THESIS PROPOSAL

Design machine learning model to predict Turfgrass Evaluation

KE DING

July 23, 2015

I have read the attached thesis proposal and, in my opinion, it proposes work which is adequate in depth and scope to serve as the culminating experience for the Master's Degree in Computer Science. I would agree to chair this committee or serve thereon.

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# Introduction

# Literature Survey

## Manually Turfgrass Evaluation

The National Turfgrass Evaluation Program (NTEP)[[1]](#footnote-1) is a leader in evaluation of turfgrass species. The turfgrass industry in the USA and many parts of the world rely heavily on NTEP data. The information collected and summarized by NTEP is currently requested in thirty countries.

Turfgrass breeders, researchers, and extension specialists use NTEP data to determine adaptation and use of cultivars and experimental lines. Seed companies rely on this data for advertisement and sales. Government agencies, like highway and parks departments, use NTEP data when writing specifications for bids and purchasing. Most importantly, end-users, like golf course superintendents, sports turf managers, sod growers, lawn care service operators, and grounds managers, frequently use the data before purchasing seed or sod. It is the interest of all of these users that has made NTEP data the standard for the turfgrass industry in the USA.

The quality and scientific merit of NTEP data is extremely important. However, the evaluation of turfgrass species and cultivars is a difficult and complex issue. Furthermore, turfgrass evaluation is generally a subjective process based on visual estimates of factors, like genetic color, stand density, leaf texture, uniformity and quality. These factors cannot be measured in the same way as other agricultural crops. Turfgrass quality is not a measure of yield or nutritive value. Turfgrass quality is a measure of aesthetics (i.e. density, uniformity, texture, smoothness, growth habit and color), and functional use. The most common way of assessing turfgrass quality is a visual rating system that is based on the turfgrass evaluator's judgement.

Subjective measures of this type are always subject to criticism and concern. However, it is a well-established fact that properly trained observers can effectively discern subtle differences between turfgrasses, using the visual rating system.

### Things to Consider

Visual ratings require consistency to ensure their merit. One person should take the data for a study. Avoid changing the person collecting visual ratings during the course of a growing season. Ideally, the same person should collect the visual ratings until the study is terminated. Keep a photographic record of treatment differences. Photos or slides are helpful in tracking treatment differences.

Before taking data, observe the study. Do you see visual differences in color, density, uniformity, disease incidence, environmental stress or other factors? If so, your visual ratings should reflect these differences. Walk around the treatments. Identify the range of differences that you see. What are the best and worst treatments? What treatments are in the middle of the range? You may wish to mark these plots to use as a reference. You can refer back to them as you rate the study, keeping your ratings as consistent as possible. This process allows you to establish your rating range for each time that you rate the treatments.

Visual ratings are based on a 1 to 9 rating scale. One is the poorest or lowest and 9 is the best or highest rating. Use as much of the rating scale as is reasonable and feasible. Base your range on the overall differences that you observe. It is important that you do not compress the rating scale. Rate only in whole numbers.

It is ideal to conduct visual evaluations on cloud-covered days, when shadows and reflections are minimal. Take data between midmorning to early afternoon, when the sun is at its highest. Keep the sun at your back. Avoid recording visual ratings on partially cloudy days. The intermittent cover causes sun flecks, and periods of brightness and shadows, making it difficult to evaluate treatment differences. It is best to have someone record data or use a data recorder. This approach speeds up the data collection and reduces glare resulting from glancing back and forth between paper and green verdure.

With some characteristics, like genetic color, differences are more evident prior to mowing. Mowing direction causes difference in light reflection and may influence color ratings. If the turf is mowed prior to rating, it is best to mow replications in the same direction. This will minimize reflection differences.

### Turfgrass Quality

Quality is based on 9 being best and 1 being poorest. A rating of 6 or above is generally considered acceptable. A quality rating value of 9 is reserved for a perfect or ideal grass, but it also can reflect an absolutely outstanding treatment plot. The NTEP requires quality ratings on a monthly basis.

Quality ratings will vary based on turfgrass species, intensity of management and time of year. Within species quality ratings are relative. Among species they are not. For example an acceptable quality rating of 6 within tall fescue cultivars is not relative to the same value given among Kentucky bluegrasses. An acceptable quality rating value for a utility turf differs from the same value for a bentgrass putting green.

Quality ratings take into account the aesthetic and functional aspects of the turf. Quality ratings are not based on color alone, but on a combination of color, density, uniformity, texture, and disease or environmental stress. Turfs growing in a study may receive the same numeric quality rating, but the factors influencing that rating may differ. For example, one turf may receive a quality rating value of 5 based on overall color and density, while another may receive the same value based on disease incidence and its impact on turfgrass density.

It is important to keep these facts in mind, when rating turfgrass quality. It is also important to keep this in mind when interpreting data from various studies.

### Genetic Color

Genetic color reflects the inherent color of the genotype. It is based on a visual rating scale with 1 being light green and 9 being dark green. Take genetic color ratings when the turf is actively growing and is not under stress. Chlorosis and browning from necrosis are not a part of genetic color.

Color charts, like those sold by the Munsell Color Company, Inc., are helpful in describing turfgrass color and serve as a reference. Color charts are useful in maintaining consistent visual color ratings.

### Turfgrass Density

Turfgrass density is a visual estimate of living plants or tillers per unit area. Dead patches of turf are excluded. A visual rating of 1 to 9 is used with 9 equaling maximum density. Turfgrass density can be determined quantitatively by counting shoots in a specified area. Counting is time consuming and labor intensive. Visual turfgrass density ratings are highly correlated to counts and require much less time and labor input. Shoot density varies by time of year. It is best to take density ratings in the spring, summer, and fall to account for seasonal variation. This is particularly true for cool-season turfgrasses.

### Percent Living Ground Cover

Percent living ground cover is based on surface area covered by the originally planted species. It is generally used to express damage caused by disease, insects, weed encroachment, or environmental stress. Percent living ground cover is often measured in the spring, summer, and fall. This timing allows one to track the turfgrass response to various stresses during the growing season.

### Turfgrass Texture

Turfgrass texture is a measure or estimate of leaf width. The visual rating of texture is based on a 1 to 9 rating scale with 1 equaling coarse and 9 equaling fine. Visual assessment of texture is difficult and less than precise. However, physical measurement is tedious, time consuming and labor intensive. Physical measurements are also variable. Care must be taken to measure leafs of similar age and stage of development. Visual ratings of texture can be used successfully to separate cultivars within species. Visual assessment of leaf texture should be done when the turfgrass is actively growing and is not under stress.

### Other Color Data

#### Spring Green-up

Green-up is a measure of the transition from winter dormancy to active spring growth. It is based on plot color not genetic color. The visual rating of spring green-up is based on a 1 to 9 rating scale with 1 being straw brown and 9 being dark green.

#### Winter Color

An assessment of color retention during the winter months. It is based on a 1 to 9 visual rating scale with 1 equaling straw brown or no color retention, and 9 equaling dark green. It assesses overall plot color and not genetic color.

#### Seasonal Color/Color Retention

Seasonal color and color retention ratings are a measure of overall plot color. The scale used is 1 to 9 scale with 1 being straw brown and 9 being dark green. Seasonal color can be used to successfully differentiate color differences based on damage caused by disease or insect pests, nutrient deficiency or environmental stress. Color retention is used to assess the ability of the entry to hold color as seasons change. This is especially useful in quantifying the response of warm-season grasses to temperature changes or frost occurring in fall.

### Other Data

#### Pest Problems

Pests include disease, insects and weeds. The NTEP reports disease and insect injury based on the turfgrass resistance, using the 1 to 9 rating scale with 1 equaling no resistance or 100% injury, and 9 equaling complete resistance or no injury. Insect incidence may also be determined as counts per unit area. Always identify disease and insects to genus and species. Verify the genus and species through the appropriate specialist (i.e. plant pathologist, entomologist, etc.). Weed infestation or encroachment is generally expressed as percent ground cover. Weeds should be identified to genus and species.

#### Environmental Stress

Stresses, like drought and winter injury, cause severe turfgrass damage. Turfgrass cultivars differ in their ability to tolerate and recover from these stresses. Drought Stress- Drought stress resistance is assessed as wilting, leaf firing, dormancy, and recovery. A 1 to 9 visual rating scale is used with 1 being complete wilting, 100% leaf firing, complete dormancy or no plant recovery; and 9 being no wilting, no leaf firing, 100% green-no dormancy, or 100% recovery.

#### Winter Injury

Freezing or direct low temperature, desiccation, and frost injury can comprise winter injury symptoms. It is important to identify the cause of the winter injury symptoms. Turfgrass species and cultivars differ in their responses to each of these stresses. Direct low temperature and desiccation injury are generally expressed as a visual estimate of percent damaged ground cover. Frost injury is expressed on a 1 to 9 rating scale with 1 equaling 100% leaf injury and 9 equaling no injury.

#### Traffic Tolerance

Traffic tolerance is the combination of wear and compaction stress that occurs whenever a turf is exposed to foot or vehicular traffic. Wear injury occurs immediately upon trafficking a turf. Wear injury symptoms are often expressed within hours and definitely within days. Compaction stress injury is more chronic. It is expressed over time. The NTEP reports traffic tolerance as visual estimate of turfgrass tolerance using a 1 to 9 rating scale with 1 being no tolerance or 100% injury, and 9 being complete tolerance or no injury.

#### Thatch Accumulation

Thatch is generally a measured value. Compressed thatch depth is preferred. It gives values with reduced variability. Collect 4, 5-cm plugs of turf-, remove the verdure; place a 1 kg weight on the surface of the thatch; and measure the compressed thatch depth in mm. Thatch accumulation measurements are time consuming and labor intensive.

## Image Pre-Processing

Image pre-processing method to retrieve the desired area by either some edge mark or dot mark.

### Canny Edge Detector

The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. It was developed by John F. Canny in 1986. Canny also produced a computational theory of edge detection explaining why the technique works.

Edge detection, especially step edge detection has been widely applied in various different computer vision systems, which is an important technique to extract useful structural information from different vision objects and dramatically reduce the amount of data to be processed. Canny has found that, the requirements for the application of edge detection on diverse vision systems are relatively the same. Thus, a development of an edge detection solution to address these requirements can be implemented in a wide range of situations. The general criteria for edge detection includes

1. Detection of edge with low error rate, which means that the detection should accurately catch as many edges shown in the image as possible
2. The edge point detected from the operator should accurately localize on the center of the edge.
3. A given edge in the image should only be marked once, and where possible, image noise should not create false edges.

To satisfy these requirements Canny used the calculus of variations – a technique which finds the function which optimizes a given functional. The optimal function in Canny's detector is described by the sum of four exponential terms, but it can be approximated by the first derivative of a Gaussian.

Among the edge detection methods developed so far, canny edge detection algorithm is one of the most strictly defined methods that provides good and reliable detection. Owing to its optimality to meet with the three criteria for edge detection and the simplicity of process for implementation, it becomes one of the most popular algorithms for edge detection.

### Peak local max

First binaries the image by indicated threshold, red channel in our case.

Then find peaks in an image, and return them as coordinates. The peak local maximum function returns the coordinates of local peaks (maxima) in an image. A maximum filter is used for finding local maxima. This operation dilates the original image. After comparison between dilated and original image, peak local max function returns the coordinates of peaks where dilated image equal to the original.

Then link the peak coordinates to retrieve the desired area.

## Image feature Extraction

### Color feature

Historically, field experiments investigating turf- grass have been evaluated by visual ratings. Although relevant information may result from such evaluations, final inferences may be questionable because of  
the subjective nature in which the data were collected. Recently, digital image analysis techniques have been developed that allow researchers to objectively measure turfgrass characteristics such as percent ground cover and turf color[[2]](#footnote-2). The analysis techniques select pixels representing turf within an image so that they may be further processed for the evaluation of interest. The ground cover techniques allow researchers to accurately measure parameters such as establishment rates, disease incidence, and recovery from injury or dormancy. The color methods allow for comparison of genetic color among varieties, as well as responses to fertility or other management variables.

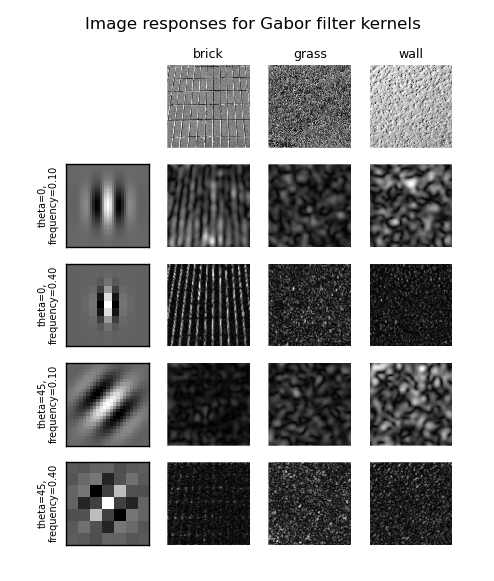
#### Greenness

#### Color percentage

### Texture feature

#### Gabor filter banks for texture classification[[3]](#footnote-3)

Texture features that are based on the local power spectrum obtained by a bank of Gabor filters are compared. The features differ in the type of nonlinear post-processing which is applied to the local power spectrum. The following features are considered: Gabor energy, complex moments, and grating cell operator features. The capability of the corresponding operators to produce distinct feature vector clusters for different textures is compared using two methods: the Fisher (1923) criterion and the classification result comparison. Both methods give consistent results. The grating cell operator gives the best discrimination and segmentation results. The texture detection capabilities of the operators and their robustness to non-texture features are also compared. The grating cell operator is the only one that selectively responds only to texture and does not give false response to non-texture features such as object contours



#### GLCM Texture Features[[4]](#footnote-4)

A co-occurrence matrix or co-occurrence distribution (less often *co-occurrence* matrix or *co-occurrence* distribution) is a matrix that is defined over an image to be the distribution of co-occurring values at a given offset. Mathematically, a co-occurrence matrix C is defined over an n × m image *I, parameterized by an offset*  as:

where i and j are the image intensity values of the image, p and q are the spatial positions in the image I and the offset depends on the direction used \theta and the distance at which the matrix is computed d. The 'value' of the image originally referred to the grayscale value of the specified pixel, but could be anything, from a binary on/off value to 32-bit color and beyond. Note that 32-bit color will yield a 232 × 232 co-occurrence matrix!

Really any matrix or pair of matrices can be used to generate a co-occurrence matrix, though their main applicability has been in the measuring of texture in images, so the typical definition, as above, assumes that the matrix is in fact an image.

## Machine Learning Model

### Linear Model

### Support Vector Machine

### Artificial Neural Network

# Research Goal

# Methodology

# Evaluation of Results

# Tentative Table of Contents for the Thesis

# Tentative Timetable for Completion of the Thesis

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1. Morris and Shearman, “NTEP Turfgrass Evaluation Guidelines.” [↑](#footnote-ref-1)
2. Karcher and Richardson, “Quantifying Turfgrass Color Using Digital Image Analysis.” [↑](#footnote-ref-2)
3. Grigorescu, Petkov, and Kruizinga, “Comparison of Texture Features Based on Gabor Filters.” [↑](#footnote-ref-3)
4. Haralick, Shanmugam, and Dinstein, “Textural Features for Image Classification.” [↑](#footnote-ref-4)