Turf Analyzer User Guide

Turf Analyzer is small yet powerful software program designed to analyze turfgrass images for turfgrass quality parameters, including green coverage, color, density, uniformity, and overall turf quality. It is Java-based and will operate on Windows, Mac, or Linux operating systems. Relative to previously published methods on digital image analysis in turf using SigmaScan Pro v 5.0 (Richardson et. al, 2001; Karcher et al., 2003; Karcher and Richardson, 2005), Turf Analyzer offers additional analysis and thresholding options, the ability to analyze high-resolution images, and processing times that are 2 orders of magnitude faster than SigmaScan.

Reliable results for Turf Analyzer are dependent on high-quality, representative digital images of the turfgrass canopy of interest. It is recommended that images are taken using a light box and fixed camera settings (aperture, shutter speed, ISO, white balance, etc.) to remove the effects of automated camera adjustments and variable ambient light. For more information on collecting quality turfgrass images for analysis, see Karcher and Richardson, 2013.

The following instructions outline the steps necessary to complete an analysis of a batch of turfgrass images once Turf Analyzer has been downloaded and registered. Any questions, problems, or suggestions regarding the program should be directed to turfanalyzer@gmail.com.

Select the images to be analyzed

- Open Turf Analyzer and browse to the folder containing the images to be analyzed by clicking the "Change" button within the "Select a directory" dialog near the top of the Turf Analyzer window.

Color analysis

- Select the "Color" tab.
- Check the "Perform color analysis" box.
- Turf Analyzer can either calculate the average color of the entire image or calculate the average color of only the green turfgrass within an image that does not include 100% green turfgrass coverage.
    - If color is to be calculated for the entire image, check the "Use entire image to calculate average color" box.
    - If color is to be calculated for only portions of the image corresponding to green turfgrass, check the "Use threshold settings…" box. Then, use the "Threshold" tab to determine how Turf Analyzer selects green turfgrass (see "Threshold settings" section).
- Results will be reported as average Red, Green, Blue, Hue, Saturation, and Brightness values, as well as a Dark Green Color Index (DGCI) value. In addition, a color rating value may be estimated (see quality analysis below).

Cover analysis

- Select the "Cover" tab.
- Check the "Perform cover analysis…" box.
- Use the "Threshold" tab to determine how Turf Analyzer selects green turfgrass (see the following "Threshold settings" section).
- Results will be reported as Percent Cover values. In addition, a cover rating value may be estimated (see quality analysis below).

Threshold settings

- Threshold settings must be set when performing a cover analysis or when threshold settings are used for color analysis. Threshold settings are the hue (0 – 360 degrees), saturation (0 – 100%), and brightness (0 – 100%) ranges that will be used by Turf Analyzer to select image pixels corresponding to green turfgrass.
    - ***Note for SigmaScan users:*** *To convert a SigmaScan hue threshold value to an equivalent Turf Analyzer value, multiply by 1.4. SigmaScan uses a 255 unit threshold range, whereas Turf Analyzer uses a 360° based threshold range. Therefore the conversion of 1.4 is simply 360/255.*
- Click the "Threshold" tab.
- In many cases, the default settings work well for discriminately selecting portions of an image that correspond to green turfgrass. The default threshold settings are:
    Hue: 70 – 170; Saturation: 10 – 100; Brightness: 0 – 100.
    - To use these default threshold settings, click the "Use Defaults" button.
- The "Threshold Finder" tool is useful if appropriate threshold settings are unknown, or to confirm that current threshold settings will work well for selecting green turfgrass within the images to be analyzed. Click the "Use Finder" button to use this tool.
    - To begin using the "Threshold Finder" tool, select a representative image form within the folder of images to be analyzed.
    - Within the "Select threshold values" dialog, adjust the sliders to adjust the hue, saturation, and brightness threshold ranges. Pixels that are not included within the threshold settings will turn black. To adjust a setting by a single unit, click on the slider and then use the up/down keyboard keys.
    - ***Note for SigmaScan users:*** *The SigmaScan threshold tool covers the selected pixels with an overlay whereas Turf Analyzer leaves the selected pixels visible while blackening non-selected pixels.*
    - To toggle between the threshold image (with blackened pixels) and the original image, click either the "View Original Image" or "View Threshold Image" button.
    - Use the smaller image on the right of the "Select threshold values" dialog to zoom in on various portions of the image to determine which pixels are included in the threshold settings ranges. Click on the smaller image and use the mouse wheel to zoom in/out. Click and drag the blue rectangle within the smaller image to view threshold settings at other image positions.

    - Click the “Use a different image” button to browse and select another image for testing with the “Threshold Finder” tool.
    - Once appropriate threshold settings are determined, click the “Use threshold settings” button.
- Turf Analyzer can save a threshold image for each image that is analyzed. A threshold image is similar to the original image, except that portions of the image that were included in the analysis, based on the threshold settings, are highlighted in bright green. Check the “Create threshold images” to save threshold images in a subfolder named, “BatchThresholdImages”, which will be located in the same folder as the images to be analyzed.

Density analysis

Turfgrass density analysis is based on the principle that images containing a dense stand of turf will have a greater number of leaves per unit area, and therefore a greater number of smaller shadows (dark areas between leaves) per unit area. Therefore, it is important that all images are taken under standard, controlled conditions (height, lighting, and camera settings). Perform the following steps to analyze turfgrass images for density.

- Select the “Density” tab.
- Check the “Perform density analysis” box.
- The threshold ranges on the “Density” tab are for selecting shadows within the image. The default shadow threshold settings are:
  Hue: 0 – 360; Saturation 0 – 100; Brightness: 0 – 23.
- Results will be reported as Density Measurement values that represent the shadow distribution within each turfgrass image analyzed. Higher Density Measurement values correspond to higher turfgrass density. In addition, a density rating value may be estimated (see quality analysis below).

Uniformity analysis

Uniformity analysis is based on how uniform the turfgrass canopy appears when viewed from 5 to 6 feet above the turf canopy. Uniformity is not necessarily related to turfgrass coverage. For example, a turf canopy that is greater than 95% green turf coverage could have a few bright yellow dandelion flowers that would result in low uniformity. Conversely a “turf” canopy that was infested with dandelions might have high uniformity, albeit uniformly yellow. Perform the following steps to analyze turfgrass images for uniformity.

- Select the “Uniformity” tab.
- Check the “Perform uniformity analysis” box.
- Enter the area (in square feet) represented by each image. The default area of 2 ft^2 corresponds to images collected with a standard light box.
- Results will be reported as a Uniformity Measurement value, with higher numbers corresponding to more uniform turf.

Frame analysis

The "Frame" tool within Turf Analyzer is useful when analyzing turfgrass images from small and/or non-rectangular areas, such as greenhouse pots or lysimeters. The entire turfgrass area of any shape or small size can be analyzed using the "Frame" tool in Turf Analyzer. A frame should be placed over the turfgrass area of interest when taking pictures. The resultant image should include only the frame and the turfgrass area (nothing outside the frame). Also, the frame color must contrast the colors of the turf (and/or soil) in the frame interior. Bright pink or purple frame colors work well and frames can be constructed easily from poster board or cardstock. To use the "Frame" tool, perform the following steps:

- Select the "Frame" tab.
- Check the "Use a frame" box.
- Determine the appropriate hue, saturation, and brightness ranges for selecting the frame in the images to be analyzed. These settings may be determined using the "Threshold Finder" tool as described above under the "Threshold settings" section. When the settings are correct the frame interior of the Threshold Image should be completely black (no black should appear on the actual frame).
- Alternatively, the hue, saturation, brightness ranges may be entered directly within the "Frame" tab if they are already known.

Quality analysis

Turf Analyzer is capable of estimating quality rating values for turfgrass images from the combined analyses of color, cover, density and/or uniformity. Quality ratings are calculated by first converting each of the color, cover, density, and/or uniformity results into rating values (typically on a 1 to 9 scale). Then, those rating values are used to calculate a **weighted average** representing an overall quality rating value.

For each analysis parameter, the user should input the appropriate maximum and minimum rating values present among the images to be analyzed. The user does not have to rate specific images, but rather input the range of rating values represented among the turfgrass images for each analysis parameter.

In addition, the appropriate relative weights of each analysis parameter should also be entered. For example if cover carries three times the importance of color, and twice the importance of density, and uniformity in determining quality, then the weights should be 3, 1, 2, and 2 for cover, color, density, and uniformity, respectively. To use the "Quality Rating" tool, perform the following steps:

- Select the "Quality Rating" tab.
- Check the "Perform quality rating box".
- Input the minimum and maximum rating values represented among the images for each analysis parameter checked.

- Input the relative weights for determining the overall quality for each analysis parameter checked.
- To display intermediate analysis values such as Percent Cover, DGCI, Denisty Measurement, and Uniformity Measurement, in addition to quality rating values, check the "Show Intermediate Values" box.

Analysis results

- Once the image directory has been selected and all analysis settings input, click the "Analyze" button to execute the analysis.
- Turf Analyzer will display an analysis progress window. Total analysis time will depend on the number of parameters evaluated and the resolution of the images.
- Once the analysis has completed, Turf Analyzer will save the results in a data file named, "BatchResults.csv" in the same directory containing the images. A notification screen will appear when the analysis is complete allowing the user view the results contained within the data file.
- The data file contains all user settings at the top of the file followed by the results for all parameters evaluated. Each row of results contains the image file path and file name followed by the results for each analysis that was conducted.

Version Updates

- Turf Analyzer 1.01 - fixes a bug that makes the Uniformity analysis malfunction after having used a frame.

References

- Karcher, D. E., and M. D. Richardson. 2003. Quantifying turfgrass color using digital image analysis. Crop Sci. 43(3):p. 943-951.
- Karcher, D. E., and M. D. Richardson. 2005. Batch analysis of digital images to evaluate turfgrass characteristics. Crop Sci. 45(4):p. 1536-1539.
- Karcher, D. E., and M. D. Richardson. 2013. Digital image analysis in turfgrass research. In Stier, John C., Horgan, Brian P., and Bonos, Stacy A. (eds.) Turfgrass: Biology, Use, and Management. Madison, Wisconsin: American Society of Agronomy.
- Richardson, M. D., D. E. Karcher, and L. C. Purcell. 2001. Quantifying turfgrass cover using digital image analysis. Crop Sci. 41(6):p. 1884-1888.