A Novel Approach to Temperature-Emissivity Separation Using a Multiple-Window Smoothness Criteria

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Introduction

- Calculating temperature and emissivity of targets using aerial imagery is a complicated problem requiring optimization.
- The target’s temperature must be known in order to calculate the emissivity.
- Aerial imagery gives the spectral radiance, but not the temperature.
- An optimization approach called the spectral smoothing method is modified to test three novel approaches:
  - Moving-window method
  - Variable-width moving-window method
  - Multiple-moving-windows method
- 17 targets of varying materials were tested.
- The goal is to find a method which:
  - Works well on a wide range of target materials.
  - Accurately estimates the temperature and emissivity of highly reflective targets.

Spectral Smoothing

- The spectral smoothing method states that the atmospheric emission lines in a subregion, or window, of the spectra from 8.12 – 8.6µm are accentuated when the incorrect target temperature is used to calculate emissivity.
- This means that when the emissivity is the smoothest, or has the least change in slope, then the corresponding temperature should be the temperature of the target.

Problem

- Highly reflective targets.
  - Targets such as polished metal have a low emissivity, which is strongly effected by any changes in the atmosphere during measurements. It is very difficult to get accurate results for these targets.
  - Incorrect temperature estimation.
    - Atmospheric emission lines are at a minimum given the correct target temperature, when using the spectral smoothing method.

Moving-Window Method

- This method is the same as the current one, except that instead of a fixed subregion from 8.12 – 8.6µm, the subregion changes position over the entire spectra, from 8 – 14µm. The smoothest region is selected to find the temperature.

Multiple-Moving-Window Method

- Using a window with a predefined, fixed width, this method uses every possible combination of a predefined number of windows to find the combinations which produces the smoothest curve.
- Four windows with a width of 1µm were arbitrarily chosen in this research.

Variable-Width Moving-Window Method

- Similar to the moving-window method, but the window also varies in width.
- For each predefined width, the window moves through all positions in the spectra in order to find the best temperature.

Results

- The difference between each of the new methods, and the existing method is negligible according to unpaired t-tests between the new and current methods.
- Using an α of 0.05, p-values of 0.5624, 0.7566, and 0.9780 were found.
- None of the novel methods produced usable results for highly reflective targets.
- Future work includes continued testing with a larger number of samples.

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