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# SVM-BASED CLASSIFICATION APPROACH FOR SYNTHETIC-IMPULSE MICROWAVE IMAGING

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# Technical Report N. 1

## *SVM-based Classification Approach for Synthetic-Impulse Microwave Imaging*

### *Problem Geometry*

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# 1 Introduction

Surface-Penetratic Radar (SPR) is aimed at providing an image of the objects buried in an inaccessible host medium. Such a scenario generally occurs in many applications, ranging from to the search of objects in the subsoil [1] to through-wall imaging (TWI) [2]. In order to effectively reconstruct an accurate image of the investigation area, many methodologies based on x-rays, ultrasonics, eddy currents, or microwaves have been investigated. In such a framework, microwave imaging techniques are very promising since electromagnetic fields at centimeter wavelenghts can penetrate non-ideal conductor materials and are usually low power and relatively inexpensive.

Recently, thanks to the development of effective ultrawideband (UWB) hardware, wideband microwave imaging systems have been proposed. Compared to single-frequency approaches, such systems allow to collect a wider amount of information, since the scattered field can be measured at different frequencies in the working bandwidth and/or in the time-domain. In order to take advantage of multi-frequency data, signal processing plays a key role. Different techniques combining pre-processing treatments and microwave imaging are currently used to construct an image of a scene [3]. In addition, time-reversal (TR) data processing has been recently employed in order to detect positions of the targets in a Synthetic-Impulse Microwave Imaging System (SIMIS) [4].

In such a framework and within the GALILEO 2008 project, the research units, ELEDIA @ Univ. Trento and LEAT @ Univ. Nice, are currently involved in the integration of a SVM-based classification approach in the SIMIS for the reconstruction of the position and the shape of targets. Such a report is focused on the description of problem geometry as well as of the specification of the SIMIS.

# 2 Description of the Problem Geometry

A set of $N$ circular cylindrical scatterers with barycenters $\left(X_n^{obj}, Y_n^{obj}\right)$, $n = 1, ..., N$, radius $r_n$ and height $h_n^{obj}$, $n = 1, ..., N$ are located inside an investigation area $D_I$. The $n$-th scatterer is characterized by the dielectric properties $(\epsilon_r, \sigma)_n$, while the relative permittivity and the conductivity of $D_I$ are $\epsilon_{rD}$ and $\sigma_D$, respectively. The measurement system is located outside $D_I$ as shown in Fig. 1 and consists of a linear array of $M$ exponential tapered slot (ETS) antennas, equally spaced by $s$. Each antenna can be used either as a transmitter or a receiver, so $M^2$ measurements are available if all the possible combinations of emitting and receiving antennas are considered. In particular, when the $m$-th antenna is both transmitter and receiver the $S_{11}(f)$ reflection parameter is measured, otherwise the transmitting parameter $S_{21}(f)$ is collected in the frequency range $f_{min} < f < f_{max}$. Alternatively, an extra antenna can be used as transmitter while the array elements act as receivers. The main advantage of the second configuration is that different emitting antenna typologies and positions can be employed without affecting the receiving system. However, in such a case only $M$ $S_{21}(f)$ parameters are available.

The measurements are performed both with and without the scatterer in order to obtain differential data, wherein the contribution of the environment is removed by subtraction.

As for the specifications of the SIMIS, the system collects the scattering measurements by means of $M = 8$ ETS antennas working in the frequency band between $f_{min} = 1.4\,GHz$ and $f_{max} = 20\,GHz$ (Fig. 2). Each antenna can be employed as a transmitting and receiving device by means of two electromechanical microwave 1-to-$M$ multiplexers. A two-port vector network analyzer provides RF signal to the transmitting antenna and measures reflection and trasmission $S$ parameters.

## References


[1] H. Schubert and A. Kuznetsov, *Detection of Explosives and Landmines: Methods and Field Experience*. Kluwer Academic Publishers, Boston, 2001.

[2] D. D. Ferris and N. C. Currie, "A survey of current technologies for through-wall-surveillance (TWS)," *Proc. SPIE*, vol. 3577, pp. 62-68, 1998.

[3] D. J. Daniels, *Ground Penetrating Radar*, 2nd ed., IEE Radar, Sonar, Navigation and Avionics Series. The Institution of Electrical Engineers, London, 2004.

[4] A. Cresp, I. Aliferis, M. J. Yedlin, C. Pichot, and J.-Y. Dauvignac, "Investigation of time-reversal processing for surface-penetrating radar detection in a multiple-target configuration," submitted to *2008 European Radar Conference* (*EuRAD08*), 30-31 October, Amsterdam, 2008.

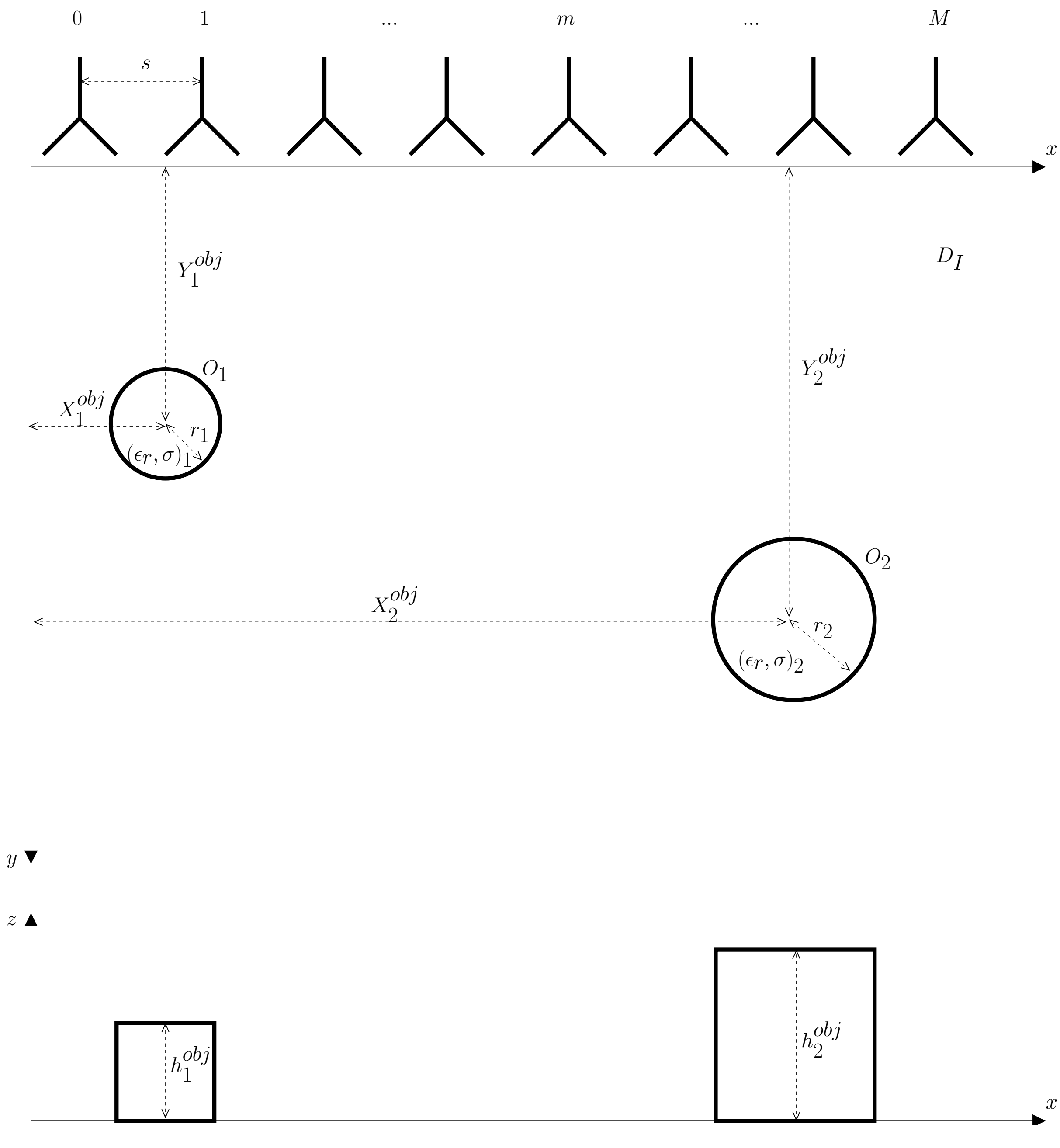


**Fig. 1** - Geometry of the measurement system.

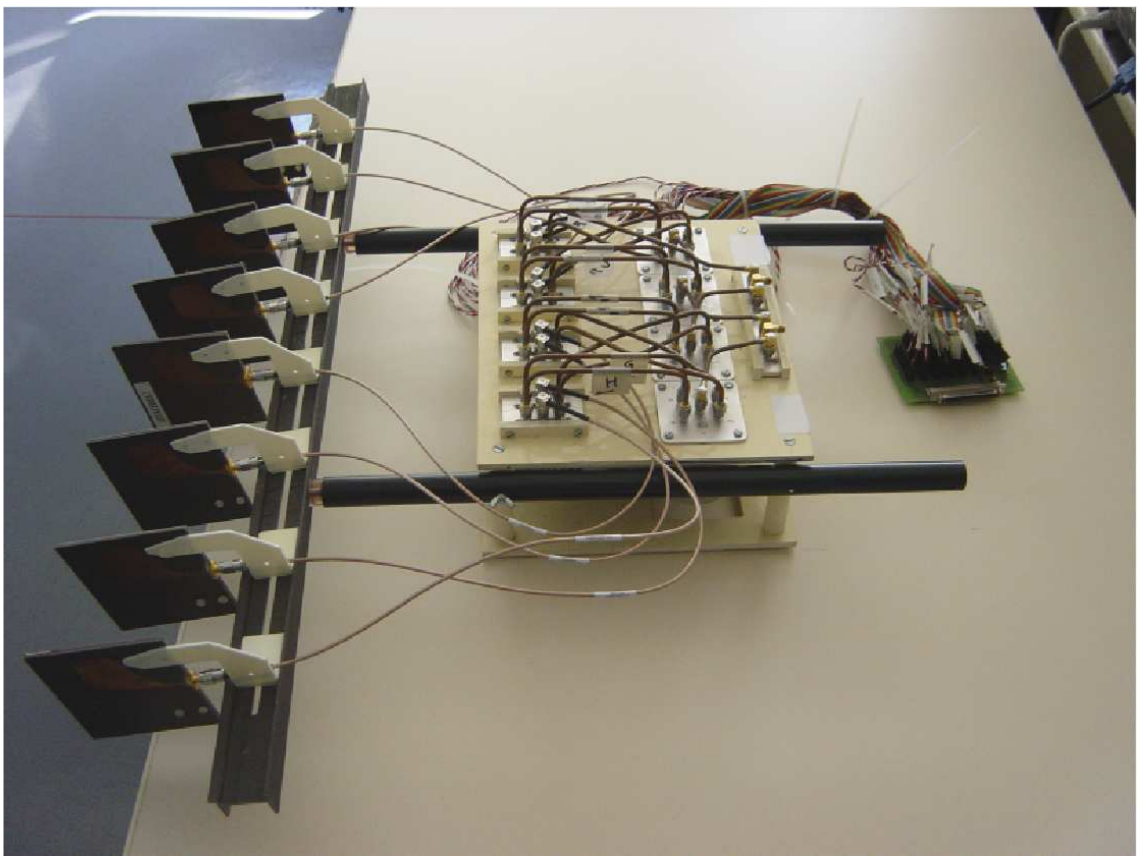

**Fig. 2** - Prototype of the SIMIS radar.