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Student Internship Program Report

Organization 5712

Remote Sensing and Exploitation

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History

This is my third summer working at Sandia National Laboratories in organization 5712. I am a physics major at Reed College in Portland, Oregon. My work at Sandia began during my senior year at Eldorado High School, when I worked part time and received school credit for participating in the internship program. During that time and two ensuing summers I worked on a variety of projects. These experiences included testing a number of optical-electronic systems, performing such tasks as determining the spectral responsivity of photodiodes and placing optical/electronic systems in front of a variety of light-sources in order to generate calibration curves. I also contributed to the computer generation of data to model a hypothetical satellite-mounted detection system using SSGM (Synthetic Scene Generation Model) and the Khoros visual programming software Cantata on a UNIX operating system. Other experiences included pre-flight satellite testing, and work in the field deploying a suite of sensors and data collection equipment in Nevada.

Current Task Overview

This summer I am involved in image analysis using the software development tools of the Khoros programming environment. I am working on a project whose goal is to identify superimposed spectra obtained from remote-sensing equipment. The spectra to be identified are those of chemical warfare agents and precursor chemicals from the industrial processes used to manufacture them. Identifying these spectra is a challenge when they are mixed with each other and with incident light from the ground and atmosphere--photons that are both reflected from the sun and emitted as blackbody radiation. In order to model this process, I am working on a Khoros program that will add noise to laboratory-obtained spectra from a variety of chemicals. This altered data will mimic what a remote sensing device is likely to record in the field. Given this example of likely field results, developing an ideal sensor and a method to identify spectra from such data will continue for a number of years.

Technical

The data generated by various proposed remote sensing instruments is in the form of a hyperspectral cube, which is a spatially 2-dimensional image where and each pixel consists of a full spectrum (sampled contiguously). The result is a 3-dimensional image. A 'push-broom' type instrument that images one spatial pixel line at a time produces this image (similar to a scanner or copier). While a typical push-broom device images each spatial line with a single line of pixel elements, the hyperspectral device smears the image spectrally with a diffraction grating and then images with 2-dimensional pixel element array instead. Thus each spatial line becomes a 2-dimensional image with spectral data, and these are stacked together to produce a hyperspectral image. The desired Khoros program will take this image and add noise dependent on atmospheric transmission, sensor specifications, and electronics' characteristics.

The Khoros environment is a suite of programs arranged in a predictable architecture and the ability to handle a wide variety of image types. The default data operators and image viewers can handle images that fit within the description of the "polymorhic data model." This can include location, time, 'value' (e.g. gray-level), 'mask' (marks validity of specific pixels; in my case this could mark water-absorption regions of the spectrum as 'bad'), and 'map' data (e.g. mapping a 256 'value' range to an RGB map of 256 colors). The various operators can, therefore, easily handle a hyperspectral image cube. The predictable architecture bundles the programs together in 'toolboxes' that allow for the easy addition of functionality by linking programs together. Programs are written in the C language.

Chronology

When I first arrived this summer, the nature of my tasks for the next 2 ½ months were yet to be determined. On my second day working at Sandia, I attended a meeting of the various engineers who were shaping this program. At this point the technical specifics of the remote sensing device were being debated and the goals of the project were in question, and it was eventually decided that more research would need to be done into what type of system would perform best. I eventually became involved in an effort to model the noise of such systems, an important step for the continued development of a requisite sensor. Since then, I've spent the majority of my time learning the basics of image processing, Khoros programming, and understanding the methods used in similar systems to analyze data. Researching the basics consumed a great deal of time, but has been necessary to understand the tasks at hand. This includes gaining knowledge of various digital formats and how, mathematically, one can perform manipulations to yield information about the image. This gave me the ability to understand papers that describe methods used by engineers on this and other projects to process multispectral data. Since then I have been learning to use the Khoros environment to implement the desired noise addition. A similar project was undertaken a number of years ago, and the result was a Khoros toolbox that operates in a fashion similar to what I need. I am currently attempting to alter this toolbox to fit the desires of my employers.

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