Experiment Spatial-Spectral Target Detection

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Support Crew: TBD

Short Title: Spatial-Spectral Target Detection

Objectives: The aim of this experiment is to detect and distinguish between targets of similar material but with different shapes, using imagery of a scene with known targets taken with an airborne hyperspectral imager – and if available – an airborne panchromatic imager. Hyperspectral imagers typically provide high resolution spectral measurements but often produce images with relatively coarse spatial resolution. Including the panchromatic imagery allows us to explore the following: fusing a spatial descriptor derived from the (coincident or near-coincident) pan imagery with a spectral descriptor derived from the HSI, and a joint spatial-spectral descriptor for pansharpened HSI data. We can then compare those approaches to that of applying a joint spatial-spectral descriptor to HSI data alone. Ground truth reflectance spectra and target positions will be recorded by the support crew.

Deployments: The targets are blue and brown vinyl tarps. Several 8ft by 10ft (2.44m by 3.05m) tarps were cut and shaped into 36 targets. All tarps were purchased at the same time and appear to be of consistent composition from one tarp to the next. The table below gives a thorough description of most of the targets' dimensions:

Table 1: Description of symmetric geometric targets

Shape	Edge/Radius	Area	Max GSD for Full Pixel
Circle	3.43ft / 1.045m	36.89ft^2 / 3.427m^2	2.42ft / 0.738m
Equilateral Triangle	9.23ft / 2.813m	36.89ft^2 / 3.427m^2	2.0ft / 0.610m
Square	6.07ft / 1.850m	36.89ft^2 / 3.427m^2	3.04ft / 0.927m

All target shapes were designed to have the same surface area so that light reflected off each target will be equally apparent to the sensor. Five blue and five brown copies of each target were constructed, for a total of 30 symmetric targets.

Six copies – three blue and three brown – of an asymmetric target were created:

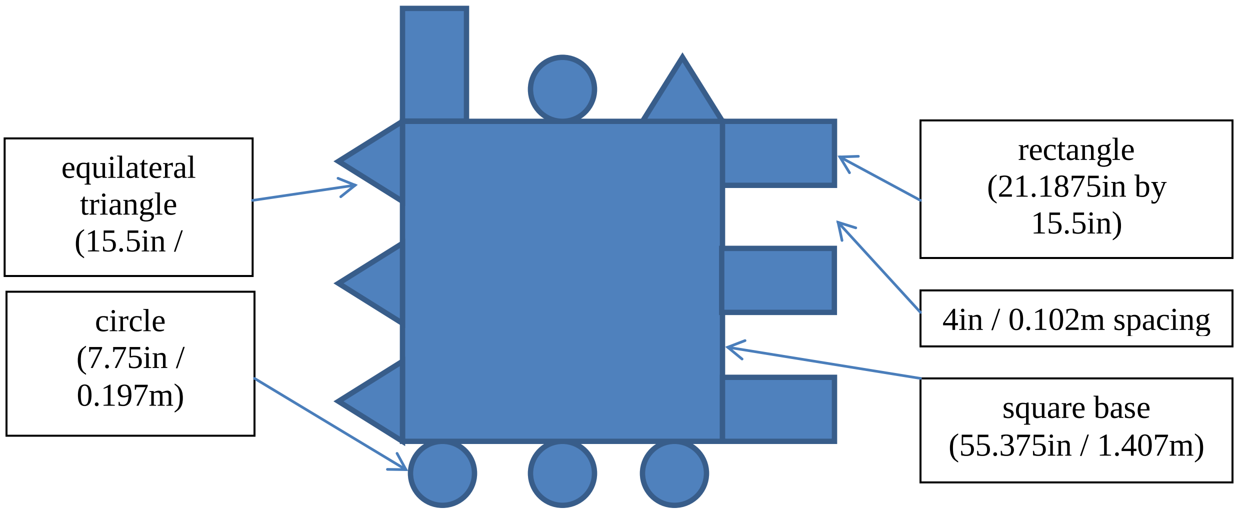


Figure 1: Asymmetric target description

The total surface area of this shape is also equivalent to that of each symmetric shape. Its asymmetric design allows spatial feature extraction algorithms to determine and relay information about orientation.

The vinyl material is not entirely opaque and it has a bit of a shiny finish. We first examined both blue and brown tarp materials with an Ocean Optics USB2000 miniature fiber optic spectrometer, which takes standoff measurements and relies on an external source for illumination. Pieces of the vinyl tarp material were placed on top of live grass during a sunny afternoon, as they would be deployed during an experiment. Compare those samples to ones taken of the tarp material when it is loosely backed by a tile of Spectralon®. The figure below plots the reflectance of the blue tarp for both cases.

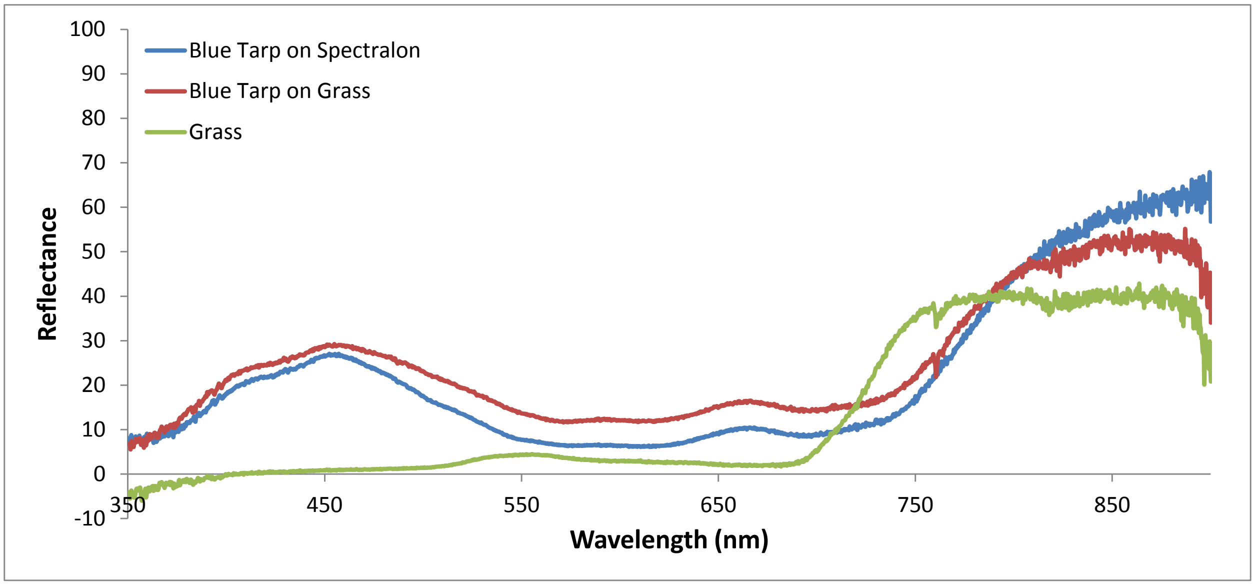


Figure 2: Blue tarp reflectance samples taken against grass and Spectralon®

Interestingly the reflectance of the tarp over the visual wavelengths increased when the Spectralon® was removed. Illumination changes due to clouds might be causing this – but after 800nm the lower response of the grass might be having more of an effect. The next figure shows the result of repeating the experiment for the brown tarp material.

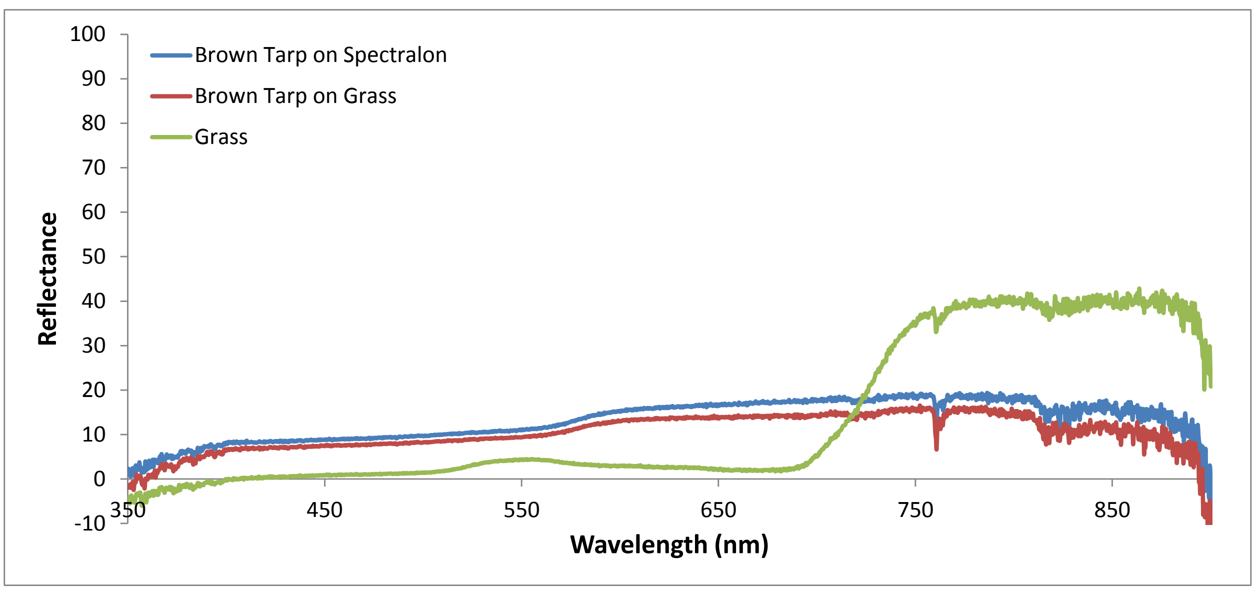


Figure 3: Brown tarp reflectance samples taken against grass and Spectralon®

The brown tarp, being of noticeably heavier stock, is not all that affected by the background change. It is likely that the difference here is due to slight changes in illumination. Visually it was difficult to determine where the grass might be bleeding through the blue tarp, and nearly impossible with the brown tarp. The fact that the tarp is not pressed solidly against the bulk of the grass underneath the tarps seems to mitigate the spectral effect of the grass.

The following images show examples of the equilateral triangle tarps, blue and brown, respectively.

Figure 4: Blue equilateral triangle target


Figure 5: Brown equilateral triangle target

The image below shows how the triangle tarps are folded and taped on the ground-facing surface with a twine rope running inside two of the legs to aid in staking the tarp down and maintain the tarp's shape.


Figure 6: Close-up of blue equilateral triangle vertex

Although they are not shown here, the square and asymmetric tarps are rigged similarly, except that all sides contain a rope segment. The circle tarps do not contain any tape or twine rope and must be secured with at least three segments of clear fishing line run across the surface. The rope and fishing line are then tied down to 7in aluminum stakes. Fluorescent survey flags for marking target locations can be provided.

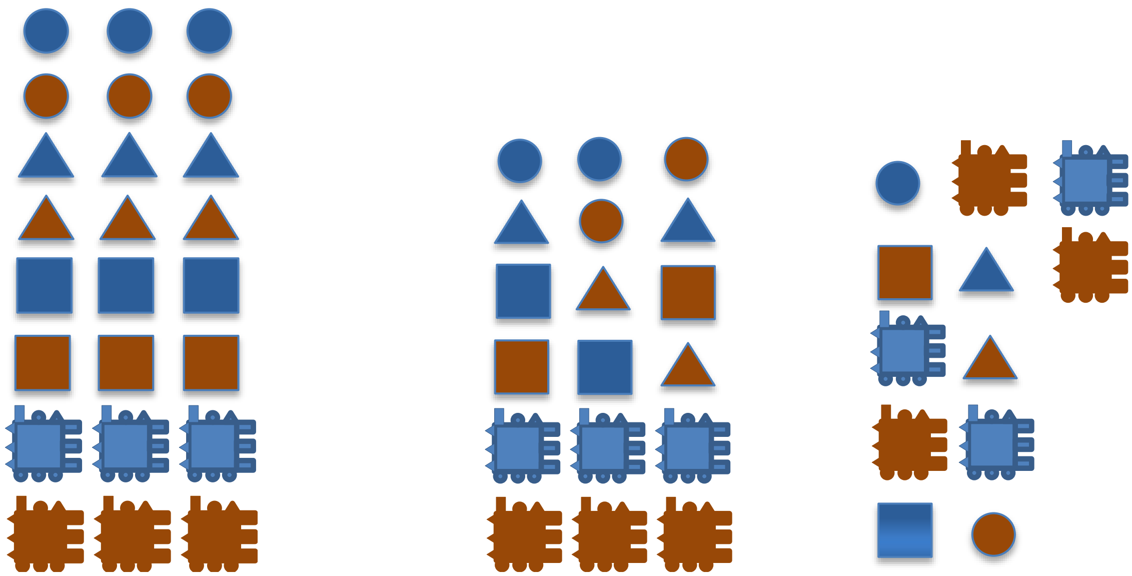
The table below outlines ideal, adequate, and worst case scenarios for the targets we wish to deploy with 20ft spacing.

Table 2: Target layout scenarios

Scenario	Triangle	Square	Circle	Asymmetric	Total	Required Area
Ideal	3 each color	3 each color	3 each color	3 each color	24	$5400ft^2$ / $502m^2$
Adequate	2 each color	2 each color	2 each color	3 each color	15	$3200ft^2$ / $297m^2$
Worst Case	1 each color	1 each color	1 each color	3 each color	9	$1600ft^2$ / $149m^2$

Based on our telecon on July 12, it seems that two passes in a single day will be made with multiple sensors and open space is limited. Therefore any of these scenarios are suitable for us although we would prefer to set out more targets if possible.

The layout of the grid and positioning of the targets does not affect our exploitation and analysis of the data, although if similar objects are grouped together in a clean, regular pattern it makes generating image truth much easier. Some potential layouts:



(a) Ideal Scenario (b) Adequate Scenario (c) Worst Case Scenario

Figure 7: Graphic description of target layout scenarios

If the grassy baseball fields and other grassy open areas near the “Main GT Site” waypoint (42°54'22.27"N, 77°45'55.80"W) are available, then there are numerous places where even the “ideal scenario” can be executed. See the figure below which includes nominal target array boundaries with center coordinates. Note that only one of these sites is needed to set up all targets.

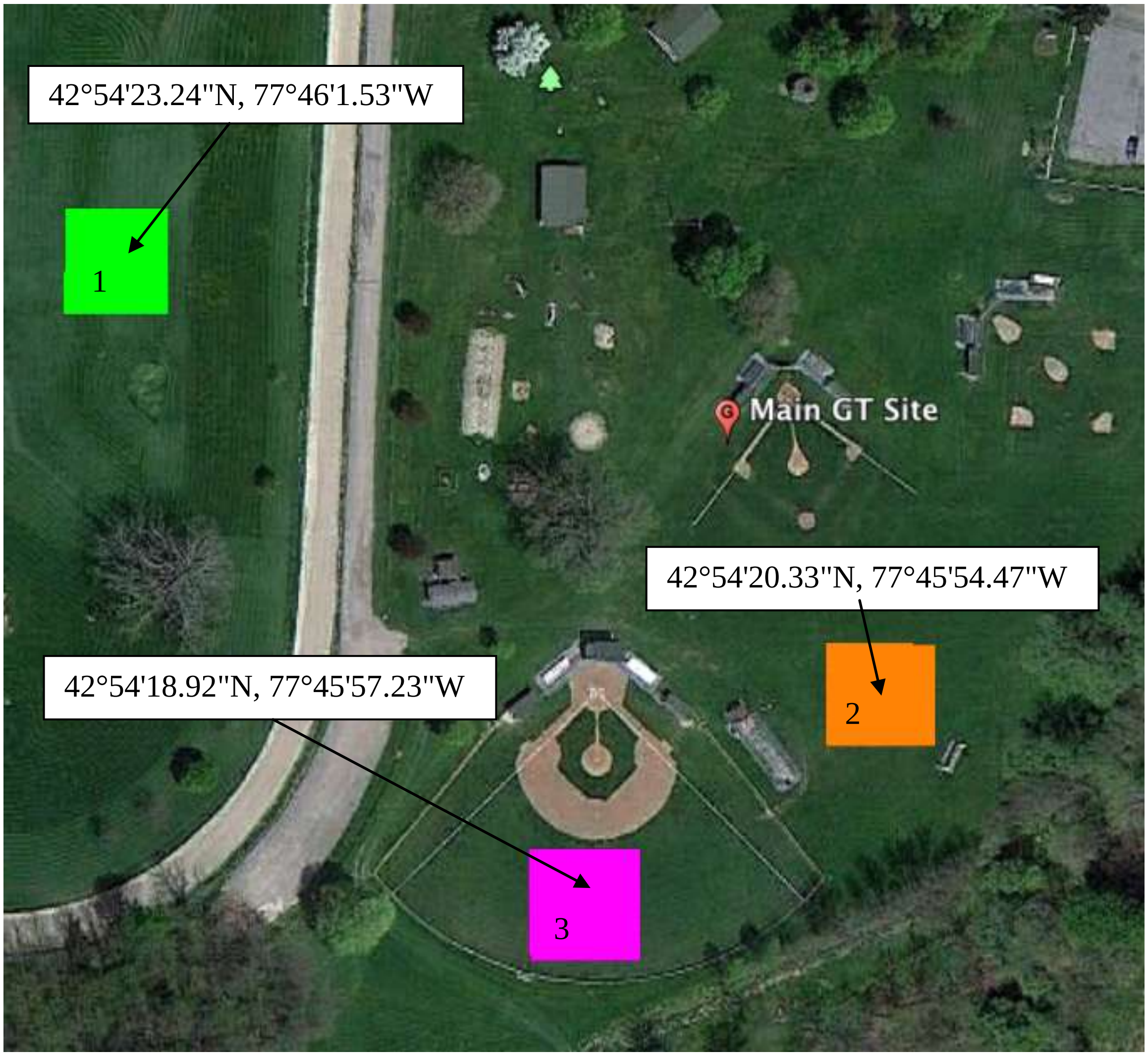


Figure 8: Potential target array sites near Main GT Site waypoint

The open grassy area near the green rectangle (#1) is most preferable since it is unobstructed by trees and man-made objects. The orange rectangle (#2) shows how the array could be fit within a more confined area. Finally, the magenta rectangle (#3) is a worst case scenario where the targets could be arranged within a highly cluttered area.

We would most likely set up the targets, or at least put out survey stakes, on the day prior to the data collection.

Flight Lines: Any near-nadir flight lines covering the 5400ft^2 (502m^2) or less area containing the targets in a single pass would be preferable.

Flight Constraints: Ideally the imagery would be collected at a time when the path between the sun and the target area is not obstructed by clouds, likely between late morning and afternoon local time. While a 0.6m GSD would be required to guarantee at least one fully resolved HSI pixel on each of the targets, it is not a strict requirement for the experiment. However, we request full coverage of the target array with a panchromatic imager at 0.15m GSD or better. We request that the time between the pan and HSI passes is minimized, but barring major illumination changes between the passes, this should not be a problem. A second pass with the hyperspectral and panchromatic sensors is also requested at similar GSDs.

We would also like to move a small number of targets around within the target array area between passes, so that this data might be useful for change detection studies.

Ground Truth Required:

1) Accurate GPS locations of the targets
2) Reflectance spectra of a few of the targets in place on grass

Equipment List: We will be providing:

- All target tarps, takes, survey flags, extra rope

And borrowing:

- Differential GPS receiver provided by AFRL