PROJECT COGITO

Cognitive radar for enhanced target recognition

The COGITO project represents one of the first attempts to apply a cognitive architecture to the problem of target recognition. Today, in fact, most of the “Cognitive Radar” architectures, either implemented or under study, are focused on the radar capability to automatically select the regions of the frequency spectrum that are free of either intentional or unintentional radio frequency interferences. It should be noticed that such a way of working resembles that of a cognitive radio system more than a cognitive radar system. The concept of cognitive radar for target recognition is based on the system’s ability to understand the environment and to autonomously manage the radar system degrees of freedom (transmitted waveform and received signal processing parameters) as well as the target recognition algorithms. A cognitive radar that is specifically designed for automatic target recognition will aim at maximizing target recognition performances by exploiting a priori knowledge of the external environment as well as by learning from its successes and failures.

The aim of this project is to develop and test, both on simulated and real radar data, different cognitive radar architectures for automatic target recognition. The project will also provide a performance comparison between classical HRR/ISAR classifiers and the newly developed cognitive architectures. In order of appearance, the images below show an implementation of the COGITO system concept in an operative scenario, the overall system architecture, a more detailed classifier block diagram, where the feedbacks toward the system intelligence are highlighted with different colours, and preliminary results obtained by using a dataset composed of e.m. target models of 4 cars. Results are provided in terms of accuracy, error and precision and are meant to compare the advantage of using cognition when the external environment changes. In the example provided in Fig. 4, the environment changes in terms of SNR. In this case, the system adapts to the environment changes by applying the on-line learning approach proposed in the COGITO project. Other scenarios have been simulated to prove the classifier capability to drive the transmitter parameters (bandwidth, number of receiving spatial channels and full-pol acquisition).

[1] Martorella M, Gelli S and Bacci A (2021). “Ground moving target imaging via SDAP-ISAR processing: Review and new trends” Sensors. 21(7) ISSN: [DOI] [URL]

Technical Sheet
Funding institution:
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IDS, FHR, MBDA
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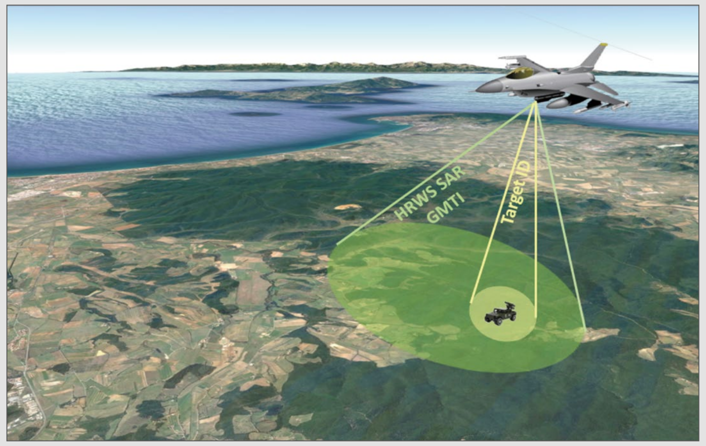
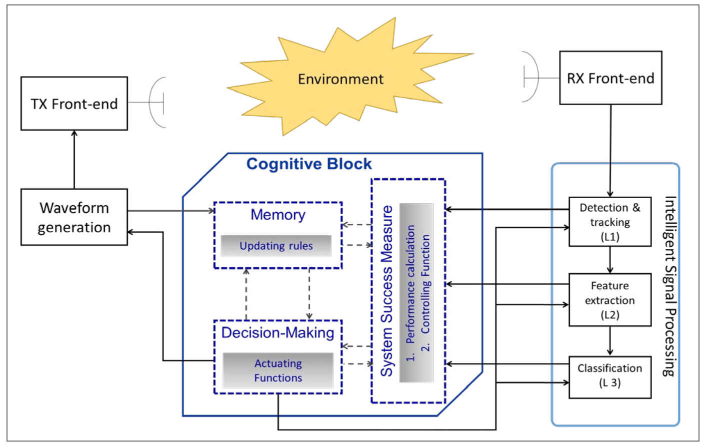
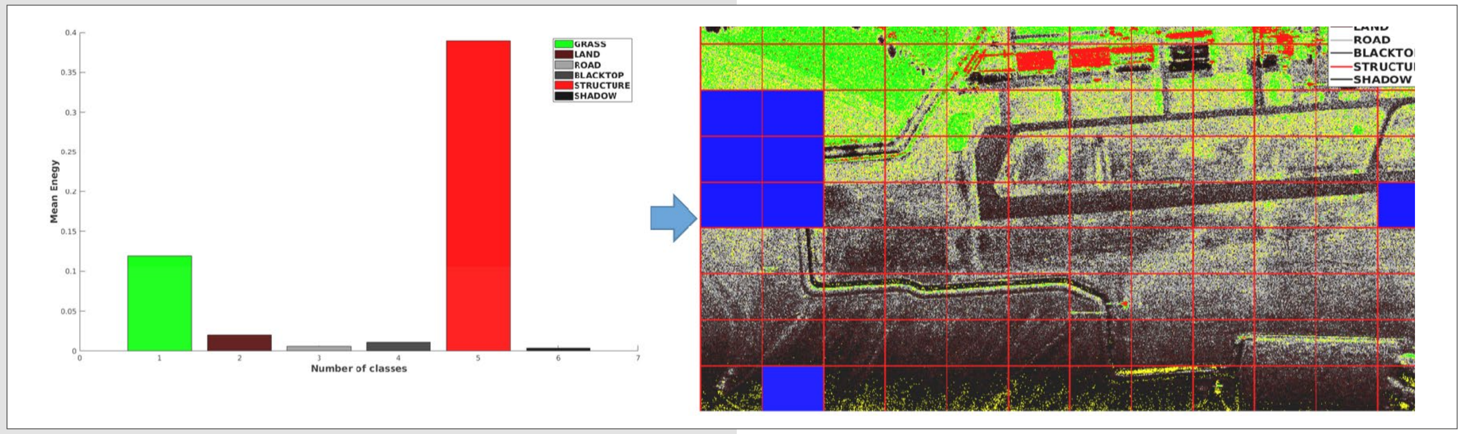
Involved countries
Italy, Germany



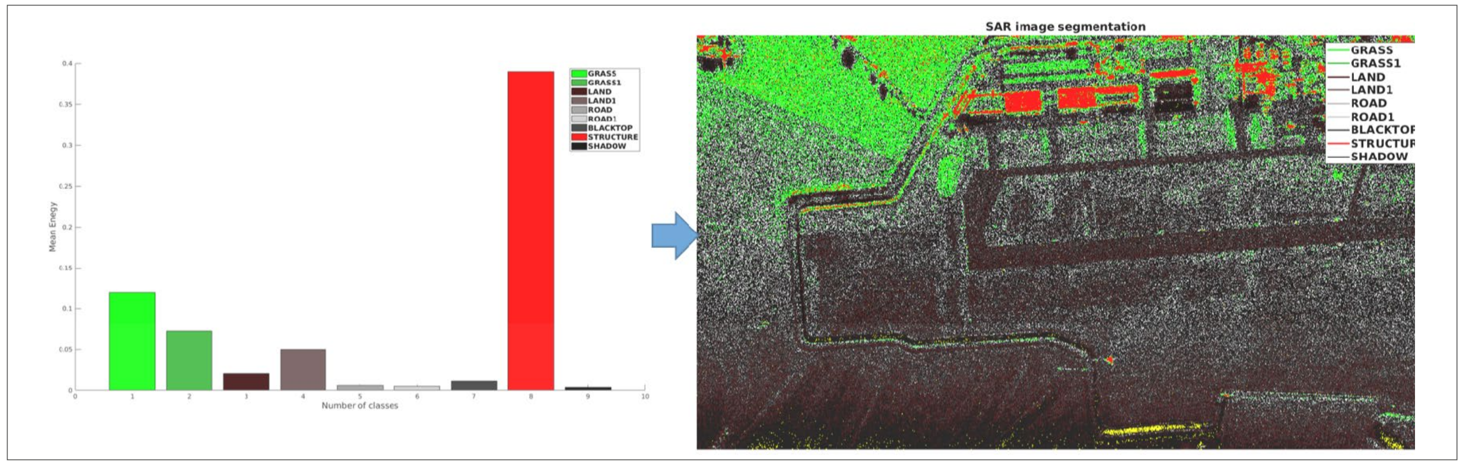
(a) Cogito conceptual idea and operative scenario



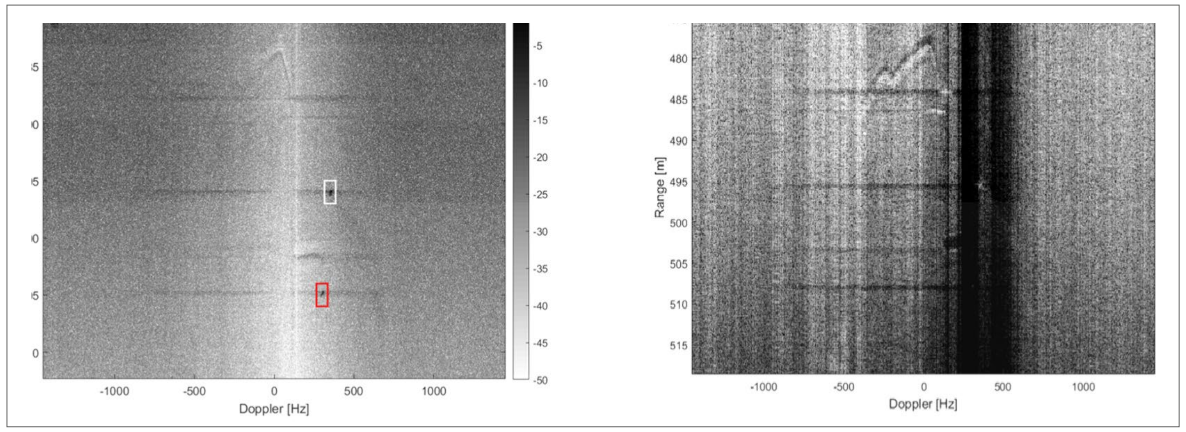
(b) Block diagram for a cognitive radar high level architecture [2]



(c) Cognitive SAR image segmentation-first step: Blue squares are the areas for which the SAR segmentation algorithm shows uncertainties [2]



(d) Cognitive SAR image segmentation-second step: The SAR segmentation memory is updated using the new detected pixels and the SAR segmentation is performed again only on the blues areas that are now classified pixel by pixel without uncertainties [2]



(e) Cognitive SDAP for moving target detection (left) compared to the non cognitive SDAP algorithm (right). The results on the right side shows a worsts mitigation of the background clutter and the moving targets (those highlighted with the rectangles in the left figure) cannot be detected. This is a portion of the SAR image shown in (d) (below the landing strips of the airport) [2]

Simulation 1: fine tuning strategy against SNR

Performance comparison: SNR (Time ↓)

Accuracy [%]	$28.52dB$	$24.42db$	$19.21dB$	$16.57dB$	$15.44dB$	$12.30dB$
Baseline classifier	**100**	**100**	90.75	**83.25**	74.92	58.58
Fine tuning at $28.52dB$	100	100	90.75	83.17	74.92	50.04
Fine tuning at $24.42dB$	100	100	99.83	83.17	74.92	58.58
Fine tuning $9.21dB$	100	100	100	83.25	74.92	52.63
Fine tuning at $16.57dB$	100	100	100	83.17	74.92	66.31
Fine tuning at $15.44dB$	**100**	**100**	100	**83.17**	83.17	66.47

Error rate [%]	$28.52dB$	$24.42db$	$19.21dB$	$16.57dB$	$15.44dB$	$12.30dB$
Baseline classifier	0	0	4.62	8.38	12.54	20.71
Fine tuning at $28.52dB$	0	0	4.75	8.42	12.54	24.98
Fine tuning at $24.42dB$	0	0	0.839	8.38	12.54	23.09
Fine tuning $9.21dB$	0	0	0	8.38	12.54	23.63
Fine tuning at $16.57dB$	0	0	0	8.42	8.42	16.85
Fine tuning at $15.44dB$	0	0	0	8.42	8.42	16.76

Precision [%]	$28.52dB$	$24.42db$	$19.21dB$	$16.57dB$	$15.44dB$	$12.30dB$
Baseline classifier	100	100	92.87	89.97	87.48	84.18
Fine tuning at $28.52dB$	100	100	92.72	89.94	81.64	-
Fine tuning at $24.42dB$	100	100	99.83	89.94	81.64	83.97
Fine tuning $9.21dB$	100	100	100	89.97	81.66	74.26
Fine tuning at $16.57dB$	100	100	100	89.94	89.94	85.65
Fine tuning at $15.44dB$	100	100	100	89.94	89.94	85.68

(f) An example of how the system adapts the training set against SNR variations over time. The performances are measured in terms of accuracy, error and precision. The cognitive classifier, after the on-line learning process (last line of each table), is compared with a non-cognitive classifier (baseline classifier, first line of each table)