Research on 3D Canopy's Reflectance Model Of Semi-arid Grassland

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Abstract:

A model for light interaction has been developed to compute bidirectional reflectance from realistic 3D canopies approximated by an arbitrary configuration of plants. It can well simulate multi-spectral reflectance of semi-arid nature grassland.

Semi-arid grassland is an important natural resource in China, so the monitoring of semi-arid grassland is very necessary to the protection of terrestrial ecosystems .The current development of remote sensing technology can provide improved spatial and spectral resolution of remote sensing data, which are valuable tools for grassland monitoring. The remote sensing technology requires robust theoretical canopy reflectance models, which can describe the complex process of the radiative transfer within canopy (Goel, 1992). In this paper, a suitable 3D canopy's reflectance model will be introduced .It can describe directional reflectance properties of semi-grassland canopies in terms of canopy architecture parameters and optical scattering properties of discrete phytoelements.

A realistic grassland scene is generated. Effectively and efficiently representing realistic structures of grassland is a prerequisite to study the radiation regime of grassland canopies. So, it is important to render 3D vegetation scenes accurately. The algorithms to render simulated realistic grassland canopies are based on CLAMP model (The Clumped Architecture Model of Plants) (Rochdi et al., 2002). Of this model, grassland canopy is represented by three-dimensional objects or clumps of vegetation distributed over a background. CLAMP model is designed to universally describe vegetation canopy through a few key agricultural structure parameters (plants density, LAI, LAD and coefficient of extinction), which can be adjusted according to the specific types of vegetation, so the model is adapted to accommodate,

with a high flexibility.

The visibility and brightness of the scene objects are determined after creation of 3D canopies scene. Given a specified geometry, the way to determine the visibility and brightness of the objects is the reverse ray-tracing procedure method (Gerard and North, 1997), which is introduced as follows. Assuming leaves as double-Lambertian objects, scenes are separated into small grids. Given a direction, a ray is traced from the sensor, and then cast towards canopy. When the ray hit a grass leave, the cover types are determined as grass leave, otherwise, grass plane. If the intercepting object is a grass leave, the cell grid also retrieves the downward distance traveled through the canopy. Then, the ray is redirected towards the sun, when the ray hits another grass leave, the cell grid is labeled as shadowed, otherwise illuminated. Four components of 3D canopy scene are obtained (illuminated leaves, illuminated ground, shadowed leaves, and shadowed ground) by above introduced method. An index is assigned a value representing one of four components. By assigning these values to the initial grid cell from which the ray was traced, a two-dimensional shadowing pattern for the scene is generated. So we can accurately get four components at the sub-leaf level.

Based on Geometric Optical principle, the canopy's reflectance is calculated as the linear combination of four components with their corresponding reflectance. Amongst, the leaves and soil reflectance are given by field-measured data, obtained in the field experiment in Sept. 2009. The experiment was performed in Gongge'er prairie, Keshiketeng Qi, Chifeng City, Inner Mongolian Autonomous Region, China. The field observation instrument we took was a portable field ASD spectroradiometer. Its selected wavelength range is 350 nm to 2500 nm, and its spectral resolution is 1nm.

The accuracy of 3D canopy's reflectance model is validated by comparing with HJ satellite data at synchronous time. The results reach a good agreement and their RMS are 6.1%, 4.2%, 3.7%, 8.9% at four bands respectively, the precision of 3D Canopy's reflectance model can meet requirement of research work. What's more, sensitivity validation studies are presented. The strategy shows potential influence factors attribute on observed BRF, such as LAI (leaf Area Index), a key parameter in agriculture and ecology. In order to study the LAI influence on grassland canopy's BRF, LAI are set as 0.50, 1.00 and 3.00, and the other input parameters are fixed. From the comparison, we can conclude that, at the red-band, the greater the LAI value is, the lower the canopy's reflectance value is. This phenomenon is due to red light is easily absorbed by leaves. On the other hand, at the near-infrared band, the trend is just opposite, the greater the LAI value is, the greater the canopy's reflectance value is. This is largely caused by leaves' strong reflection at near-infrared band.

We have developed a 3D canopy's reflectance model that parameterizes the reflectance of semi-arid grassland canopies from optical properties of leaves and soil. Based on the realistic 3D grassland scene generated by CLAMP model; A reverse tracing method is used to compute four components of the scenes; The canopy's reflectance is calculated by computing four components with their corresponding field-measured reflectance as the linear combination principle; The results show that the model is suitable for simulating semi-arid grassland and describing the physical phenomenon. The 3D canopy's reflectance model will find interesting applications in a number of domains, e.g., retrieving meaningful properties of natural grassland such as canopy cover and LAI; considering simulating canopy's reflectance as the field measured data under certain conditions.

Keywords: Semi-arid Grassland; 3D canopy scenery; computer simulation; CLAMP; canopy's reflectance; field measured data; HJ satellite

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