Open field trials of lidars & HS (Hyperspectral Sensors)

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Abstract

Two kinds of sensors will be highlighted (and shortly explained whenever necessary):

1. 3-D lidars (or laser radars)
2. Hyperspectral Sensors (HS).

Using results recorded during the NATO field trials SCI-145, it will be shown that **both previous sensors**

- can remove camouflage means (i.e., decamouflaging effect)
- and are able to discriminate between fake targets (i.e., decoys) and real targets.

As a conclusion, they are able to **defeat most CCD** (Camouflage, Concealment & Deception) measures.

Background

A NATO SCI/SET Symposium was organized to represent the state of the art in sensors which are currently designed to overcome limitations posed by existing and emerging CC&D (Camouflage ,Concealment and Deception) technologies. Advances were reported in almost all domains of the electromagnetic spectrum. **For example, laser based 3-dimensional (i.e.,3-D lidars) viewing systems and laser vibrometry (or coherent lidars) have an inherent capability to off-set existing CC&D. Hyperspectral sensors are potentially able (cfr the CDT and the measurement campaign the week before the Symposium) to "remove" any camouflage except maybe fresh natural camouflage.** From papers given and ensuing discussions it was evident that in view of the multitude of sensors which, through proliferation, may become available world-wide, it will be more difficult for existing CC&D technologies to hide NATO Forces, and increased efforts for come up with new technologies must be undertaken.

The Symposium was held back-to-back with **the NATO RTO Joint SCI/SET Cooperative Demonstration of Technology (or CDT)** on Sensors and Sensor Denial by Camouflage, Concealment and Deception, RTO SCI-145 CDT. The CDT which took place at the former Air Field of the Belgian Forces in **Zutendaal (Airbase)** substantiated many of the statements and arguments of the Symposium.

3-D lidars (laser radars)

Two kinds of lidars were used the RTO SCI-145 CDT:

- 3-D incoherent scanning pulsed lidar from Sweden whose 3[rd] dimension is range

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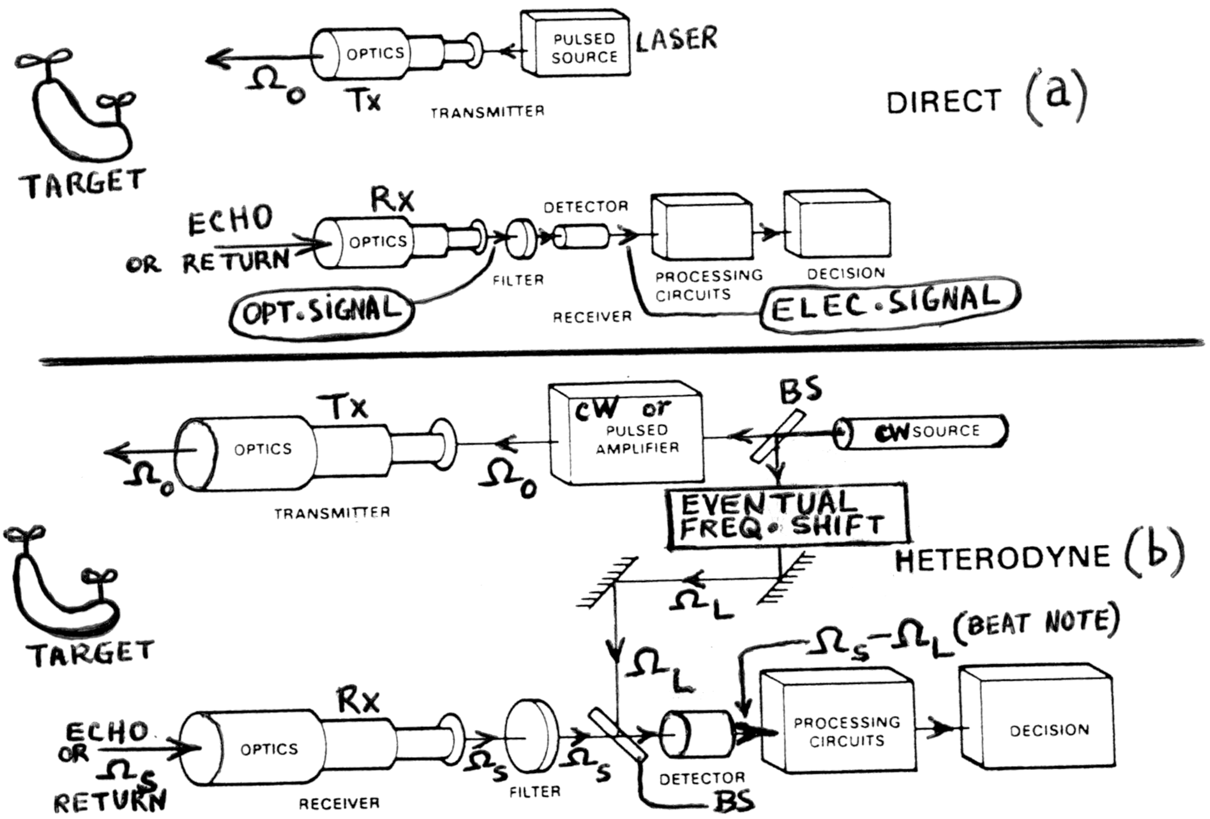
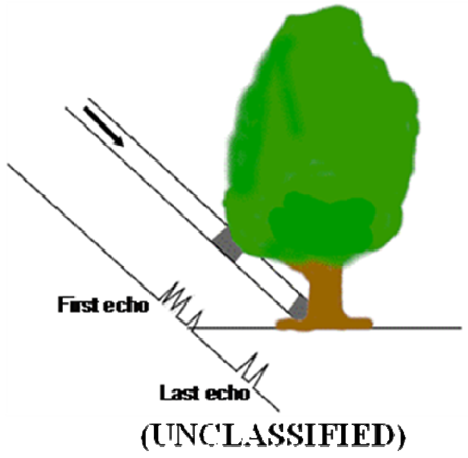
- (CW)Laser vibrometer from FGAN-FOM, i.e., 3-D coherent lidar using micro-Doppler processing to sense vibrations (set up by, e.g., running engine) .

Incoherent vs coherent lidars (BS denotes a beam splitter**)**



1. 3-D incoherent scanning pulsed Swedish lidar



First or last echo can be selected!

Conclusions – results

The laser pulses have penetrated all nets (more or less)

- Returns from targets behind camouflage were recorded

- The result indicates the potential advantage with 3-D laser radar for target detection and classification

2. Laser vibrometry by coherent lidar from German FGAN-FOM

Laser vibrometers may pick up camouflaged covered targets, static or moving, due to remaining surface vibrations; such vibrometers are able to discriminate between fake and real targets.

Outline and prospectives about HS (hyperspectral) sensing

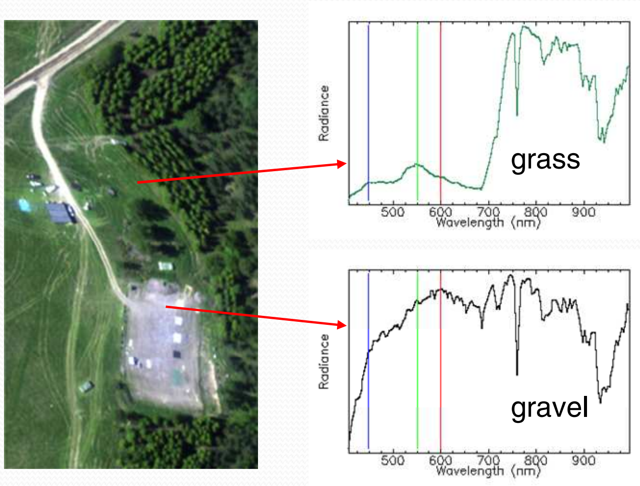
Hyperspectral sensors may offer significant improvement over existing sensors in detecting camouflaged and hidden targets. As a result, there has been strong interest in the development of hyperspectral target-detection algorithms. Many articles have appeared in technical journals in the last several years. Of particular interest, the IEEE Signal Processing Magazine issue of January 2001 (volume 19, issue 1), which was dedicated to hyperspectral processing, contains several survey articles describing various algorithms.

Each valuable sensor should exhibit a high spatial resolution, i.e., pixel as small as possible. The hyperspectral sensor is the paradigm of all multispectral sensors, because the HS additionally exhibits a high spectral (or wavelength) resolution and, thereby, with the advent of high performance staring arrays, the HS sensing is potentially able to defeat any CCD measures.

Hyperspectral Principles

- By means of a dispersive element (either a prism or a diffraction grating), the whole waveband of the sensor is spectrally sampled in about a hundred narrow subbands.
- In each subband a 2-D image (x, y) of the scene is recorded .
- A computer code (i.e., signal processing) combines the 100 subband images with the **material spectra** (reflectance spectra in the case of visible or NIR light) from a **data base** to sort out the various materials (i.e., the various soils and/or vegetations) in the **final composite image** (see example of such a composite image on next image).The information extraction is performed by a thematic algorithm which necessites always a **data base** unless it would be an anomaly detection algorithm which requires a sufficiently homogeneous background. We are not going to deal with the sensor calibration nor with the atmospheric correction (always performed in order to remove the various absorption bands of the atmospheric gases) .

- Records detailed information about the incoming spectrum: hundreds of "colours" for each pixel
- The spectrum is a characteristic signature for a surface
- Potential for detection and classification of targets
- Potential for auto-mated image processing



- Possible platforms: UAV or ground based

1. Anomaly detection

Concept : find pixels whose spectra deviate from background without a priori knowledge of the various reflectance spectra

Method:. the computer makes (by modeling statistical variation of background as a mixture of multidimensional Gaussians) a statistical analysis of background and will color in black everything resembling the background, i.e., the lighter the color of the processed image pixel , the larger the deviation relative to the background. Thresholding can be applied, meaning everything above threshold is red colored, while everything below threshold remains black colored !

Result: This anomaly detection algorithm unveils all targets except the targets with natural camouflage (fresh cut tree branches).