Sensitivity of different methods for simultaneous evaluation of emissivity and temperature through multispectral infrared thermography simulation

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This study focuses on the simultaneous evaluation of temperature and emissivity with multispectral infrared thermography (IRT). It leans on the study and development of an IRT simulator able to address 3D scene in static or dynamic configuration. The sensitivity of 4 different temperature and emissivity joint estimation methods are then evaluated.

**Results**

Comparison of 4 methods to estimate simultaneously emissivity and temperature through multispectral infrared thermography simulation

**Introduction and nomenclature**

**IRT Simulator through the radiosity method**

- **View factor**
  - Geometrical coefficient for radiative exchange between two diffuse elements
  - $F_{A_1 A_2} = \int_{A_1} \frac{\cos(\theta_1) \cos(\theta_2)}{\pi r^2} dA_1 dA_2$

- **Radiosity equation**
  - $B_{k, \Delta \lambda_i} = M_{k, \Delta \lambda_i} + (1 - \epsilon_{k, \Delta \lambda_i}) \sum_{j=1, j \neq k}^{N} V_{k j} F_{k j, \Delta \lambda_i} \Delta \lambda_i$

**Temperature and emissivity retrieval**

With Bouguer’s law and for infinitesimal surfaces:

$$E_{\text{sensor}, \Delta \lambda_i} = \frac{\Theta_{\text{source}, \Delta \lambda_i} \cos(\Theta_{\text{sensor}})}{\pi^2} \cos(\Theta_{\text{source})} d\Theta_{\text{source}} \Delta \lambda_i$$

$$\Rightarrow$$

Undetermined system with $\epsilon_{\Delta \lambda_i}$ and $T$ unknowns

$$E_{\text{sensor}, \Delta \lambda_i} = \int T^4 \frac{\epsilon_{\Delta \lambda_i}(\lambda) \cos(\Theta_{\text{source}})}{\pi^2} \cos(\Theta_{\text{source})} d\Theta_{\text{source}} \Delta \lambda_i$$

**Non linear optimization**

$$\arg\min_{\lambda} \sum_{k=1}^{N} \left\| \epsilon_{\Delta \lambda_i}(\lambda) - \epsilon_{\Delta \lambda_i, k}(\lambda) \right\|^2$$

$$\epsilon_{\Delta \lambda_i, k} = \int T^4 \frac{\epsilon_{\Delta \lambda_i}(\lambda) \cos(\Theta_{\text{source}})}{\pi^2} \cos(\Theta_{\text{source})} d\Theta_{\text{source}} \Delta \lambda_i$$

**Bayesian (Monte-Carlo Markov chain (MCMC))**

**Conclusion and perspectives**

**Bibliography**


