quarterly report for

Applications of High Performance Statistical Modeling to Image Analysis of Forest Structure

submitted to:

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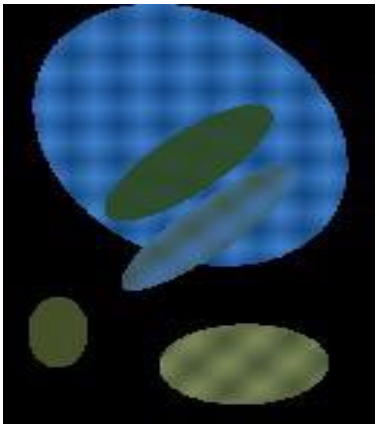

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The need to automatically determine the scenic beauty of a forest scene has been the prime source of motivation for this project. In prior efforts, commonly used features like RGB colors, entropy, number of trees, etc. were used to classify images for scenic beauty [1, 2]. The primary goal of this project is to expand the scope and use various signal processing techniques to extract more diversified information automatically from forestry images. Software is being developed for automated evaluation and modeling of forest structure. We anticipate the result of this effort will be a comprehensive collection of statistical modeling techniques that can be applied to modeling of visual changes in forest dynamics by season, year, and cutting practices.

During the first three months of this project, we have laid a firm base from which we will begin implementing algorithms for recognizing important objects from a forest scene. Most object recognition algorithms start by segmenting a digital image into smaller blocks for reduced computational complexity [4]. Thus we have implemented frame-based analysis of the images as a first step.

To study the benefits of using alternate color models instead of the more commonly used RGB scale, we have incorporated the NTSC YIQ scale (which is used in television broadcasts) as features into our PCA (Principal Components Analysis) classification system. The system was trained using the standard training set and was tested on a 160 image test set. Several interesting observations regarding the distribution of the YIQ in forestry images is worth a closer look.

We noticed that the I and Q (hue and saturation) values are concentrated in very a small portion of the possible range these features could occupy. This is demonstrated for I in Figure 1. Clearly the histogram depicts a non-uniform, Gaussian like distribution in a small range. If the YIQ values are extracted without taking this behavior into consideration, we run into intractable computational problems in PCA.

As a solution to this problem we compute the YIQ values on an exponential scale, and then generate a histogram of these values to determine their range. A histogram is recomputed using this range for the YIQ values. This however does not guarantee that all the bins in the histogram

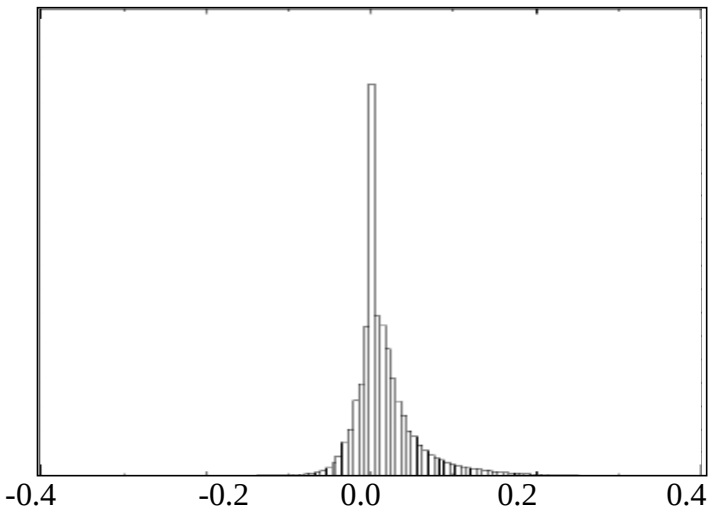

Figure 1.Histogram of I values in the USFS training data. Notice the narrow range of possible values occupied by actual data.

are non-zero. This could potentially cause matrix-inversion problems. Gaussian smoothing has been employed to alleviate this problem. The system which uses YIQ values alone as its feature set performed at 51% classification error. When compared to the system performance of 40% obtained using only RGB as features, one may conclude that YIQ may not be the best color model for scene analysis. However, further analysis is required to evaluate the efficacy of these features for scenic beauty estimation.

In [3] the effect of colors on scenic beauty was studied as a function of the season. In non-winter seasons, green and yellow were positively related to the scenic beauty of a forest scene where as blue and brown were negatively related. Blue and brown had maximum visibility in winter, yellow in fall, green in summer. Blue and brown colors reduced the scenic beauty whereas yellow and green enhanced them. From these results, it is evident that yellow and brown play a vital role in humans' perception of the scenic beauty of images. We are currently incorporating brown and yellow as features into the classification software.

We will soon start building object recognition capabilities into the software using two-dimensional hidden Markov models (HMM), a successful statistical paradigm used in several pattern recognition problems. Another interesting technique that will be applied to the current problem of object recognition is a machine learning paradigm called Support Vector Machines (SVM) [5]. The above mentioned techniques have been found to be very effective in face-recognition problems.

In summary, over the past 3 months we have created a framework for implementing object recognition algorithms to assist in the scenic beauty estimation of forestry images. An alternate chrominance-luminance color model, YIQ, has been used for the classification of images. The results indicate that YIQ model may not be a good replacement for the more commonly used RGB color model. The use of brown and yellow colors in estimating the scenic beauty of images is under study.

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