University Defence Research Collaboration (UDRC) Signal Processing in a Networked Battlespace

WP4: MIMO & Distributed Sensing

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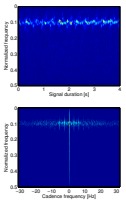
Brief Summary of Last 3 Months (Oct-Dec 2013)

- A novel algorithm for scalable and robust micro-Doppler classification was developed and tested;
- The analysis of the performance of novel fractional Fourier transform based waveform libraries was continued;
- The analysis of Compressed Sensing application on micro-Doppler signals was continued;
- The development of the Passive Radar demonstrator using GNSS signals was continued (receiver integration stage);
- The development of an automatic target identification algorithm for Distributed MIMO Radar Sensor was started, the preliminary results on the real Gotcha Dataset are encouraging;
- Two conference paper for the IEEE Radar Conference were submitted (a paper on micro-Doppler classification and another on novel waveform libraries);
- A Journal paper has been submitted to the IEEE Transactions on Aerospace and Electronic Systems;
- Two University of Strathclyde fully funded UDRC PhD studentships have been awarded. Mr Gaglione and Mr Ilioudis will start in Jan. 2014;
- Eight 24 GHz radar kits have been ordered;
- A one day meeting with the DSTL Fellow Brian Barber was attended, 11^{th} November 2013;
- The IMA Mathematics for Defence Conference was attended and a paper was also presented, 24^{th} October 2013;
- The UDRC themed meeting on Source Separation and Sparsity was attended, 30^{th} October 2013;
- The ISP 2013 conference was attended and a paper was presented, 2^{nd}-3^{rd} December 2013;
- The UDRC II launch event was attended, 4^{th} December 2013.

Spotlight: Micro-Doppler Classification Using Pseudo-Zernike Moments

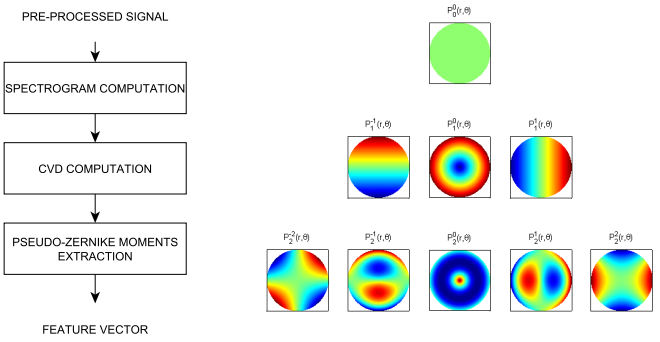
- The capability to analyse, synthesise and classify micro-Doppler signatures is of great interest for advanced automatic target recognition systems;
- Obtaining high performance classification, independent from scene, angle of observation and scattering intensity is an open challenge;



Algorithm and Properties

- In our approach the Cadence Velocity Diagram (CVD) is obtained from the Spectrogram of the received signal;
- The CVD contains informations about the micro-Doppler shifts and their periods;
- The Pseudo-Zernike Polynomials are used as basis to represent the CVDs;
- Rotational, Translational and Scale invariance are possible when using the polynomials;
- No subspace computation needed (e.g. PCA), from the CVDs just the moments must be extracted (extremely low computational cost!!!);
- The Pseudo-Zernike Moments are then used as Feature Vectors for Classification;

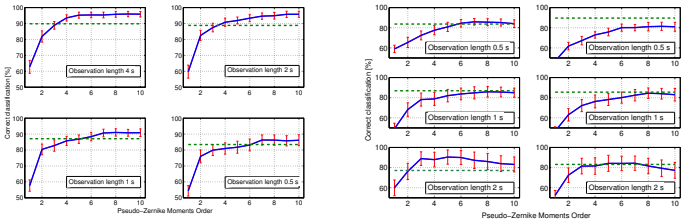
Algorithm and Properties (continued)



Proposed algorithm and example of Pseudo-Zernike Polynomials.

Results on Real Data

- Two real datasets have been used to test the developed algorithm;
  - Ku band data and containing people walking, running and crawling alone or in group;
  - X band data containing humans and horses with different velocities;
- The Pseudo-Zernike based algorithm has been compared with the results obtained by the mean-frequency profile algorithm [1];
- Simulated helicopter data have been used to demonstrate the advantages of Pseudo-Zernike moments versus Zernike Moments.



Results for the real Ku and X band data

Future Activities

- Continue the development and testing of the novel automatic target identification algorithm;
- Continue the analysis of Compressed Sensing application on micro-Doppler signals;
- Continue the development of the Passive Radar demonstrator using GNSS signals;
- Continue the waveform libraries analysis and modelling;
- Preparation of one conference and one journal paper on the DMRS automatic target identification algorithm;
- Start using the 24 GHz radar kits for data generation.

References:

[1] Jaime Zabalza, Carmine Clemente, Gaetano Di Caterina, Jinchang Ren, John Soraghan, Stephen Marshall,Robust Micro-Doppler Classification using SVM on Embedded Systems, IEEE Transactions on Aerospace and Electronic Systems (in Press)

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