

## New Staff Scientist - Pano Spiliotis

In the spring of 1999 I graduated with a BS in Imaging Science. My plans were either to go on to graduate school or to obtain a job. Luckily, I was able to get both by working here at MCSL. I have been working since June of 1999 and have enjoyed every minute of it. My duties include general lab maintenance and in the upcoming year I will be involved with coordinating summer short courses facilities, taking over full responsibility of PC and Mac systems, and participating in marketing the graduate program. As an undergraduate, I had a chance to work with Dr. Arney on my senior thesis entitled *Multi-Dimensional Segmentation of an Oil Painting*. Below is the abstract and results of my experiment.

To identify artifacts in an oil painting, one must understand the painting and its properties. An art conservator is able to determine artifacts in a painting because he/she has knowledge of the techniques used in the construction. The art conservator uses different types of techniques to enhance discontinuities in an oil painting. These techniques include physical inspection, illumination with ultraviolet black light, infrared imaging, x-ray imaging and other traditional methods. While these techniques are individually useful in art conservation, they can be made more useful by advanced image analysis methods. This research uses multi-dimensional segmentation to improve the determination of discontinuities. Multi-dimensional segmentation is a procedure that has been used in medical and remote imaging, but rarely in the art world; it takes multiple images, identifies common information and

uses it to identify similar regions in the imaged object. Two images are sent through a multi-dimensional image segmentation routine to obtain image content of the physical object. We have determined and verified that segmenting certain areas of the histogram will reveal areas that are not original to the painting.

My results show that Figure 1 is a painting that is believed to be from the Renaissance Era. There was no documentation presented with the painting. The owner (anonymous) suspects the painting is from the European Renaissance and asked us to examine the painting. The boxed area was used for this experiment due to the evidence that it was cleaned in that area. Figure 2 and Figure 3 are a raking angle image and an infrared image taken of the boxed area in Figure 1, respectively. The 2 dimensional segmentation procedure proved to be very effective in segmenting an area with a discontinuity.



Fig. 1



Fig. 2



Fig. 4

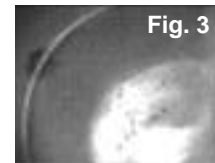


Fig. 3

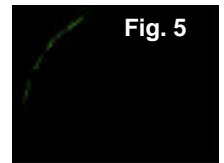


Fig. 5

tinuity. Figure 4 is an example of what the histogram looks like. The boxed area is the area used for segmentation. To verify this discontinuity, an art conservator was brought in to explain the probable history. Using his own knowledge of Renaissance paintings and the results of this research, he confirmed that a discontinuity exists in the painting. Looking at Figure 3, he acknowledged that a halo is present, but something was underneath that could not be identified. However, when looking at Figure 5.0 (with 2 dimensional segmentation), the underlying mark was revealed. With this information, he explained that in the past, halos were painted with gold, and when they were cleaned, the cleaning solvent would remove the gold. This would leave a mark on the painting. Then, the halo would be repainted. Therefore, this procedure revealed that the area examined is not original to the painting.

For more information visit:  
<http://www.cis.rit.edu/research/thesis/bs/1999/spiliotis/title.html>

# Texture and Color Tolerances

The MCSL has been actively involved in color difference research for improvement and evaluation of color difference formula for scientific and industrial use. In the recent years there has been increased interest in the research on parametric effects in color difference evaluations. The CIE Technical Committee 1-28 on parameters affecting color-difference evaluation has been established to coordinate research in this area. One of the potentially important parametric effects is the influence of texture.

Texture plays an important role in defining appearance of physical objects as well as images. However, very little is known about its effect on color difference perception. There are several aspects that underlie the problem. The databases that serve as a foundation for currently used color difference formulae are based on large fields of uniform color. However, very little is known about the usability of this model in predicting color difference of textured patterns. There are many materials with texture. Another important aspect that involves texture is metrology. Most quality control operations involve spectrophotometers as the primary instruments of color difference quantification. Texture appearance is very sensitive to both viewing and measuring geometry. The goal of my thesis was to study how texture may affect color difference judgments.

There two stages of this research. First stage was devoted to developing a technique for simulation of the appearance of real texture object on a CRT display. Three plastic texture samples of patterns used in automobile interior finishes were used as texture templates. The difference in appearance was modulated by varying illumination geometry. Two conditions were used: diffuse illumination of a standard light booth and directional lighting accentuating texture relief. These templates were used in two psychophysical experiments in the second stage of the experiment. For the first experiment only gray scale images of texture were utilized, whose average  $L^*$  was controlled on a cali-

brated CRT. For second experiment an array of color images was created from 3 texture patterns: one simulating diffuse lighting conditions and two images simulating directional illumination. Five groups of images were created with the colorimetric characteristics of each group around the 5 color centers recommended by CIE for color difference research for 10o observer. For each group, images with the difference of 1 unit  $DE^*94$  were. The difference refers to the average XYZ (and consequently  $L^*a^*b^*$ ) of the images. The images were chosen to sample along one dimension in the color space (lightness, chroma and hue), while maintaining other dimension values constant. The images were generated using a 3-D texture-simulation computer program written by G. Johnson of MCSL.

In the second stage of the research two psychophysical experiments were performed. The goal of the first experiment was to determine the ability of a human observer to make assymetrical matches between gray texture images and uniform fields on a CRT monitor. The observer had control via a mouse slider over the uniform field, whose brightness he/she was asked to match to the average perceived brightness of the texture image. The average  $L^*$  of the image was controlled by the experimenter. The results of showed that on average there was no statistically significant difference between the observer match and the average  $L^*$  of the image. The only exception was found for darker images of coarse texture. No deviation fro the average was found for fine texture of the same structure.

The second experiment was designed to investigate the effects of texture on the color difference perception. An adaptive psychophysical technique QUEST, which is based on two alternative forced-choice method was utilized to estimate tolerance threshold for 5 color centers mentioned above. The results demonstrated that the presence of a texture pattern increased tolerance for hue irrespective of the texture studied. The chroma dimension remained unaffected, while

high variability in the lightness data produced inconclusive results. When the textures were compared, it was found the  $L^*$  thresholds were significantly higher for the images simulating directional lighting compared to the images of diffusely illuminated objects. On the other hand, no difference in tolerances for chroma and hue was found.

In conclusion, the presence of texture increases color tolerances for Hue, while not influencing the perception of Lightness and Chroma. The illuminating geometry is an important viewing conditions factor in color difference evaluations of textured samples, whose influence cannot be assessed through conventional spectrophotometry.

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M.S., Color Science Candidate

## Roy & Koichi Receive Award



The Journal Award recognizes an outstanding contribution in the area of basic science, published in the Journal of Imaging Science and Technology during the preceding year.

The 1999 Journal Award (Science) is presented to Koichi Iino and Roy S. Berns for their scientific papers entitled "Building Color Management Modules Using Linear Optimization I and II" published in JIST, Volume 42, number 1, page 79 and Volume 42, number 2, page 99.