An End to End Hyperspectral Scene Simulator with Alternate Adjacency Models and Its Comparison with CameoSim

I. Introduction

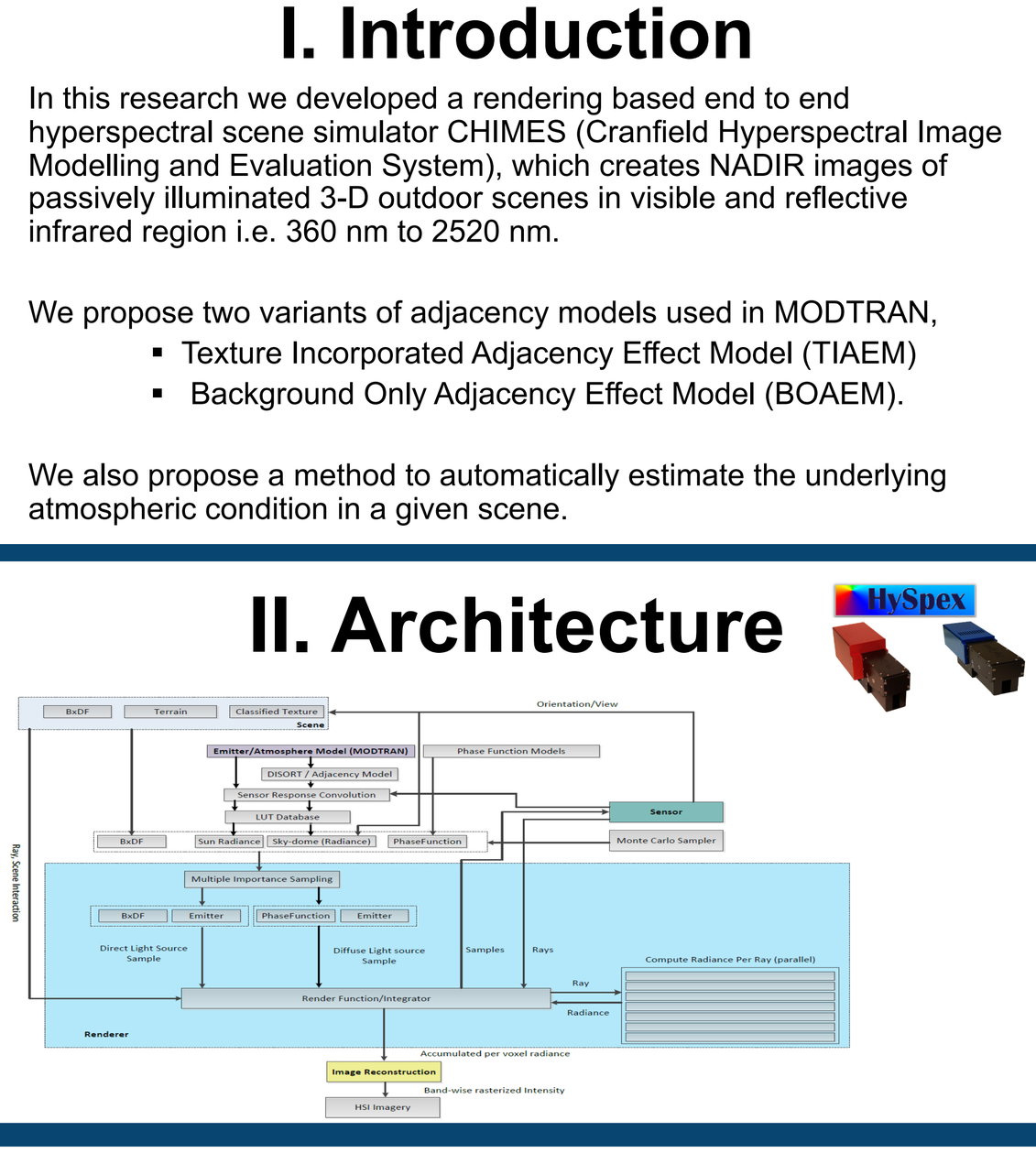
In this research we developed a rendering based end to end hyperspectral scene simulator CHIMES (Cranfield Hyperspectral Image Modelling and Evaluation System), which creates NADIR images of passively illuminated 3-D outdoor scenes in visible and reflective infrared region i.e. 360 nm to 2520 nm.

We propose two variants of adjacency models used in MODTRAN,

- Texture Incorporated Adjacency Effect Model (TIAEM)
- Background Only Adjacency Effect Model (BOAEM).

We also propose a method to automatically estimate the underlying atmospheric condition in a given scene.

II. Architecture



III. Method

Rendering Equation and Types of photons

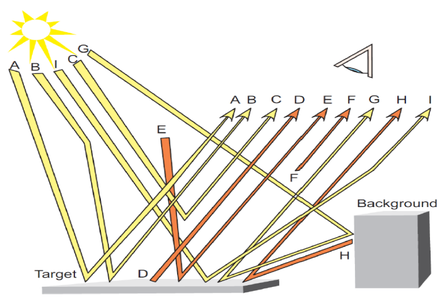
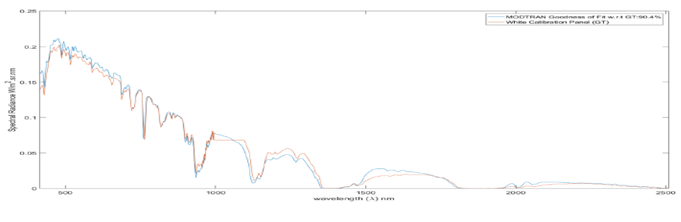


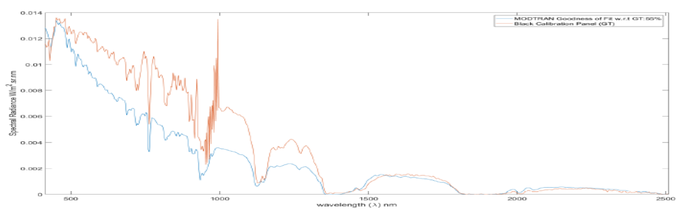
Figure 2. DIRSIG big equation components [12,24]

$$L(\lambda) = \tau_2(\lambda)\Big\{\underbrace{\frac{E_s^t(\lambda)}{\pi}\tau_1(\lambda)r(\lambda)\cos\sigma}_{\text{reflected sunshine}} + \underbrace{\epsilon(\lambda)L_T(\lambda)}_{\text{thermally emitted}} + \underbrace{\rho(\lambda)F\Big[\frac{E_{ds}(\lambda)}{\pi} + \frac{E_{dc}(\lambda)}{\pi}\Big]}_{\text{reflected sky}} + \underbrace{r_d(\lambda)(1-F)\Big[L_{bs}(\lambda) + L_{bc}(\lambda)\Big]}_{\text{reflected background}}\Big\} + \underbrace{L_{us}(\lambda) + L_{uc}(\lambda)}_{\text{atmospheric path radiance}}$$

Atmosphere search by varying optical depths $\delta = \frac{3C_w R}{2\rho r}$



(a) White Panel Estimation



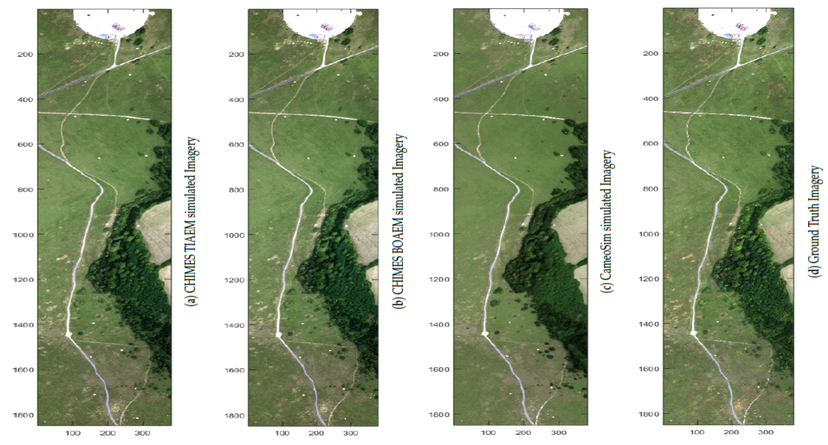
(b) Black Panel Estimation

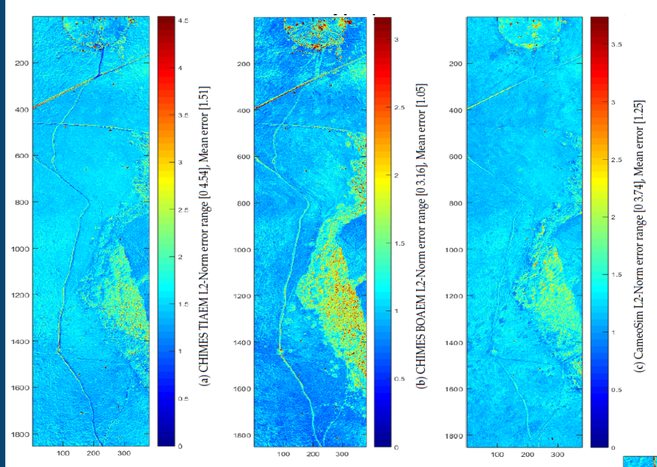
Searched Atmospheric Parameter for aerosol:

Cw = 0.22 gm/m^3
R = 0.024 Km

IV. Results and Evaluation

RGB image of simulated scene



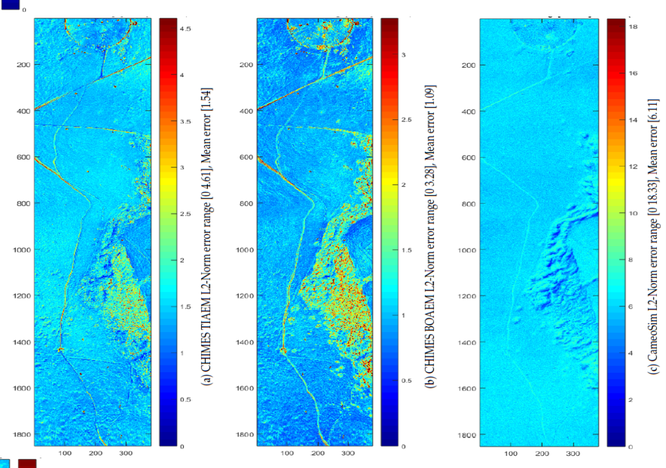


WITH CLOUDS:

L1-Norm Error of Simulated HSI Images w.r.t. GT (Flat Geometry)

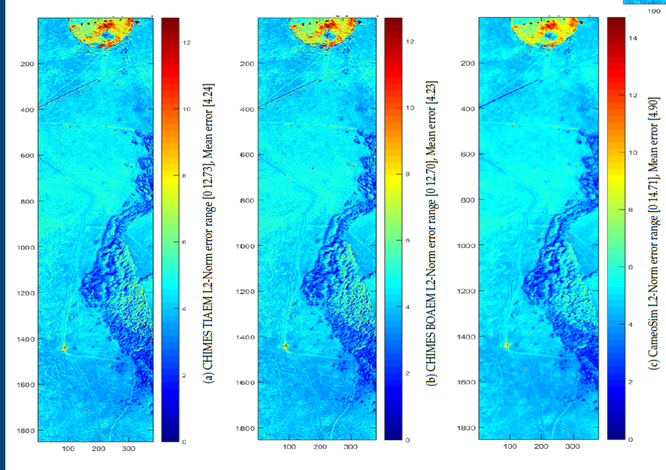
WITH CLOUDS:

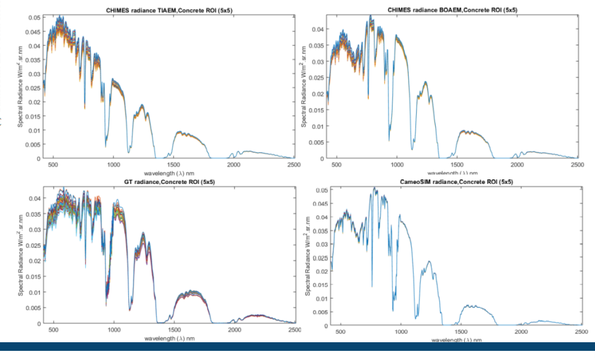
L1-Norm Error of Simulated HSI Images w.r.t. GT (DEM Geometry)



CLEARSKY:

L1-Norm Error of Simulated HSI Images w.r.t. GT (Flat Geometry)





CHIMES TIAEM produces better radiance signature shape in VNIR region compare to BOAEM and CS.

V. Conclusion

- **CHIMES BOAEM produces better results compared to CameoSim in all simulations**
- **CHIMES TIAEM produces better radiance signature shape in VNIR region compare to BOAEM and CameoSim.**
- **CameoSim yields larger L1-Norm error when DEM geometry is introduced.**
- **CHIMES BOAEM has least error even when DEM is used.**
- **All three models are close to each other when Atmosphere is clear-sky.**
- **The atmospheric search yields radiance of a simulated white panel which matches 90% with in-scene white panel.**

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CHIMES
Cranfield Hyperspectral Image Modelling and Evaluation System