Image Recognition for Alfalfa-Grass Mixtures

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Background

- Accurate prediction equations exist for estimating nutritive value and timing of spring alfalfa-grass harvest (Parsons et al., 2006, Agron. J. 98:1081–1089)
  - Weak link is grass fraction in sward
- Overall objective: Generate accurate stand composition estimate using automated image processing system
- Predictions must be better than a guess to be useful
  - How good is a guess?
    - r^2=0.43, RMSE=0.147, n=576 (Parsons et al., data from 2004)

Grass and Alfalfa Estimation Tools

Contents

- Grass Management for Dairy Cattle Home
- Grass Manual
- Information Sheets
- Tools
- Factsheets
- Other Links

Grass Management for Dairy Cattle

NOTE: Currently, these tools are Windows-only. We apologize for the inconvenience.

GMT-1: Grass NDF Estimation Download

This tool allows estimation of current NDF and target harvest height for several grass species. The user provides the current grass canopy height, planned stubble height, and target NDF at harvest.

Reference: Parsons, D., McRoberts, K., Cherney, J.H., Cherney, D.J.R., Bosworth, S., Jimenez-Serrano, F. 2012. Preharvest neutral detergent fiber concentration of temperate perennial grasses as influenced by stubble height. Crop Sci. (in press).

GMT-2: Alfalfa-Grass NDF Estimation Download

This tool allows estimation of current NDF and target alfalfa harvest height for mixed alfalfa-grass stands. The user provides the current alfalfa maximum height (tallest stem) and percent grass in stand. The user can also modify target NDF for the stand, NDF rate of change per day, and also provide a slight adjustment for estimated weather conditions until harvest.

Reference: Parsons, D., Cherney, J. H., and Gauch, H. G., Jr. 2006. Estimation of Preharvest Fiber Content of Mixed Alfalfa-Grass Stands in New York. Agron. J. 98:1081-1089.

GMT-3: Alfalfa NDF Estimation Download

This tool allows estimation of current NDF and target harvest height for pure alfalfa. The user provides the current maximum height (tallest stem), planned stubble height, and target NDF at harvest.

Reference: Parsons, D., Cherney, J. H., and Gauch, H. G., Jr. 2006. Estimation of spring forage quality for alfalfa in New York State. Online. Forage and Grazinglands doi:10.1094/FG-2006-0323-01-RS.

GMT-4: Economic Analysis of Changing Forage Content of Diets Download

This tool allows estimation of return per cow or CWT of milk as the amount of grass forage in the diet changes. Actual returns are based on the results of a dairy cow feeding trial with 4 levels of grass in the diet. The results of the feeding trial cannot be altered, but prices of ration components can be.

Reference: Cherney, D.J.R., J.H. Cherney and L.E. Chase. 2002. Performance of lactating Holstein cows as influenced by forage species, maturity, and level of inclusion. Prof. Anim. Scientist 18:316-323.

GMT-5: Economic Analysis of Changing Alfalfa-Grass Content of Diets Download

Mixed stand equations in: Parsons et al. (2006, Agron. J. 98:1081–1089)

Alfalfa-grass NDF Estimation

Determining alfalfa-grass harvest height and time

1. Choose current alfalfa maximum height

21.0 inches

2. Choose percentage of grass

45 % Grass

3. Adjust target NDF (optional)

Manual target NDF

43.5 % NDF

4. Adjust maturation rate (optional)

Estimated weather conditio unit harvest

Normal
Hot
Cool

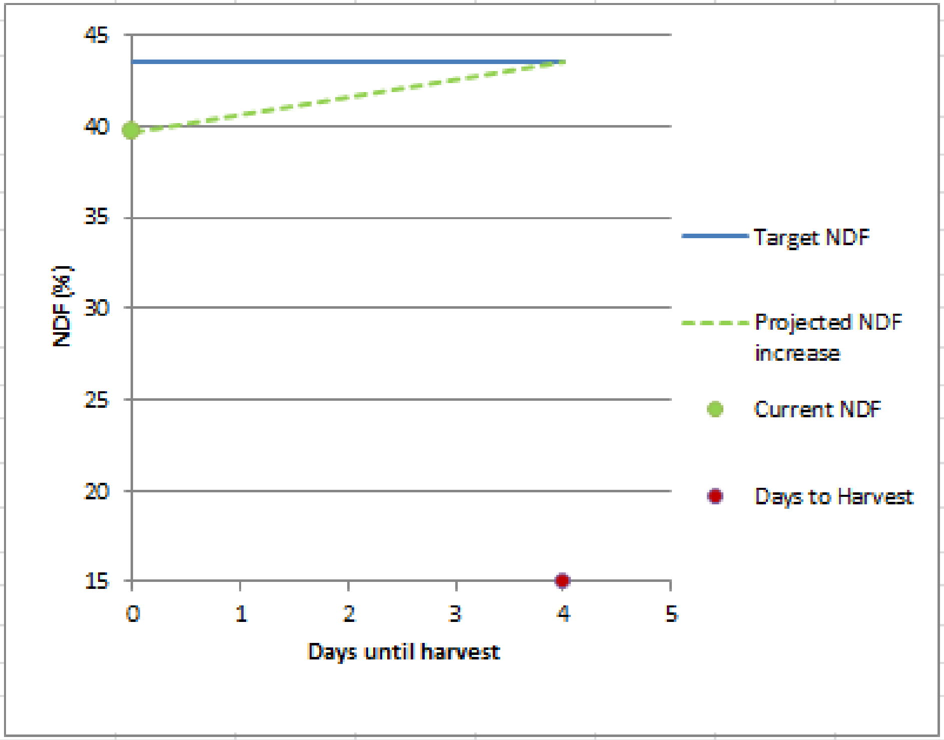
Manual maturation

0.96 NDF units/day

Current NDF: 39.5 %

Target harvest height: 26.0 inches

Approximate time to harvest: 4.0 days



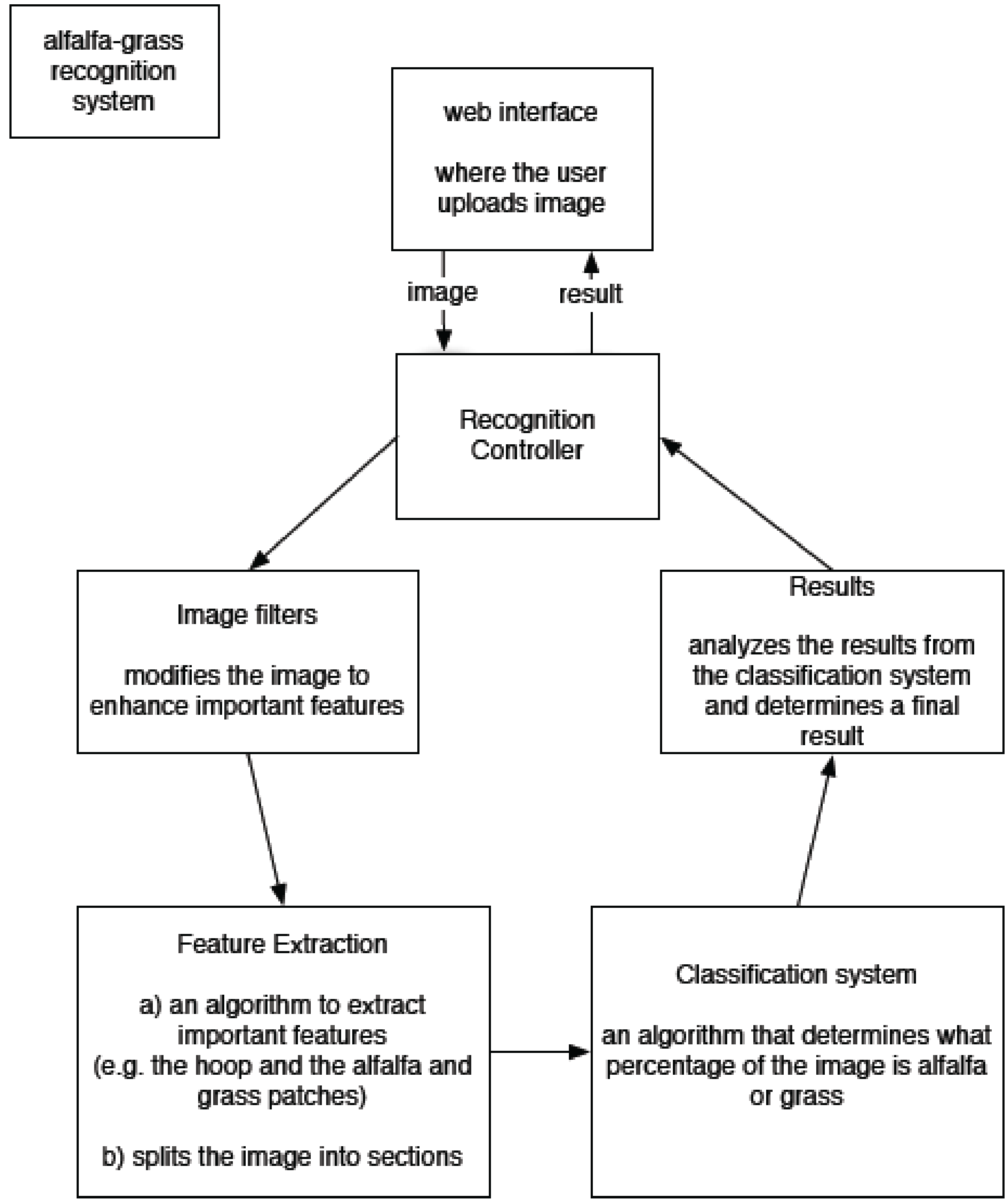
Interface

Process flow

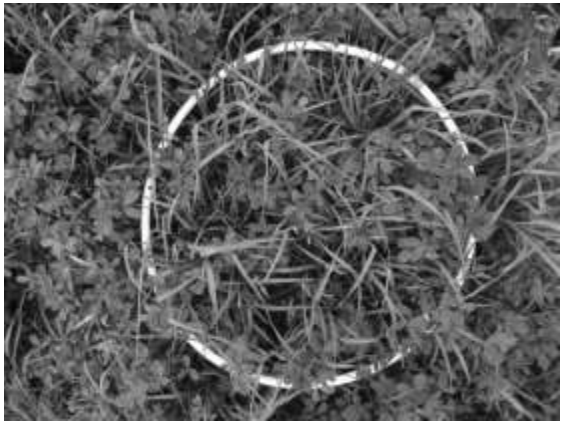
1. Capture digital images from representative samples of mixed stands in farmers’ fields
2. Determine known stand composition values for each sample.
3. Create a software system to predict composition
4. Generate a free web service on http://www.forages.org

Sampling Process




alfalfa-grass recognition system
web interface
where the user uploads image
image
result
Recognition Controller
Image filters
modifies the image to enhance important features
Results
analyzes the results from the classification system and determines a final result
Feature Extraction
a) an algorithm to extract important features (e.g. the hoop and the alfalfa and grass patches)
b) splits the image into sections
Classification system
an algorithm that determines what percentage of the image is alfalfa or grass

Hoop Extraction



- Extract all of the green pixels
- Remove all low value pixels
- Find left, right, top, bottom pixels
- Extract the hoop

Convert the hoop image to a gray scale with an emphasis on green pixels

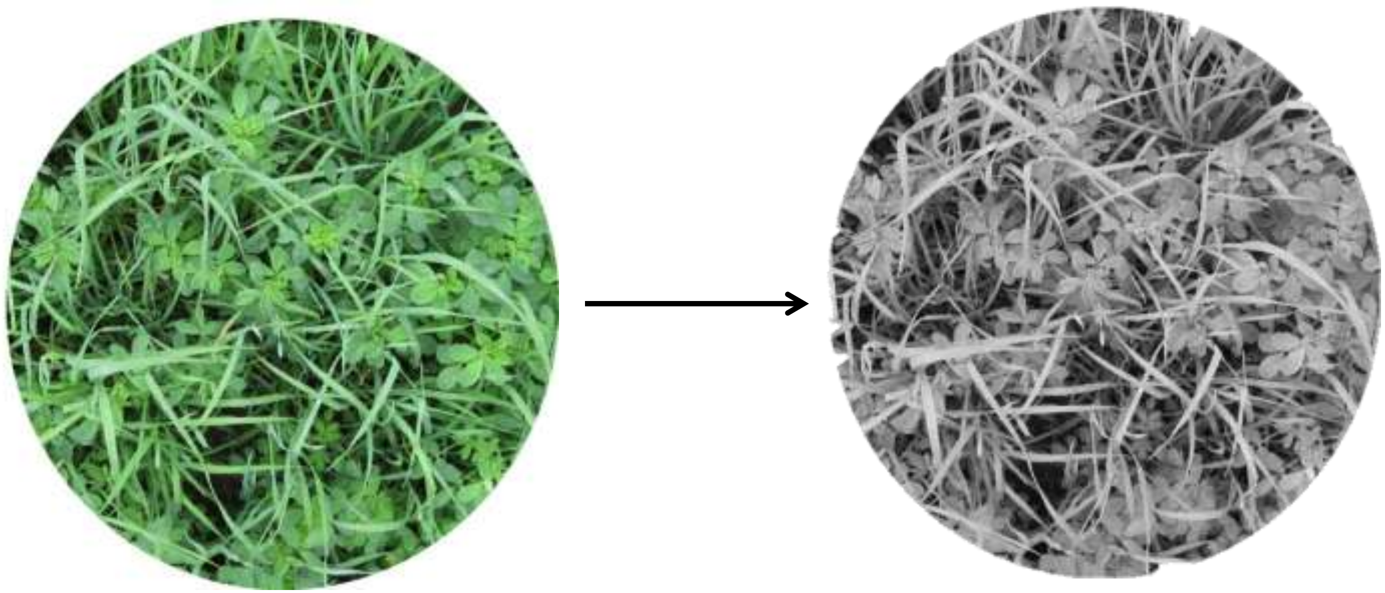
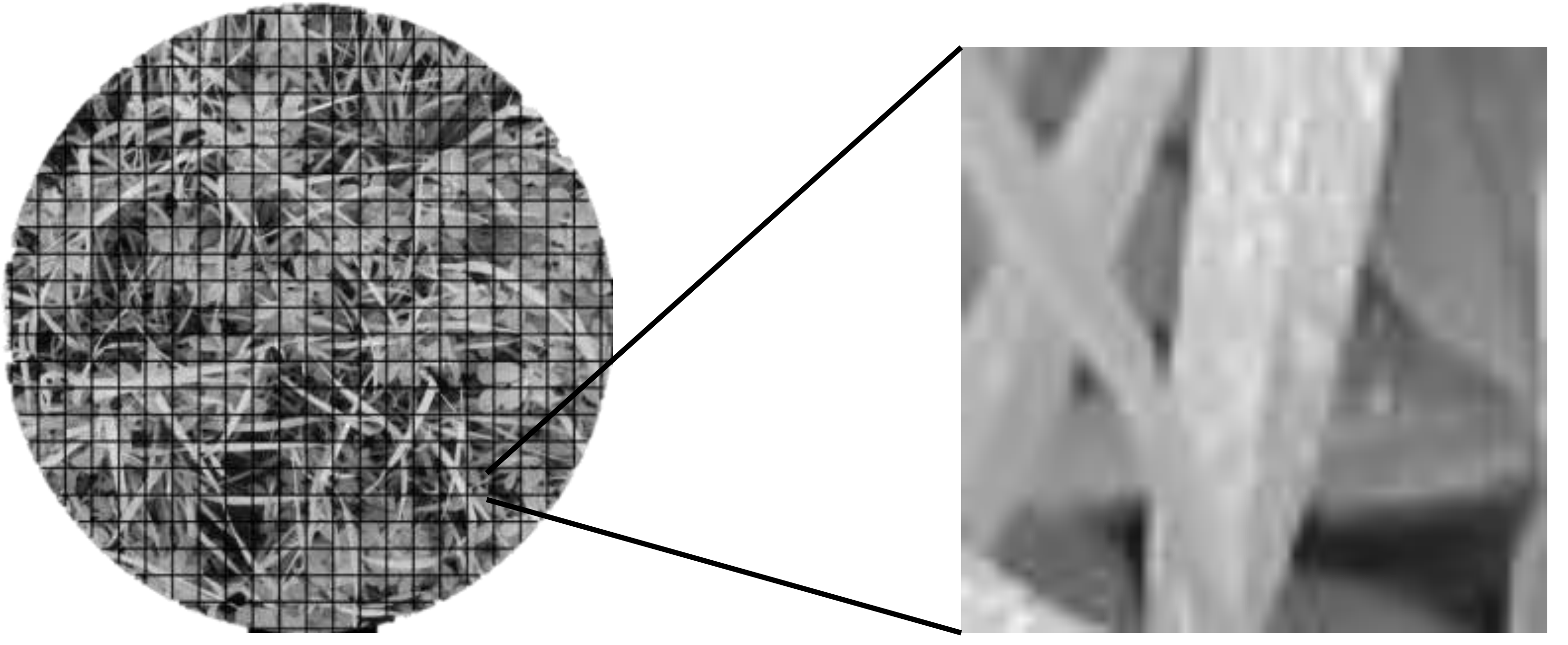


Image Classification Techniques Tested

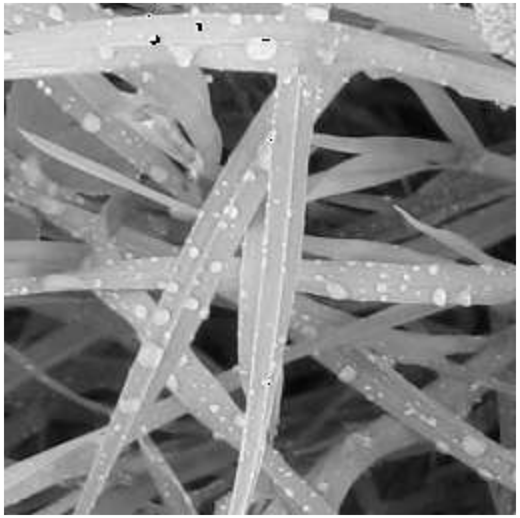
Technique	General Outcome
Geometric pattern matching	No discreet patterns in mixed stand images
Color separation	Grass and alfalfa shade of green too close, especially under variable field conditions
Blob detection	Each piece must be a separate entity to work
Tile method with Fast Fourier Transformation (Polder et al., 2007, 6th Biennial Conference of the European Federation of IT in Agriculture)	Expressed frequencies different for alfalfa and grass

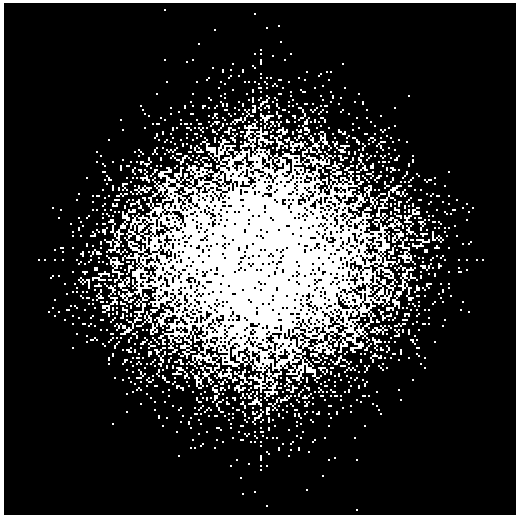
Tile Extraction

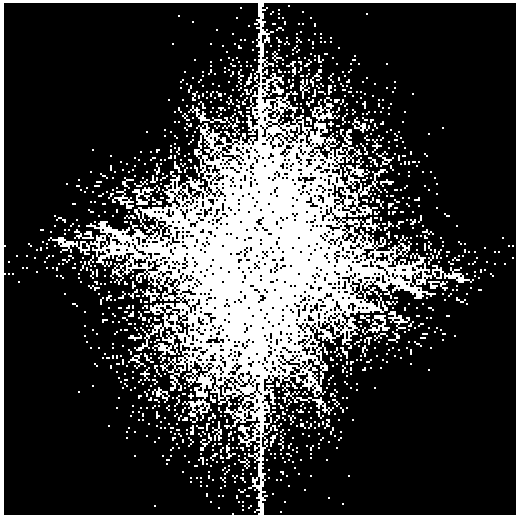


- Crop 64x64 pixel tiles
- Analyze the individual tiles

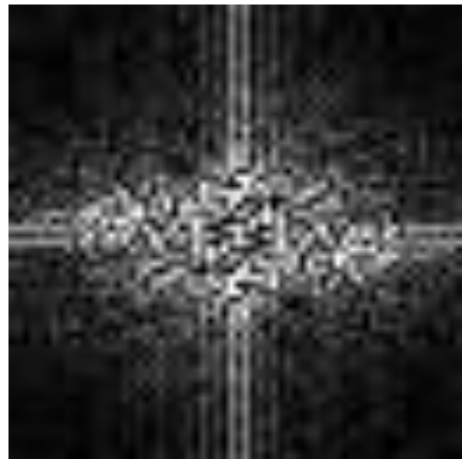
Fast Fourier Justification







2D Fast Fourier Transformation


- Run Fast Fourier algorithm on individual 64x64 tile
- Ignore all frequencies under threshold value (175)
- Lower frequencies are expressed at center of matrix; higher frequencies on the outside

2D Fast Fourier Transformation Continued

- 6 axial frequencies aggregated for x and y axis

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Tile method with Fast Fourier Transformation	Expressed frequencies different for alfalfa and grass
+ Naïve Bayes Classifier Artificial Intelligence	Poor correlation of predicted and actual values

Naïve Bayes Artificial Intelligence

- 580 digital images from 2011 with associated known values
- Decision rules defined on human noted patterns
- Simplistic examples:
  - Higher frequency above threshold value = grass
  - No higher frequencies expressed = alfalfa
  - The chance of being defined as alfalfa or grass depends on intermediate frequencies expressed
- Tile was thrown out when Naïve AI could not calculate definite probability

Predicting grass fraction with Naïve Bayes Classifier AI

Model: Actual Grass % =	n	r^2	RMSE	p
Naïve Predicted Grass %	316	0.01	0.155	0.12
Alfalfa Max + Grass Cpy	316	0.19	0.140	Model <0.0001
Grass Predicted + Alfalfa Max + Grass Cpy	316	0.20	0.14	Model <0.0001 Grass Predicted = 0.0445
OG Predicted + Alfalfa Max + Grass Cpy	121	0.43	0.102	Model <0.0001 OG Predicted = 0.0214
Quack Predicted + Alfalfa Max + Grass Cpy	39	0.43	0.106	Model = 0.0002 Quack Predicted = 0.63
RC Predicted + Alfalfa Max + Grass Cpy	74	0.22	0.107	Model = 0.0006 RC Predicted = 0.4344
Timothy Predicted + Alfalfa Max + Grass Cpy	82	0.28	0.128	Model <0.0001 T Predicted = 0.0468

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Tile method with Fast Fourier Transformation (Polder et al., 2007)	Expressed frequencies different for alfalfa and grass
+ Naïve Bayes Classifier AI	Poor correlation of predicted and actual values
+ Fourier Frequencies	Aggregated frequencies performed better than Naïve AI; collinearity problems with multivariate models
+ Support Vector Machine – trained: LIBSVM open source package (Chang & Lin, 2011, ACM Transactions on Intelligent Systems and Technology 2(3): 27:1--27:27)	Not fully tested, but preliminary results promising
+ Support Vector Machine – untrained	Seeking AI package for testing

Next Steps

- Support Vector Machine – Trained (in progress)
  - LIBSVM package (Chang & Lin, 2011)
  - Binary classification of tiles in image set
    - 6% complete for 2011 set
  - Train AI and test with different subsets
  - Grass species specific development
- Support Vector Machine – Untrained
- Reconsider threshold levels for Fourier filters
- Consider Fast Fourier alternatives

Conclusions

- Among most difficult image analysis applications
- Work in progress
- If successful, probable materials needed for use:
    - Hula hoop (26” diameter) painted white
    - Digital camera or smartphone camera
    - Measuring stick (for alfalfa max height, possibly grass canopy height, grass max height, and grass species)
    - Internet access

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