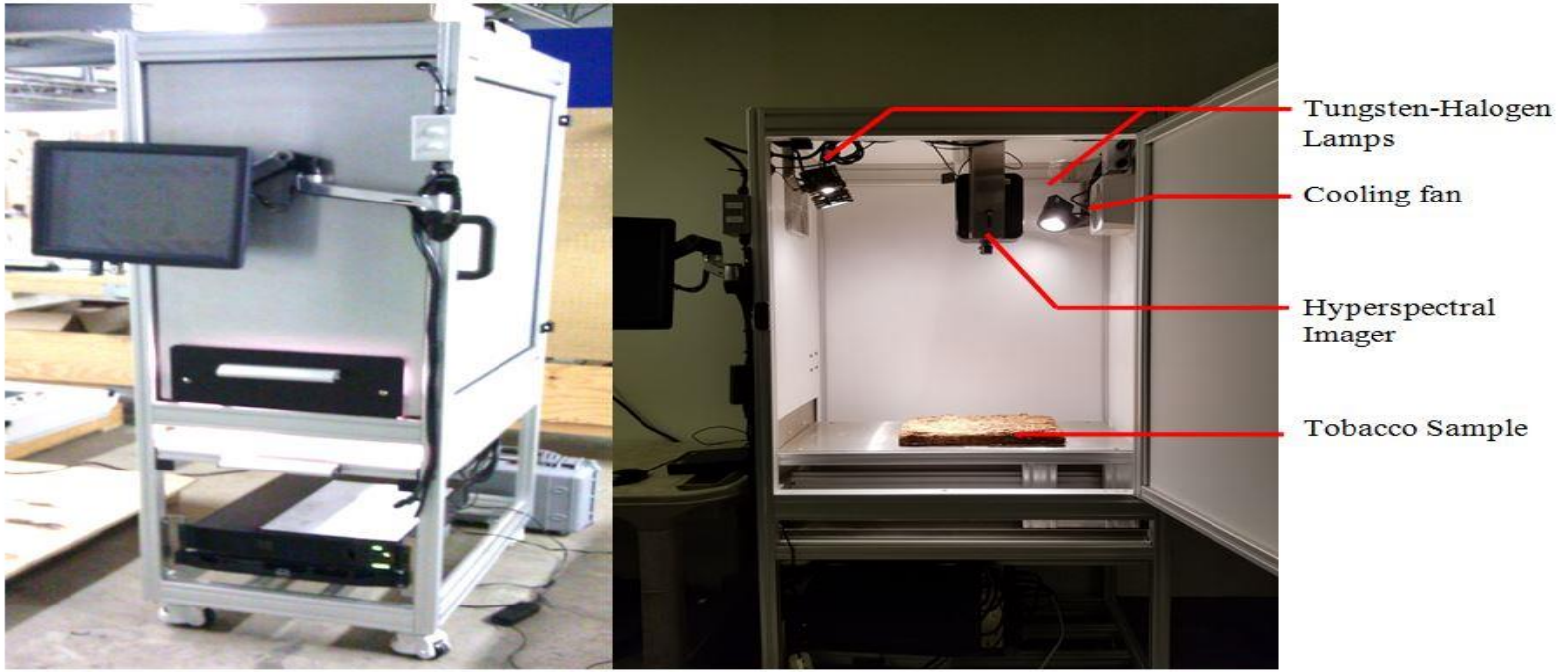


http://www.mdpi.com/1424-8220/9/1/196/htm

Project Impact and Benefits

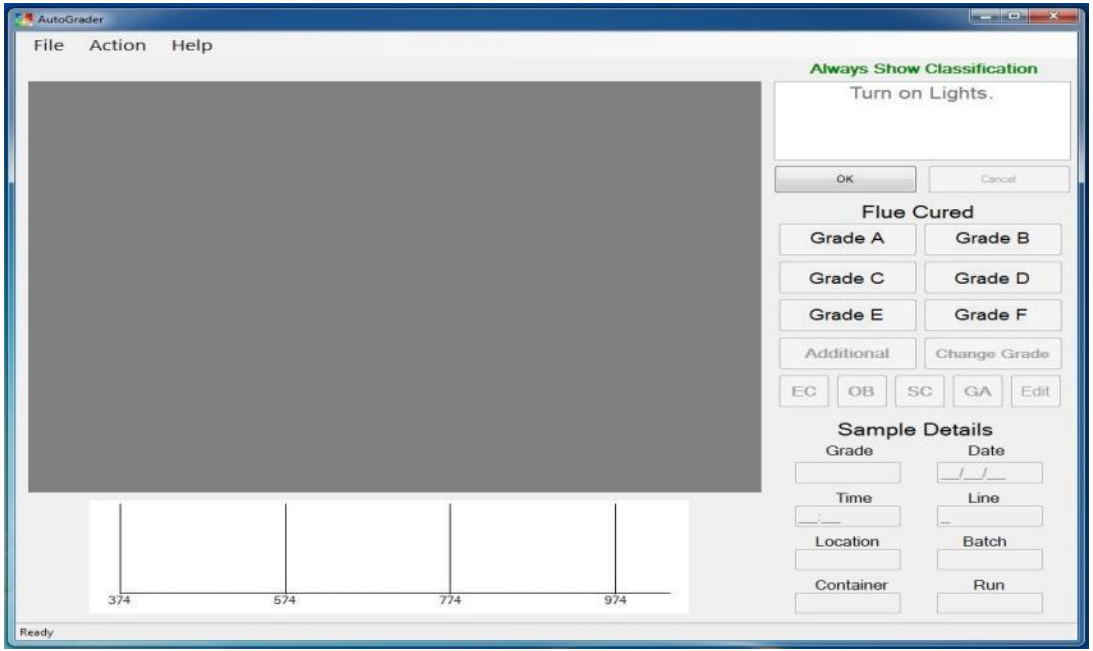
- Maintains consistency of leaf grades in a cost effective manner
- Reduces human subjectivity
- Supplements SME's time and skill
- User-friendly and real time with minimal training
- Streamlines blend grade verification process
- Supports tobacco purchases
  - Grade verification
  - Appropriate purchase price

Stemmery AutoGrader Apparatus

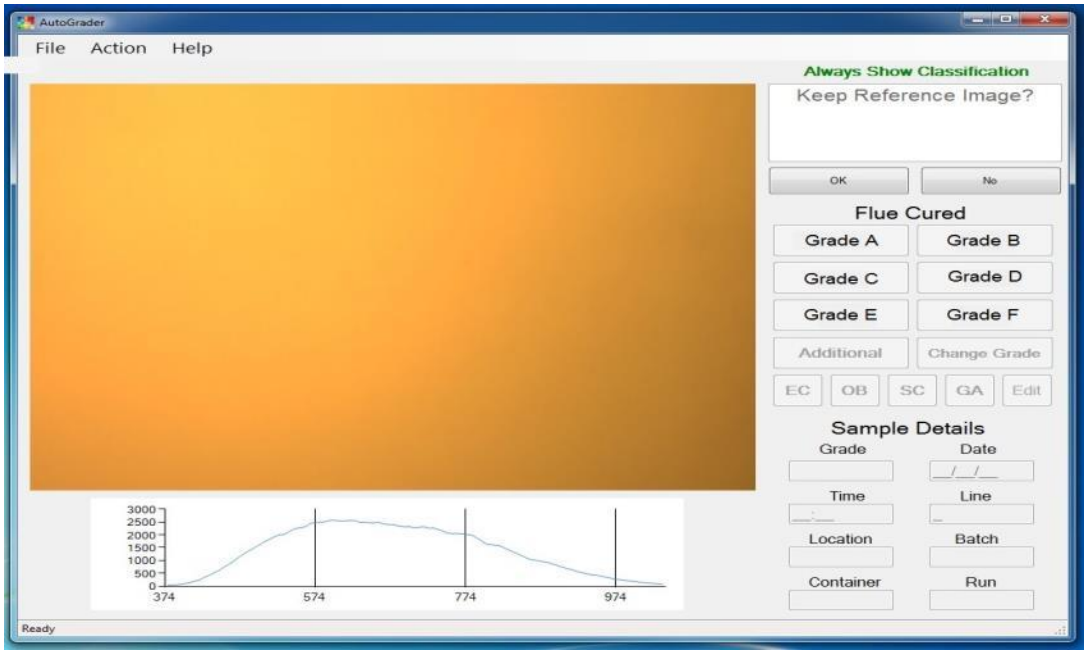


Cost per unit of ~$60k

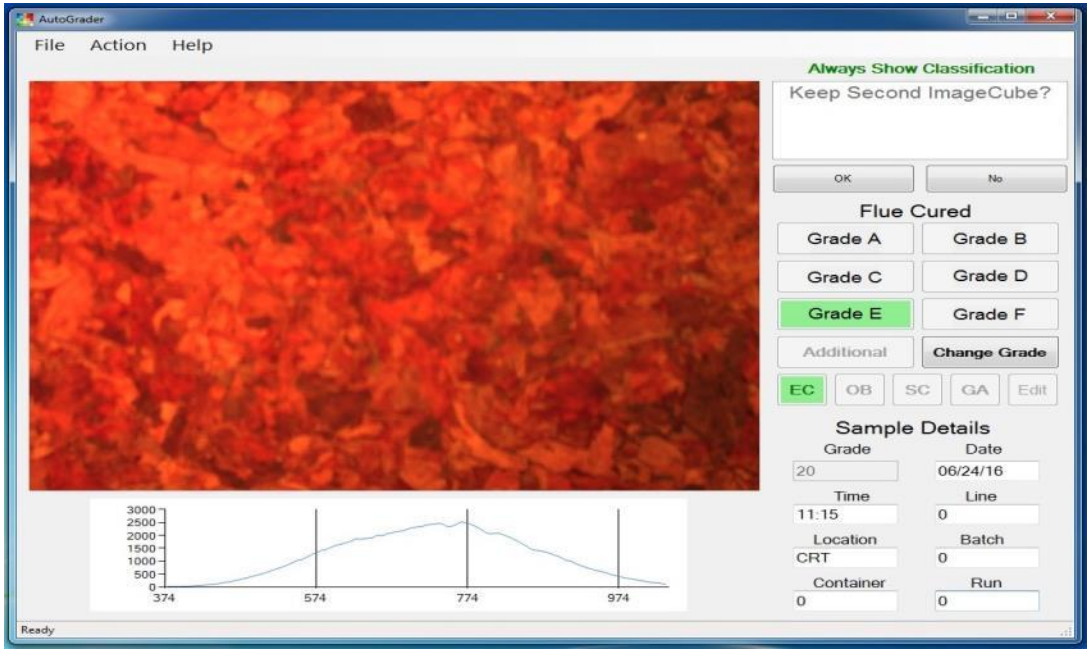
AutoGrader Program Workflow Example



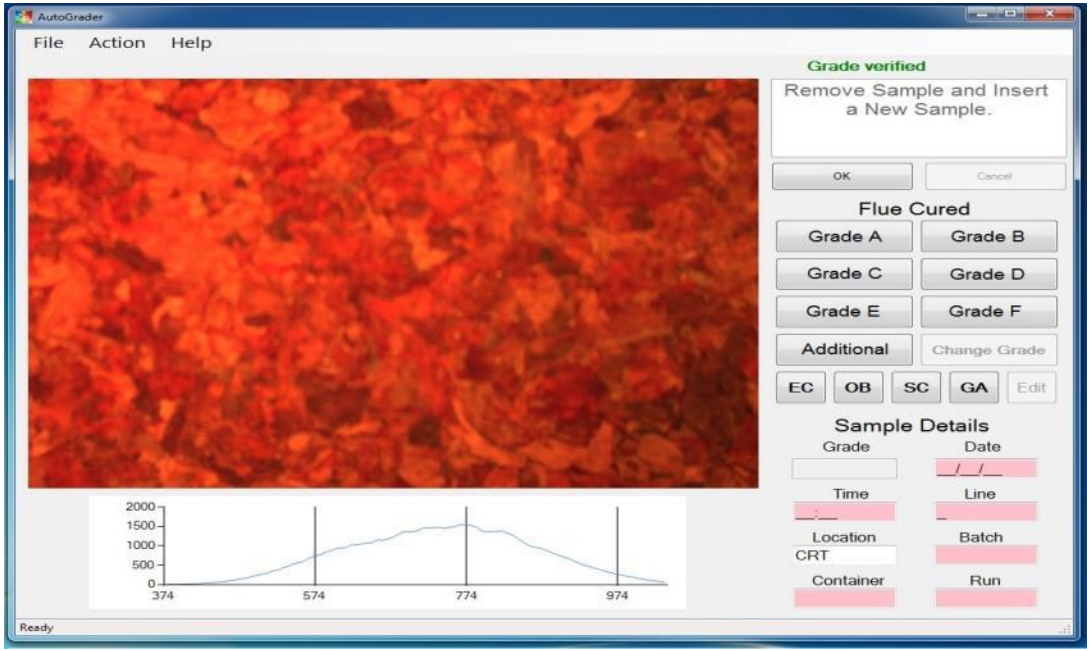
AutoGrader Program Workflow Example



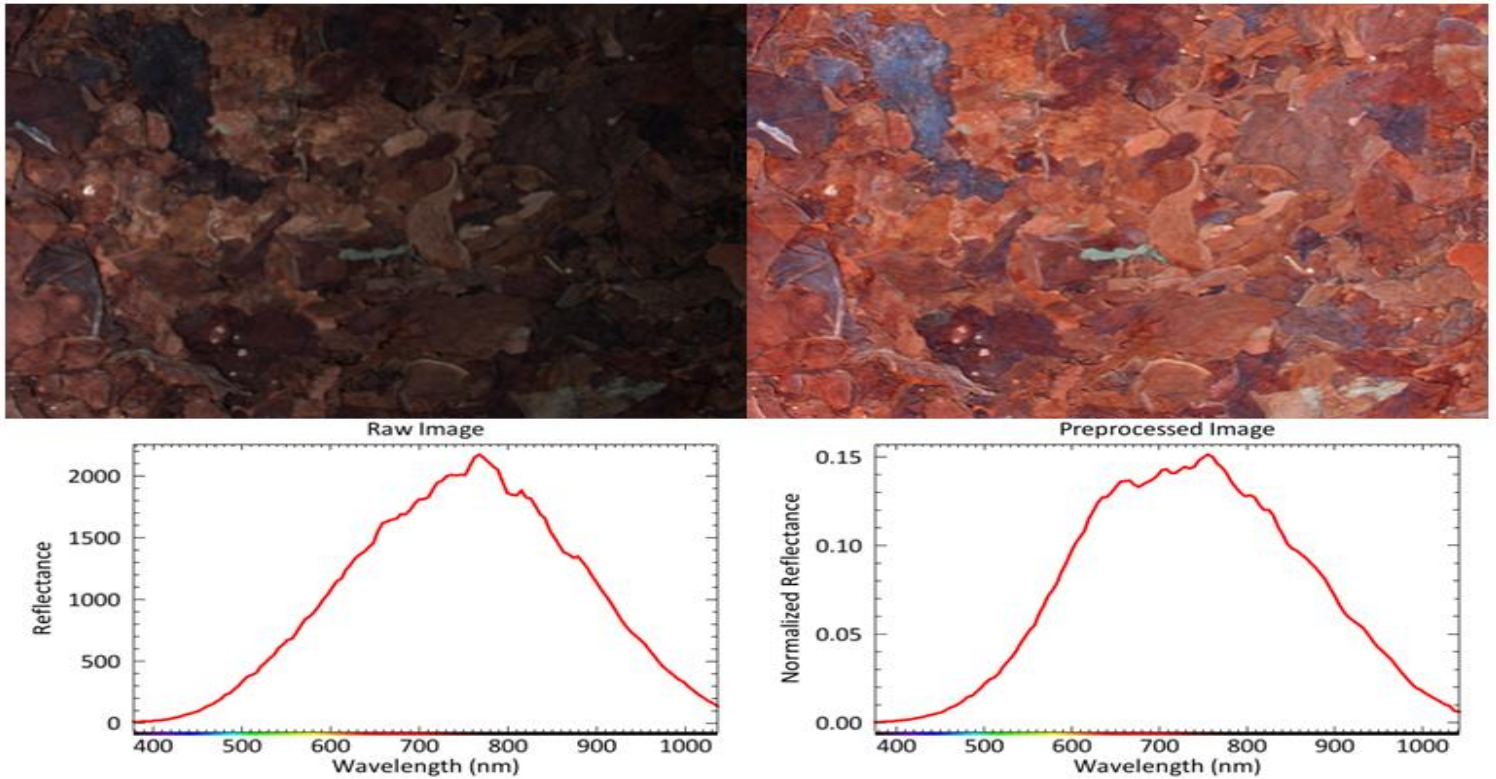
AutoGrader Program Workflow Example



AutoGrader Program Workflow Example



Preprocessing



Classification

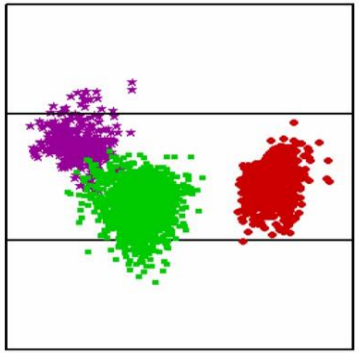
- Use Mahalanobis Distance to measure differences between control and test

- If sample is within 3 standard deviations of the labeled class centroid then it is **acceptable**

- If sample is outside of 3 standard deviations of the labeled class centroid then the class distance ratio is calculated:
    - If the class distance ratio is less than 70% then **inspect** the sample
    - If the class distance ratio is greater than 70% then it is **acceptable**

Proving Success in Tobacco

Major Groups



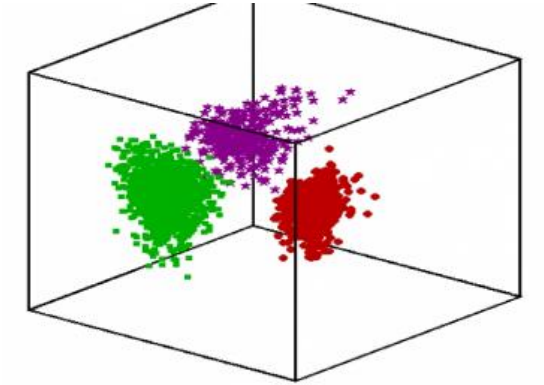
US Burley

US Flue Cured

Oriental

Proving Success in Tobacco

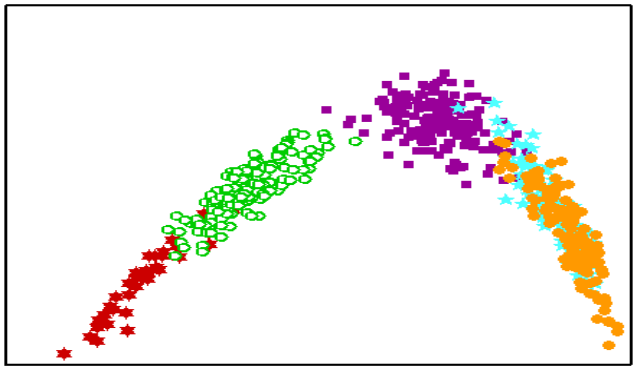
Major Groups



US Burley
US Flue Cured
Oriental

Tobacco plant

Burley Tobacco



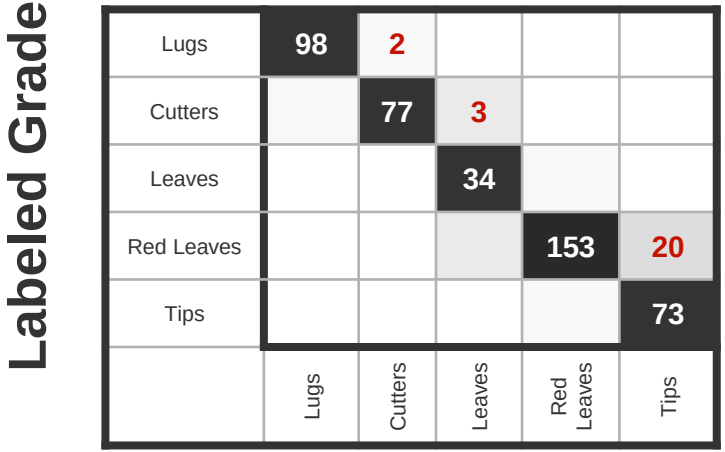
Tips
Red Leaves
Leaves
Cutters
Lugs

Hyperspectral Imaging Accuracy Success*

Flue-Cured Tobacco

East Carolina Belt

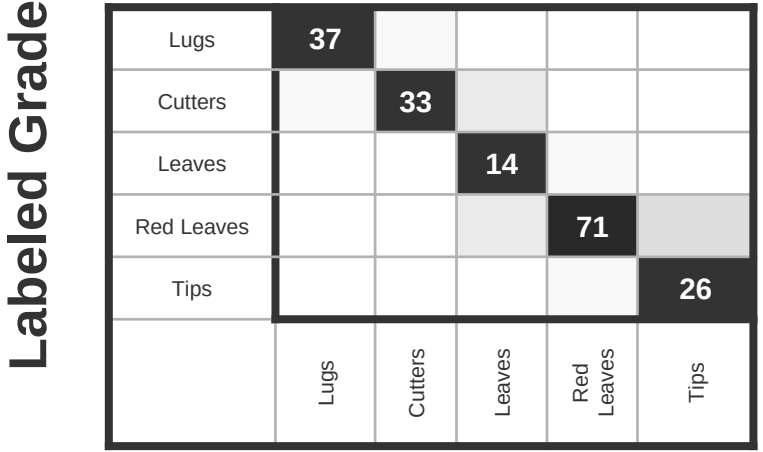
Machine Classification



Relative Classification Accuracy = 95%

Old Belt

Machine Classification



Relative Classification Accuracy = 100%

Classification Accuracy = 100%

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Hyperspectral Imaging Accuracy Success*

Burley Tobacco

Machine Classification

Labeled Grade

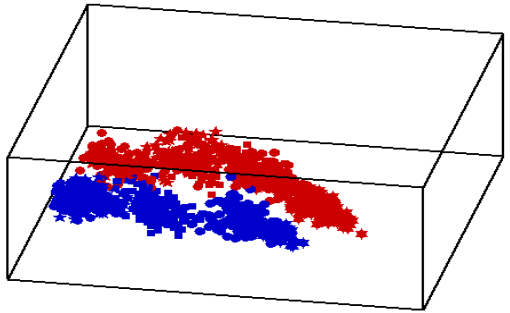
	Lugs	Cutters	Leaves	Red Leaves	Tips
Lugs	78	28			
Cutters	1	280	3		
Leaves			424	8	
Red Leaves				48	50
Tips				10	97

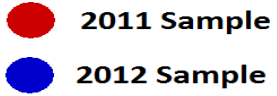
Relative Classification Accuracy = 90%

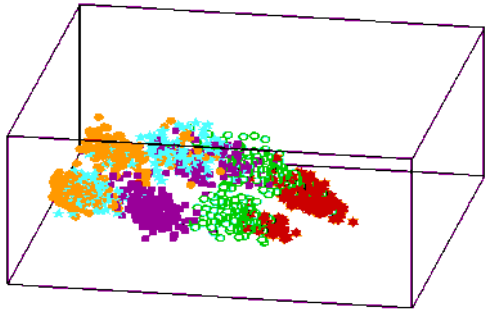
Classification Accuracy = 100%

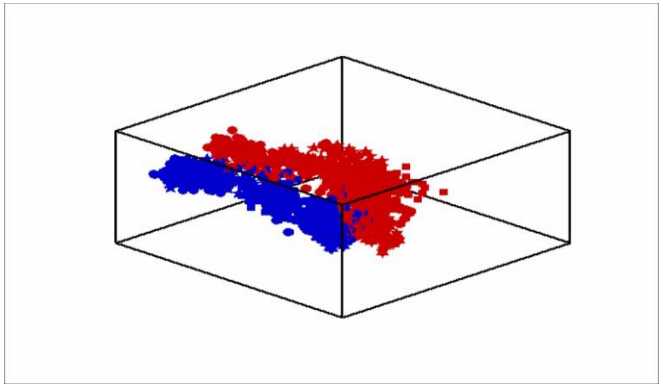
* Hyperspectral System Grading vs. ALCS Grader

Burley Annual Variation

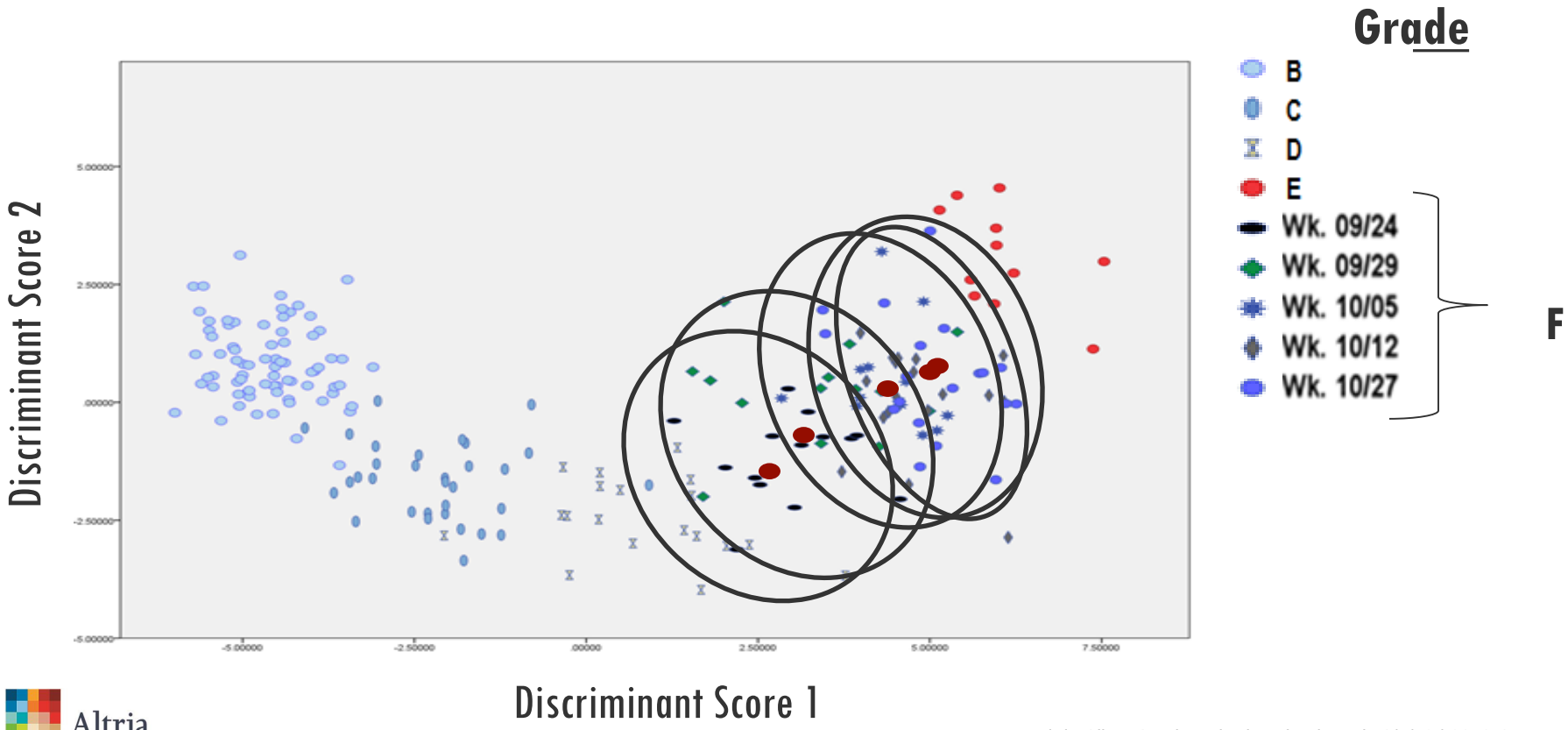








2015 Flue Cured Variation



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Implementation Challenges

- Factory personnel
  - Blown light bulbs
  - Lens out of focus
  - Required a more user friendly, robust system and protocol

- Flexibility for new grades
  - New grades can be added to database

- Calibration features
  - Master-sample feature

Conclusion

- A VNIR hyperspectral imaging system can be used for tobacco grading
- The system can successfully differentiate between the three major groups of tobacco – Burley, Flue-Cured and Oriental
- The system can differentiate between tobacco leaf stalk positions
- The relative classification accuracy ~ 93%

Reducing risk. Expanding choice.

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