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Extraction of Auxiliary Data from AVIRIS Distribution Tape for Spectral, Radiometric, and Geometric Quality Assessment

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1. INTRODUCTION

Remotely sensed data are affected by system (sensor and platform), and scene related effects. For quantitative investigations the spectral, radiometric and geometric characteristics of the system and scene have to be known.

The relevant effects and their possible influence on an image have to be specifically determined for every remote sensing system and adequate description parameters need to be updated and reported on a regular basis (Teillet, 1992) as they are carried out, e.g., for the AVIRIS system (Vane et al., 1988, Chrien et al., 1990, Chrien et al., 1991, and Chrien, 1992). It is evident that the strength of the influence of similar effects is very dependent on the accessibility of auxiliary information about such sensor systems. Degradation in a spaceborne system can normally be just reported and cannot be corrected. In contrast, an airborne sensor can be evaluated, maintained and improved periodically. Such maintenance efforts are particularly important because airborne systems are exposed to extreme and changing environments. These include tens of takeoffs and landings each year as well as extreme changes in temperature and humidity on the tarmac and in flight.

For the AVIRIS system there are environmental stresses such as changes in temperature, air pressure, humidity, vibration of the platform or scene-related reasons like atmospheric conditions, and topography. The information contained in the auxiliary files included with the AVIRIS data can be used to assess these effects and compensate for them. In addition, the spectral, radiometric and geometric calibration data contained in the auxiliary file are required for quantitative analysis of the data.

The paper describes tools to access the auxiliary information that characterizes the AVIRIS system. These tools allow the examination of parameters that may impact the quality of the measured AVIRIS image. An example of the use of this auxiliary data was carried out with regard to a parametric geocoding approach as reported by Meyer (1993). Emphasis is placed on the reported auxiliary information that describes the geometric character of the AVIRIS data in 1991. Results are presented using data from the AVIRIS flight #910705, run 6 and 7 of the NASA MAC Europe '91 campaign in a test site in Central Switzerland.

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2. THE IPSRS TOOLS

The tools are part of the quality assessment module of the Information Processing System for Remote Sensing Data (IPSRS) as initially reported by Meyer (1992) and Meyer and Itten (1992). The IPSRS approach proposes two parts, information extraction and information management, to complete processing of remotely sensed data. The first part consists of the modules' data quality assessment and preprocessing and the latter of the modules' classification and presentation.

Table 1 shows the currently available tools. These are implemented with IDL (Interactive Data Language, a proprietary language of Research System Inc. (1993)). All programs run in the foreground and have a user-friendly interface. There is the possibility to select the tools out of an overview using pop-up menus (tools.pro) or let the tasks run as a single function. All results are presented with plots (black and white and some of them in color) that can be printed to a Postscript laser printer. Additional parameters can be derived from the auxiliary data set such as pre-calibration, post-calibration (1992, 1993), dark current, offset, noise equivalent radiation (1990, 1991), noise spike replace list, spike threshold (1992, 1993), dropped line list, and geometric calibration (1992, 1993).

3. RESULTS FOR THE CURRENT DATA SET

Some plots out of the examination of the data set are presented in Figures 1-4.

Figure 1: Spectral response function full width at half maximum (FWHM) of the corresponding Gaussian function. These response functions are required to compare other spectral data with AVIRIS measurements.

Figure 2: Altitude measurements of the 1991 navigation data, based on barometric measurements, compared with the values of the ADOUR system for run 6. The ADOUR is a high-precision, dual-antenna, dual-frequency, ground-based conical radar tracking system operated by the Swiss Army (Meyer, 1993). The systematic error for the ADOUR system for elevation and azimuth is ± 0.2 mrad and for distance ± 7 m. These requirements could be confirmed for the current data set (Meyer, 1993). Accepting the ADOUR measurements to be a good representation of the reality, the plot proves that the deviation of the altitude for the navigation data is within the expected range, which is for an unaided LTN90-116 Inertial Navigation System (INS) 0.9 nmi/h (Perrin, 1993).

Figure 3 and Figure 4: Comparison of navigation roll and the instrument roll for run 6 and run 7: When the pilot begins recording AVIRIS data the sensor gyros are initialized as horizontal. Occasionally, due to aeronautical reasons, the ER-2 aircraft is not fully leveled at this time. This offset affects the quality of roll correction for the entire flight line. Figure 3 shows that the aircraft was almost levelled and that during the whole flight the possible range of $\pm 1.5°$ was never exceeded. For run 7, a large offset was present at the initialization time and caused a saturation of the roll gyro after line number 451 (Figure 4). For this flight, the saturation of the roll gyro rendered investigation of the aircraft roll at high precision impossible. Fortunately, saturation of the roll gyro occurs only rarely.

4. OUTLOOK

Beginning in the 1992 flight season, the ER-2 INS was using a GPS-based system. Test results of a similar configuration show excellent results with an accuracy of 7.05 ± 21.34 m (Perrin, 1993). These changes will make it possible to define the flight line and reconstruct the observation geometry of AVIRIS as a basic requirement for a parametric geocoding approach.

5. ACKNOWLEDGMENTS

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Table 1: Available ISPRS tools for quality assessment for AVIRIS data.

Data characteristics	ISPRS tool name	Description and remarks
Spectral		
Central band position	CentBandPos.pro	Band center wavelength [nm].
Spectral response function FWHM	Bandwith.pro	The full width at half maximum of the spectral response function (assumed to be Gaussian) [nm].
Radiometric		
Radiometric calibration	RadCor.pro	Multipliers determined in the laboratory for converting DN values to units of radiance.
Vignetting	CTVignetting.pro	Factors to correct for differences in the instrument's cross-track sensitivity.
On-board calibration	Onboardcal.pro	Numbers that are the on-board calibration high-intensity position response in DN.
Geometric		
Velocity	NavRead1.pro	N-S, E-W velocity, true air speed, vertical velocity, and ground speed reported by the aircraft inertial navigation system (INS) [m/s].
Location (INS)	NavRead2.pro	Longitude, latitude, altitude of the aircraft, reported by the aircraft INS system [degree].
Attitude (INS)	NavRead3.pro	Navigation roll, pitch, and true heading, reported by the aircraft INS [degrees].
Instrument's roll compensation	EngRead2.pro	Instrument roll with 11 symmetrically distributed readings per scanline reported by the AVIRIS instrument's rate gyro; values need to be within range of $\pm 1.5°$.
Instrument's pitch	EngRead3.pro	Instrument pitch value with 11 symmetrically distributed readings per scanline reported by the AVIRIS instrument's rate gyro [degree].
Instrument's mirror rotation	EngRead4.pro	Linearity count for the mirror rotation with 11 symmetrically distributed readings per scanline.
Quality assessment of the auxiliary data		
Roll	NavAnal4A.pro	Comparison between the navigation roll with a selected reading of the instrument roll.
Pitch	NavAnal4B.pro	Comparison between the navigation pitch with a selected reading of the instrument roll.
Altitude	NavAnal3A.pro	Comparison between the navigation altitude and the corresponding information of the high-precision, dual-antenna, dual-frequency, ground-based conical radar tracking system ADOUR (Meyer, 1993).
Ground speed	NavAnal3B.pro	Comparison between the navigation ground speed and the corresponding information of the ADOUR.
True heading, yaw, central mass direction	NavAnal5A.pro	Calculation of the yaw and central mass direction using the N-S, E-W velocity, and the true heading of the navigation data.

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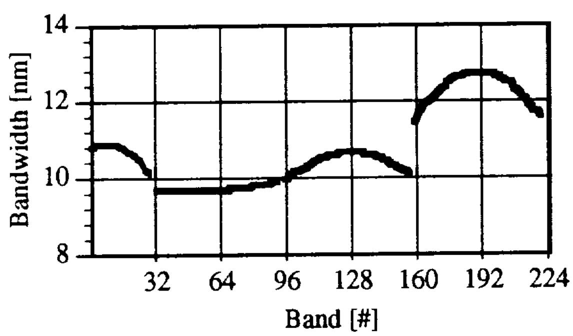

Figure 1: Spectral response function FWHM

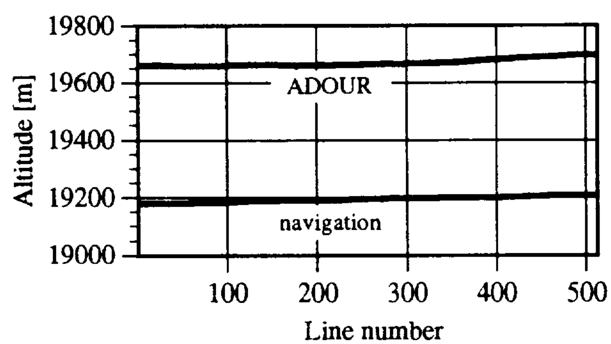

Figure 2: Altitude comparison between navigation data and ADOUR data.

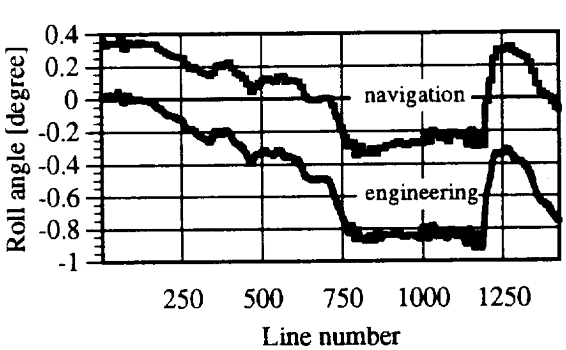

Figure 3: Comparison of navigation roll and instrument roll for run 6.

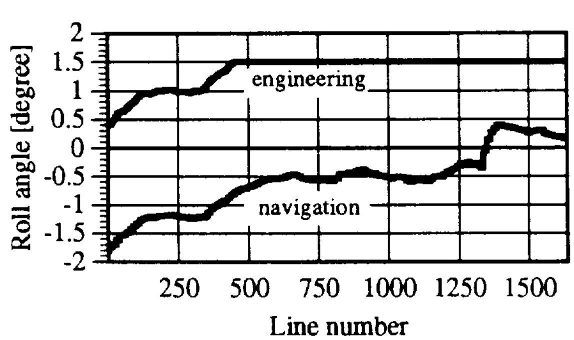

Figure 4: Comparison of navigation roll (thin line) and instrument roll (thick line) for run 7.