Specific Emitter Identification (SEI) Research

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Electronic Support SEI Research

- Context of SEI within EW
- Why do we do SEI?
- Research project
- Proof of concept
- Proof of SEI
- Issues related to SEI
- Future work
Context of SEI within EW

Electronic Warfare (EW)

Electronic Support (ES) [ESM]
“search for, intercept, locate, classify sources of intentional and unintentional radiated EM energy”

Electronic Attack (EA) [ECM]
“use EM and directed energy to attack facilities and equipment in order to degrade, neutralise or destroy enemy activity”

Electronic Protection (EP) [ECCM]
“actions taken to protect facilities and equipment from any effects of friendly or enemy EW”

• SIGINT
  • ELINT
  • COMINT

• ECM
  • DEWs
  • ARM s

• ECCM
  • EMCON
  • COMSEC

Adopted from *Electronic Warfare in the Information Age*, (1999), D.C. Schleher
Signals Intelligence

Electronic Warfare (EW)

“use EM and directed energy to control the EM spectrum”

Electronic Support (ES) \([ESM]\)

“search for, intercept, locate, classify sources of intentional and unintentional radiated EM energy”

Signals Intelligence (SIGINT)

• Electronic Intelligence (ELINT). Concerned with the characterisation of emitter signal parameters e.g. pulse width and carrier frequency

• Communications Intelligence (COMINT). Concerned with information content e.g. sms

“ES Techniques refer to the development of signal processing algorithms in order to develop an ES capability for the EDERI”

SIGINT

• ELINT
• COMINT
Context of SEI within EW

ES

Detection
Tracking
Locate
Classify

Extra class
Emitter identification

Intra class
SEI
Why do SEI?

• Identity a particular Radio Frequency (RF) emitter
  • Cooperative or non-cooperative
  • Adds a further dimension to emitter classification

• Useful in Radar, EW and Communications
  • Situational awareness of friend or foe
  • Emitter performance management over time
Research project (1)

- WdP studied possible techniques for SEI on radars
- MC – similar research project at GEW on radio transmitters
- Research done is not to develop a product
- Development of signal processing algorithms (detection and feature extraction)
- Classification algorithm
Research project (2)

- Technical aspects:
  - Detection – determine presence of signals
  - Feature extraction – calculation of values representing a specific feature
  - Features are calculated from waveform statistics and amplitude-scale transform (DWT)
  - Effectively, process performs data rate reduction on received signals
Proof of concept – Emitter Classification

- “Can we classify emitters based on their SIGINT description?”
- “Can we do this automatically?”
- “Can we reuse emitter data already captured?”
- “Can we identify EA?”
Proof of concept – Emitter Classification

- Analysis of measured data
- Pulse detection

![Graphs showing pulse time data, pulse start/end, and phase derivative.](slide10.png)
Proof of concept – Emitter Classification

- Overlapped features of units
- High correlation between features
Proof of concept – Emitter Classification

- Results show feasibility of SEI

<table>
<thead>
<tr>
<th>Normalisation</th>
<th>Percentage Training Data [%]</th>
<th>CCD [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>5</td>
<td>78.91</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>79.22</td>
</tr>
<tr>
<td>Individual</td>
<td>5</td>
<td>83.03</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>83.33</td>
</tr>
</tbody>
</table>
Proof of SEI (1)

- Extends emitter classification to identify emitters of the same type
- Here we explore the subtle differences in emitter parameters
  - Usually originates from analogue emitter subsystems
Proof of SEI (2)

- Emitter parameters tend to be severely overlapped
  - Emitters are fundamentally the same
- It is usually required to fully characterise an emitter for accurate classification
  - Many parameters require an intensive characterisation effort
- Need for an adaptable emitter database
  - Own systems are easily characterised
  - Enemy systems are generally quite difficult or impossible to characterise
Proof of SEI (3)

- Time and frequency measurement setup
- Antenna patterns, polarisation, high sample rate
Proof of SEI (4)

- Results from feature calculation show distinction between radars
- Scatter plot of 2 features – Droop and Pulse width
Dimensionality reduction

- Redundant features clutter the feature vector, has an influence on the classification
- Three different methods were used to reduce the dimensionality of the input feature vector (Correlation method, LDA, Gamma test)
- Successful reduction of features
Spectral information (1)

- Compare spectrum of unknown transmitter with set of reference spectra (computed through averaging)
- Either only the magnitude response or the magnitude and phase responses
- Only magnitude response comparison was done
- Included in future work, design of a matched filter is a possibility – this will consider both magnitude and phase responses
- Exact alignment (in time and frequency) is very important for accurate calculation of the average
Spectral information (2)

- Results of comparing an unknown radar pulse magnitude response with 3 reference magnitude responses
Classification

- A fuzzy ARTmap classifier was used
- Results are shown for different sets of features

<table>
<thead>
<tr>
<th>Combination of features</th>
<th>CCD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All 19 features</td>
<td>82.32</td>
</tr>
<tr>
<td>13 features as selected using the correlation method</td>
<td>85.42</td>
</tr>
<tr>
<td>2 features (transmitted frequency and droop)</td>
<td>92.15</td>
</tr>
<tr>
<td>7 features as selected using the Gamma test</td>
<td>84.97</td>
</tr>
<tr>
<td>4 features as selected using LDA</td>
<td>77.74</td>
</tr>
<tr>
<td>6 features as selected using LDA</td>
<td>74.93</td>
</tr>
<tr>
<td>8 features as selected using LDA</td>
<td>73.95</td>
</tr>
</tbody>
</table>
Issues related to SEI

- Incomplete data
- Complete characterisation required of own equipment for effective identification of friendly forces
Conclusion and Future work

Conclusions

- Current research shows that classification is possible on radars of the same make and model
- There are many methods that can be implemented to do SEI (feature vector, spectral information, other possible methods yet to be discovered)

Future work

- High sampling rate measurements for more detailed features
- Polarisation measurements and analysis
- Design of matched filter for magnitude and phase response comparison
- Further trials to record more of the same, including radio transmitters
Questions?