Diagnosis of Image Noise Using Mathcad

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Machine vision system performance can be degraded by various influences including camera noise, non-uniform or insufficient illumination and also illumination noise. This article describes how Mathcad[1] was used to analyze image data in order to diagnose an image noise problem.

Our vision system was a black and white video microscope which utilized coaxial illumination. The light source was a high power LED. A controller allowed the illumination level to be adjusted via computer control. The images exhibited subtle but objectionable scrolling horizontal lines.

After simple tests were performed to eliminate the camera as the source of the lines, the illumination subsystem was investigated. The first test performed was to measure the stability of the illumination by using a photodiode in front of the illumination source LED. Examining the photodiode signal on an oscilloscope revealed a 1 kHz signal. Although unexpected, it was still not clear that this was the cause of the scrolling lines in the images.

To investigate the correlation between the 1 kHz illumination noise with the lines found in the image, the illumination was set on the system so that the scrolling lines appeared while imaging a sample which also had a uniform region extending from the top to the bottom of the field of view. The presence of this uniform region would serve to simplify data subsequent data analysis. A bitmap file was saved of this image. The bitmap was then analyzed using Mathcad.

The goal of the Mathcad analysis was to determine if the frequency of the noise component measured from the light source matched the frequency corresponding to the scrolling lines in the image. A vertical intensity profile of the image was extracted and plotted, then, the horizontal axis of this plot was converted from pixels to seconds since the frame rate and sensor size of the camera were known.

Figure 1 shows the top region of the Mathcad worksheet utilized. The image was loaded into an array which allowed the individual pixels to be addressed. A cursor was drawn over the image to indicate where the profile was plotted from.

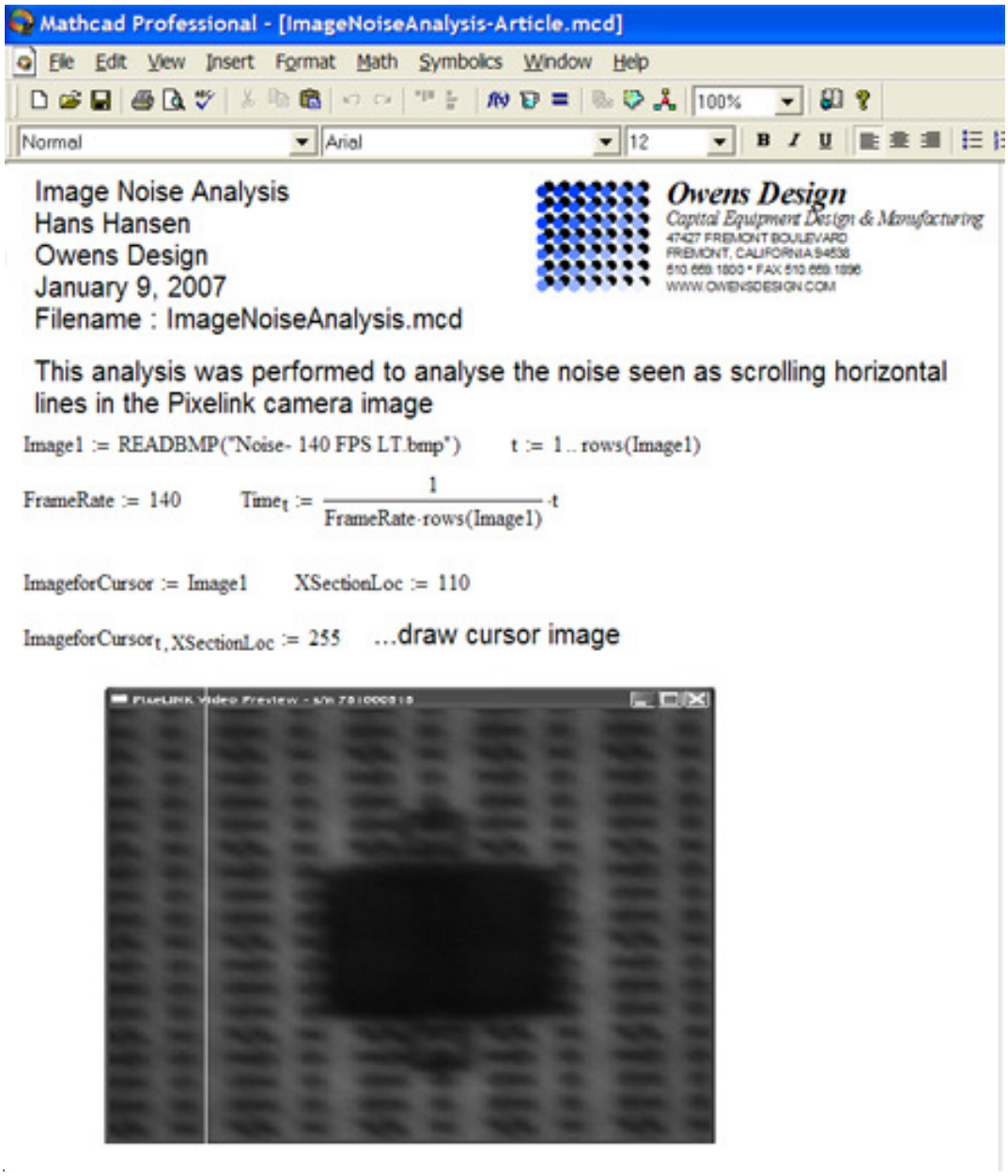

Figure 1. Mathcad Worksheet, Top Region
The vertical cursor indicates source of analysis profile to be plotted. The absence of sample structure at this location meant deviation in the profile was due to other effects.

The correlation between the signal found in the image and measured from the illumination LED using the photodiode was good, as can be seen in Figure 2.

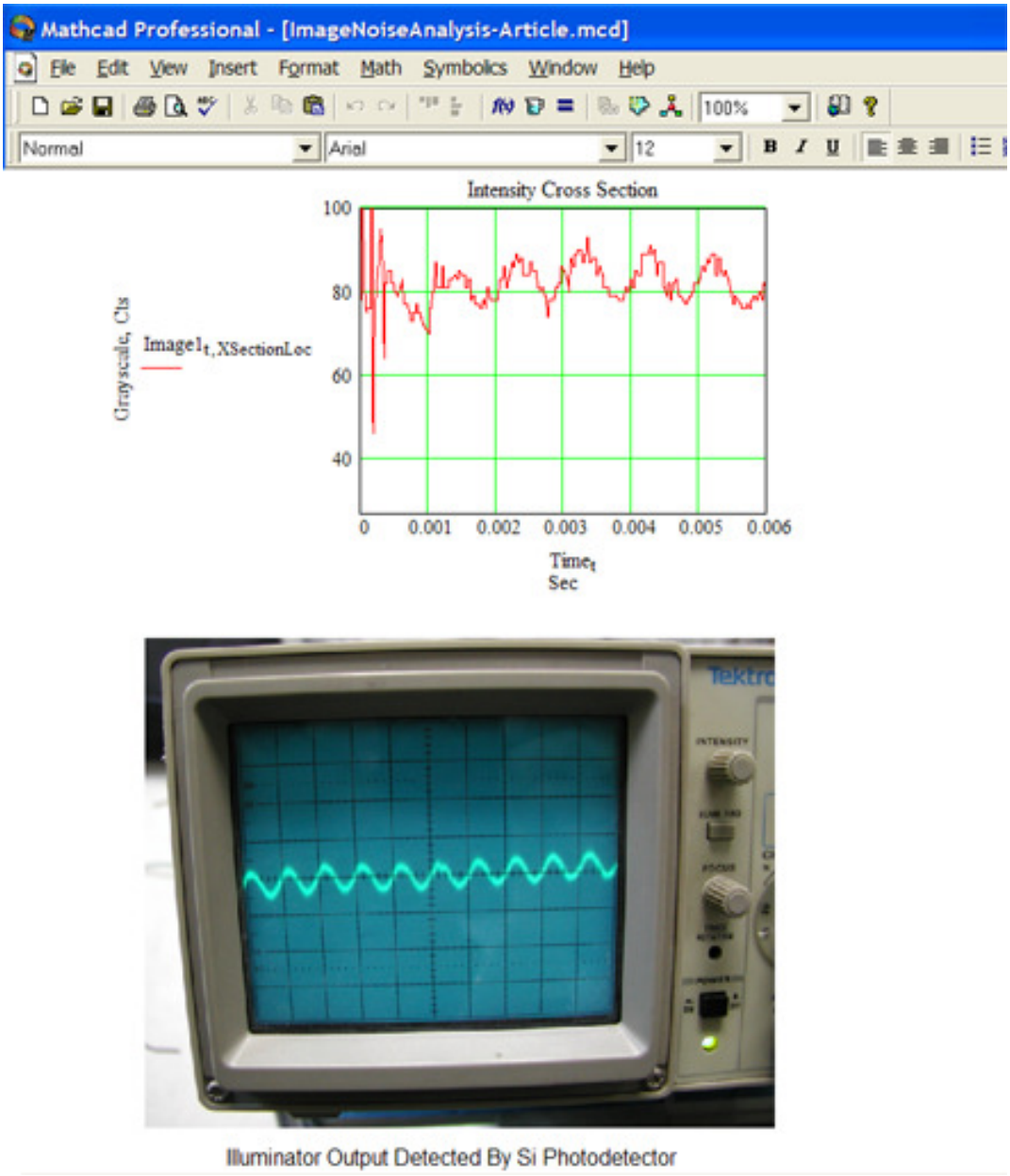

Figure 2. Mathcad Worksheet, Bottom Region
Image profile at cursor location and embedded photo of LED
Photodiode oscilloscope trace. The perturbation at the beginning
of the profile was due to the text at the top of the bitmap.

The LED controller was subsequently modified to eliminate the frequency component and then the same analysis technique was repeated to ensure that it was completely eliminated from the image. Mathcad provided a simple means of analyzing the image and displaying the data used in the analysis. Although this analysis was done with black and white images, it could easily be extended to work with color images. In this case it would be possible to examine the RGB channels individually if desired.

[1]*Mathcad is a copyrighted name of PTC.*

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