Recognition of Textural Differences in Infrared and Ultraviolet Imagery Using Fractal Characteristics

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ABSTRACT

This project utilized an algorithm written by Troy Thielen that is used to estimate the fractal dimension and lacunarity of gray-scale images. New ultraviolet and infrared images were taken throughout the project and analyzed using this algorithm. The fractal characteristics of these images were then analyzed to recognize textural differences within imagery, a useful method when attempting to recognize objects or locate targets. Differences between ultraviolet, infrared and visual imagery were analyzed, and additional implications of the recognition of textural differences were explored.

OBJECTIVE

Use fractal characteristics (dimension and lacunarity) to analyze a set of ultraviolet and infrared images taken during the research project in order to evaluate the ability of fractal characteristics to aid in the recognition of textural differences in imagery

PROCEDURES

1. Become familiar with the KDTREE algorithms by Troy Thielen to ensure accurate and proper usage (Table 1)
2. Take images in the ultraviolet (UV), infrared (IR) and visual spectrums (Figure 2)
3. Register the images using MATLAB (Figures 3,4)
   - This process takes two or more similar, yet differing images and applies a transformation to align the images
4. Apply the KDTREE algorithm to the UVIR images to determine the fractal characteristics of the images

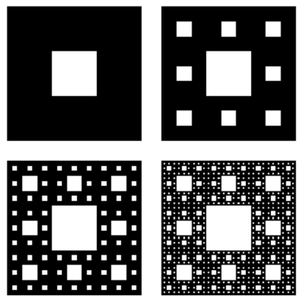


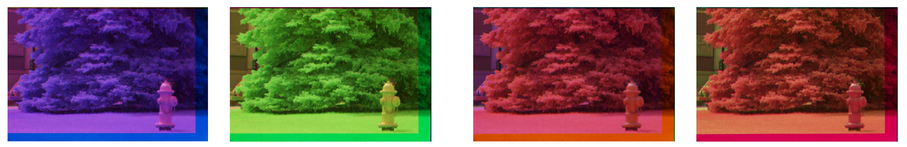
Figure 1: Cantor Set – a fractal that can be used to easily demonstrate the self-similarity characteristic of fractals

Theoretical FD	Thielen's FD	My FD
0.6309	0.6309	0.6309
1.2619	1.2619	1.2619
1.3652	1.5045	1.5448
1.4248	1.4223	1.4405
1.465	n/a	1.6230

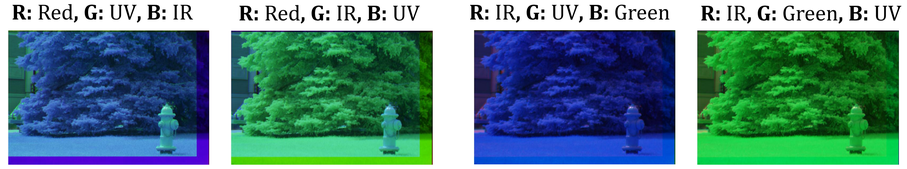
Table 1: Estimated Fractal Dimension for various Cantor sets using KDTREE Algorithm to demonstrate effective use of the algorithm

Figure 2: Sample images in visual (left), infrared (middle) and ultraviolet (right) wavelengths

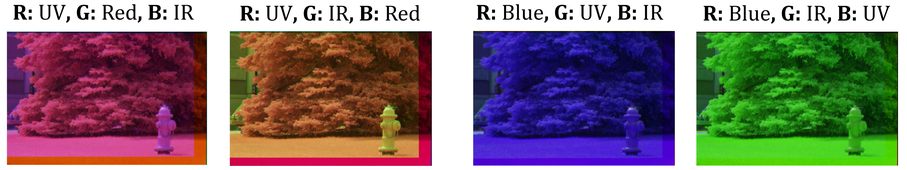
Figure 3: The separation of the visual image into its three color channels: red, green and blue



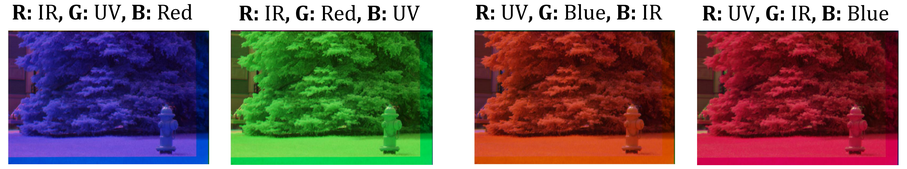
R: Red, **G:** UV, **B:** IR | **R:** Red, **G:** IR, **B:** UV | **R:** IR, **G:** UV, **B:** Green | **R:** IR, **G:** Green, **B:** UV



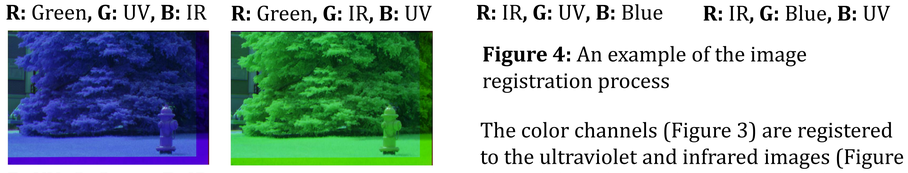
R: UV, **G:** Red, **B:** IR | **R:** UV, **G:** IR, **B:** Red | **R:** Blue, **G:** UV, **B:** IR | **R:** Blue, **G:** IR, **B:** UV



R: IR, **G:** UV, **B:** Red | **R:** IR, **G:** Red, **B:** UV | **R:** UV, **G:** Blue, **B:** IR | **R:** UV, **G:** IR, **B:** Blue



R: Green, **G:** UV, **B:** IR | **R:** Green, **G:** IR, **B:** UV | **R:** IR, **G:** UV, **B:** Blue | **R:** IR, **G:** Blue, **B:** UV



R: UV, **G:** Green, **B:** IR | **R:** UV, **G:** IR, **B:** Green

Figure 4: An example of the image registration process

The color channels (Figure 3) are registered to the ultraviolet and infrared images (Figure 2), and then the results are displayed in Figure 4.

Since the images can only contain three channels, different combinations of the red, green and blue channels and ultraviolet and infrared images are shown above.

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RESULTS

- A robust image registration method was developed that can be used for images taken in visual, ultraviolet and infrared wavelengths
- The KD-tree code that was to be used was not flexible enough to handle the multi-spectral input values, so for this reason (and limited time), the fractal analysis portion of the research was unable to be completed
- In some images in Figure 4, color differences between natural vs. manmade objects are noticeable before fractal analyses are even applied

CONCLUSION

Overall, despite the fact that the fractal analysis portion of this research project was unable to be completed, the image registration techniques employed are an important development to the future research of textural differences in multi-spectral imagery. These techniques are the primary product of this research, which will aid future research projects in this field.

FUTURE WORK

- Revise MAPPER to work with Intel's new Cilkplus implementation of Cilk from MIT and include new registration code
- Develop an image registration technique that is independent of MATLAB for implementation with MAPPER
- Adjust KDTREE algorithms to be more flexible in the type of inputs that they take

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