Monitor and Map Vegetation Dynamics

Preliminary Report
Client: Aaron Moody

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         Michael Smith
The Project:

Our overall goal is to develop a product which will track spatial and temporal patterns of vegetation from satellite data.

Our client receives monthly digital satellite images of specific areas of land containing vegetation. The image is scaled so that each pixel represents an area of land (e.g. 1 pixel = 1 km²). A Fourier Analysis tool is used to analyze the satellite image. This is used because it provides a summarization of the temporal signature and while sensitive to systematic changes in vegetation, it is relatively insensitive to data noise. Also the higher order harmonics from the resulting Fourier decomposition may capture such details as rapid surface changes associated with disturbances such as fire and deforestation.

The resulting Fourier decomposition yields an image where the color of the pixels is representative of the vegetation in the corresponding area. Images are taken of the same area over time periods (such as monthly for a year). Each image is called band. Our client would like to be able to track all the pixels from an image, a group of pixels or a single pixel over the twelve bands and thus observe the change in the vegetation over time. The pixel or group of pixels would be plotted on a polar coordinate graph where the distance from the center represents amplitude and the phase represents time of year. It would be helpful if an additional vector was then plotted between the variance in the pixel.

Our client currently uses two separate in house software tools: IPWTtool, a Fourier analysis tool. IPWTtool is used to view the satellite images, the Fourier tool is a command line program which executes a Fourier transformation on the pixels of the entire image. To construct the polar coordinate graph he uses S+. The satellite image is stored in a 2 dimensional array and each band is interleaved (see sketches below) either serially one band at a time, using row order interleaving or one array entry at a time from each band. The most laborious task is the graph which uses S+. Our client would like to eliminate S+ and have a single interface from which one could view the images, call the Fourier analysis and plot the polar coordinate graph. Currently the Fourier analysis tool will only work on an entire image and it would be preferable if one could select a single pixel.
Each band represents a single image. Each image is of the same area but from a different time. Pixel(s) will be taken from the bands and mapped onto the polar coordinate graph. The picture shows the typical way in which bands may be viewed in IPWTool. Currently IPWTool allows only three bands to be displayed at a time.

Image data is represented in a 2 dimensional array. Using the 2 sample arrays these are example of the interleaving:
1. serial interleaving
   would result in:
   123456789abcdefghij

2. row order interleaving
   would result in:
   123abc345def.......

3. The final alternative is:
   1a2b3c4d5e.......

Example of harmonics display where blue represents 1st harmonic and red represents 2nd harmonic.
## Product Features:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Rank (10★=required ; ★=fantasy)</th>
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<tbody>
<tr>
<td>1) Polar coordinate graph</td>
<td>★★★★★★★★★★★★ e</td>
</tr>
<tr>
<td>2) Linking Fourier analysis to graph</td>
<td>★★★★★★★★★★★★ e</td>
</tr>
<tr>
<td>3) Display of first and second harmonics</td>
<td>★★★★★★★★★★★★ e</td>
</tr>
<tr>
<td>4) Plot a single pixel / group of pixels</td>
<td>★★★★★★★★★★★★ e</td>
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<tr>
<td>through time</td>
<td></td>
</tr>
<tr>
<td>5) Connect pixels from each band with a</td>
<td>★★★★★★★★★★★★ e</td>
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<tr>
<td>vector</td>
<td></td>
</tr>
<tr>
<td>6) Establish IPWTool as single main interface</td>
<td>★★★★★★★★★★★★ e</td>
</tr>
<tr>
<td>7) Re-write more elegant Fourier routine</td>
<td>★★★★★★★★★★★★ e</td>
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### Interface ideas / thoughts:

See sketches above. Our ideal interface would be to use the existing IPWTool and integrate the Fourier analysis tool and the polar coordinate graph so that IPWTool would serve as a single user interface.

### Package Options:

- **Plan A:** Items 1-7 (The ideal package. All client requests satisfied.)
- **Plan B:** Items 1-5 (A satisfactory package containing bulk of client requests.)
- **Plan C:** Items 1-3 (Core requirements satisfied)
Critical Path:

Plan A:
- Ensure software is received from Moody
- Learn TCL
- Familiarization with IPWTool as a user
- Review polar coordinates and Fourier analysis
- Demonstration from Moody of typical tasks (Feb 2\textsuperscript{nd})
- Specific file format of IPW files (header and binary)

Plan B:
- Ensure software is received from Moody
- Familiarization with IPWTool as a user
- Review polar coordinates
- Demonstration from Moody of typical tasks (Feb 2\textsuperscript{nd})
- Specific file format of IPW files (header and binary)

Plan C:
Same as B above

Schedules:

- Team meets weekly Thursday at 5pm.
- Biweekly meeting with client Friday at 3:30 pm, starting February 2.