Real time detection system for MDA with hyperspectral camera mounted small satellites

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\textsuperscript{*} Speaker
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II. Background
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III. Development of a Small Space HSD
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I. Aim

1. Development of a small space hyperspectral camera
2. Consideration of a high-accuracy detection algorithm
3. Introduction of a laser communication

Development of real-time detection system using a hyperspectral camera for national defense
II. Background

- National Defense
- National Disasters
  - ex) 3.11 Tsunami
- Pollutions

- MDA (Maritime Domain Awareness)
  - Hyperspectral Camera
  - Laser Communication

- High Accuracy Detection
- Real Time Detection

Amount of International Trade on the Basis of the Method

- Marine: 99%
- Other: 1%
Happy Science University

- Data Analysis
- Laser Communication

Hokkaido Satellite Co. Ltd.

- Satellite Development
- Hyperspectral Camera Development

II. Background

Skills

- Laser Communication
- Hyperspectral Camera Development
### III. Development of a Small Space HSD

<table>
<thead>
<tr>
<th>Item</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaging type</td>
<td>Push bloom</td>
</tr>
<tr>
<td>F number</td>
<td>3.0</td>
</tr>
<tr>
<td>Ground sampling distance</td>
<td>15m</td>
</tr>
<tr>
<td>Spatial effective resolution</td>
<td>30m</td>
</tr>
<tr>
<td>Swath width</td>
<td>15km</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>450-1000nm</td>
</tr>
<tr>
<td>Spectral sampling interval</td>
<td>1.2nm – 16nm</td>
</tr>
<tr>
<td>Frame rate</td>
<td>500Hz</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>10bit</td>
</tr>
<tr>
<td>Pixel size of the detector</td>
<td>10.8μm</td>
</tr>
<tr>
<td>Telescope aperture</td>
<td>150mm</td>
</tr>
<tr>
<td>Signal to Noise ratio</td>
<td>&gt; 100 (peak)</td>
</tr>
<tr>
<td>Instrument mass (Optical System)</td>
<td>Approx. 5kg</td>
</tr>
<tr>
<td>Nominal altitude</td>
<td>620km</td>
</tr>
</tbody>
</table>

Image of hyperspectral data

![Image of Hyperspectral Data](image.png)
IV. Preliminary Experiment for RXD

Spatial Resolution: 0.5m
Observation Range: 1km

Overview of the Preliminary Experiment

- Stabilizer/A Battery of HSC1702
- Laptop for Probing/HDD for Saving Data
- GPS
- Web Camera for Monitoring
IV. Preliminary Experiment for RXD

RXD · · · Reed-Xiaoli Detector

\[ RX(y) = (y - \hat{\mu}_b)^T \hat{C}_b^{-1} (y - \hat{\mu}_b) \]

\( \hat{\mu}_b \): estimated average spectrum

\( \hat{C}_b \): estimated variance – covariance matrix
V. 1km Experiment for Laser Communication

**Requirement for semi-real time satellite-ground communication**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>File Size</td>
<td>1.2Gbit/file</td>
</tr>
<tr>
<td>Transmission Time</td>
<td>Within 8 min</td>
</tr>
<tr>
<td>Transmission Frequency</td>
<td>2~3times/day</td>
</tr>
<tr>
<td>Transmission Speed</td>
<td>100Mbps</td>
</tr>
</tbody>
</table>

Step 1: 170m Experiment (3.6MHz Video Signal)

Step 2: 170m Experiment (125MHz Sine Wave)

Step 3: 1km Experiment

Step 4: 10km Experiment

Step 5: 1000Km Experiment
V. 1km Experiment for Laser Communication

Transmission Circuit
- Light Output: 10.5mW
- Wavelength: 658nm
- Light Modulator: Amplitude Modulator

Reception Circuit
- Receiving Element: Si PIN Photo Diode
- Voltage Output: 500mV
- Optical Axis Adjustment: Dual Axes
V. 1km Experiment for Laser Communication

Result

- **1MHz**: Rectangular Wave
  - Transmission Wave
  - Reception Wave

- **10MHz**: Sine Wave

- **125MHz**: Sine Wave
VI. Summary & Future Prospects

Summary

It is possible to realize semi-real time & high accuracy MDA system by using Hyperspectral Camera & Laser Communication

Future Prospects

- Improvement of the analysis method for the anomaly detection
- 10km experiment for the laser communication
- This satellite will be launched in 3 years in our current plan