SIMULATION SYSTEM DEVELOPMENT OF INFRARED REMOTE SENSING IMAGES:HJ-1B CASE

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1. ABSTRACT

Abstract: Satellite image simulation is one of the key methods to check the expected performance of the satellites before they launched or when satellites can not provide images in other time. In order to provide a useful tool to analyze whether the payload of HJ-1B (a small satellite of the environment-monitoring constellation) is enough, we develop a simulation system for the infrared cameras, which consists of four bands including NIR band (0.75-1.10μm), SWIR (1.55-1.75μm), MIR (3.50-3.90μm) and TIR (10.5-12.5μm). The spatial resolution of NIR and SWIR band is 150 meter, while 300 meter for the MIR and TIR band. The sensor is an optical-mechanics multi-scanning system with maximum scanning degree of 29 degree.
The image simulation system consists of four main modules: 1) surface radiation transfer models including PROSPECT, SAILH, CUPID, GOMS model and etc; 2) Atmosphere transfer model MODTRAN is used to build simpler equations and setup Look Up Tables for different sun-viewer positions; 3) Sensor models including spectral response model, geometrical distortion model, MTF response model, noise model and A/D model; 4) Potential application models including the fire monitoring model and drought assessment model. We first use ASTER Products (one scene in Beijing, China, 2001.5.19) and ground measure data (2001, SHUNYI, Beijing) to get the ground true knowledge such as the land use map, vegetation cover and LAI and so on. We divided the land cover into 5 main classes: crop, forest, urban, rural residential area and water and inversed importance parameter for surface radiation transfer models according to their classes. Lacking of accurate BRDF models for urban, we have to adapt GOMS model to inverse urban and rural building density and height. For plant-soil system, we choose CUPID model (Norman, 1979) to simulate directional brightness temperature. For urban and rural area, we used statistics model to predict component temperature, e.g. the building temperature and road temperature, and used adapted GOMS model to simulate the angle effect of brightness temperature. Taking into accounts of the temporal importance, we maybe make use of new model based on physiology, physics and chemistry to inverse indispensable parameters in different time which are input above models, such as LAI, water content in soil and so on.
Among the four bands, the MIR range image simulation is the most difficult task because we have to consider the reflectivity and emissivity. We haven't found the published case to simulate the MIR band so far. We used Extended SAIL model and jerlhoff law for infrared range to simulate emissivity and BRDF for plant-soil system. For other classes, we didn't account for the directional effect in MIR band at present time. At present, we have finished the simulation system using Microsoft Visual C++ 6.0. The system was well designed because all modules are relatively independent, and easy to be extended. It can well describe the angle-dependant effect due to the swing of scanning system. For example, from the simulated image, we can find the "double eye" phenomenon at the edge. Also, the MTF blurring is significant. The potential application models are still under development. At the next step, we will make the simulation system general for different infrared sensors, different temporal images.
Keywords: Satellite image simulation, HJ-1B, infrared, simulation system

2. METHODS

The workflow of simulation starts from simulating land surface scene, atmospheric effecting scene to sensor responding and imaging (see Fig.1). We mainly present the technology frame to aim at key technology and to select utility algorithm to simulate four infrared bands of HJ-1B.The process of simulation is composed of a few scene.
Land surface can be classified with 4 types:(1)vegetation;(2)bare soil area;(3)inner water and (4) urban area. The simulation of surface scene is used to retrieve surface reflectivity and emissivity and temperature parameters according to different land

cover types based on suitable models. There are PROSPECT, SAIL, ESAIL and CUPID Model which can be used to simulate top of canopy reflectivity and emissivity and temperature.

MODTRAN be considered best model to compute atmosphere radiation transfer. However, MODTRAN will cost a lot of our time if we calculate each pixel atmospheric parameters in huge image using its standard running mode. Generally, we regard atmospheric condition same as in each image scene. Based on this postulate, we can adopt a simple and approximate algorithm to compute a group of atmospheric parameters for each image. Bach (1995) approximated the LOWTRAN7 with 4 streams. De Haan and Kokke (1996) approximated MODTRAN3. Verhoef (2002) approximated MODTRAN4 and calculated 6 atmospheric parameters. In this paper, we select same approaches according to atmosphere radiation transfer model in different infrared bands.

The synthetical response for sensor during of imaging process can be considered as a MTF (Modulation Transfer Function).Due to sensor parallel scanning, each scanned pixel in the image has a projective center. Taking into account multi-centered projection, we can utilize collinearity equation in photogrammetry to simulate the CCD spatial response. Certainly, we assumably think that the speeding of sensor platform is stable and image spatial resolution is not changed.

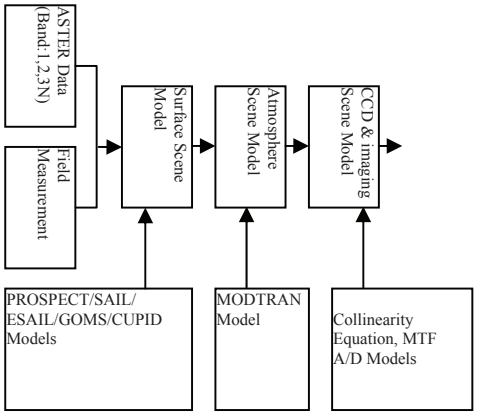

Figure 1. The workflow of HJ-1B images simulation

3. REFERENCES

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