PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Salvatore Savarese

XXX Cycle

Training and Research Activities Report – Third Year

Tutor: Amedeo Capozzoli

co-Tutor: Angelo Liseno, Claudio Curcio

1. Information

Salvatore Savarese, MS Degree in Electronic Engineering – Università di Napoli Federico II

XXX Cycle- ITEE – Università di Napoli Federico II

Fellowship type: POR FSE Campania 2007-2014/2014-2020

Tutor: Amedeo Capozzoli
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2. Study and Training activities

a. Seminars

- "Nanostructured Materials Based Biosensors: Engineering next Generation of Biomedical Devices", Prof. Luca De Stefano, 25/01/2017

- "High Performance Logic Devices and Applications to CODAC systems", Prof. Bernardo Carvalho, 09/06/2017

b. External courses

- "European School of Antennas - Antennas for Radio telescopes" at Stellenbosch University – Stellenbosch, SA, from 21/11/2016 to 25/11/2016

	Credits year 1								Credits year 2								Credits year 3									
		1	2	3	4	5	6			1	2	3	4	5	6			1	2	3	4	5	6			
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Total	Check
Modules	20	0	10	0	3	6	6	25	10	0	3	0	3	0	0	6	0	3	0	0	0	0	0	3	34	30-70
Seminars	5	0	0,8	2	1,6	0	0	4,4	5	1,4	1	0	1	0	0	3,4	5	0	0,4	0	0,4	0	0	0,8	8,6	10-30
Research	35	7	4	6	5	3	6	31	45	8	8	9	8	9	9	51	55	6	10	10	9	10	10	55	137	80-140
	60	7	15	8	9,6	9	12	60	60	9,4	12	9	12	9	9	60	60	9	10	10	9,4	10	10	59	180	180

3. Research activity

The research activity has been focused on advanced diagnosis techniques for radio telescopes for astronomical applications.
The performance of radio telescope systems can be affected by structural variations due to:

- Misalignment of the feeding structure, resulting in a lateral or axial displacement of the receiver;
- Wind stress;
- Gravitational distortion as the antenna is tilted;
- Thermal distortion with ambient temperature or sunlight.

Diagnosis methods are necessary to estimate any deviation of the antenna system from its nominal behavior in order to guarantee the maximum performance.
Several approaches have been developed during the years, and among them the electromagnetic monitoring appears today as the most appealing, because it allows a relatively simple measurement setup and a reduced human intervention.
Electromagnetic monitoring is based on the acquisition of the antenna Far Field Pattern (FFP) in amplitude and phase, or only amplitude, with the Antenna Under Test (AUT) working in receiving mode.
A natural radio star or a satellite beacon provides the signal source.
The acquisition of the FFP typically requires a very large number of field samples to get the complete information about the AUT, and the subsequent measurement process may span over several hours. A prolonged acquisition has significant drawbacks related to the continuous tracking of the source and the inconstancy of the environmental conditions.
The research activity has been focused on an optimized formulation of the diagnosis of radio telescopes aimed at reducing the number of field samples to acquire, minimizing the measurement time.
A diagnosis approach has been developed, based on the Aperture Field method for the description of the AUT radiation mechanism. A Principal Component Analysis has been employed to restore a linear relationship between the unknowns describing the AUT status and the far field data. An optimal far field sampling grid is selected by optimizing the singular values behaviour of the relevant linearized operator.
The approach has been experimentally validated in an outdoor antenna test range, which has been set up thanks to the collaboration with Istituto Nazionale di Astrofisica (INAF) of Naples.
During the third year, a computational tool based on Geometrical Optics (GO) has been developed to improve the diagnosis approach.
Indeed, once the Aperture Field has been recovered from the inversion of the measured FFP, an additional step is required to assess the AUT status from the phase distribution. Obviously, the computation of the phase distribution should be based on efficient algorithms in order to properly manage electrically large reflectors.
The GO technique developed relies on the Fast Marching Method (FMM) for the direct solution of the eikonal equation. A GO approach based on the FMM is appealing because it shows a favorable computational trend. Furthermore, the explicit solution of the eikonal equation opens the possibility to set up an inverse ray tracing scheme, which proves particularly convenient compared to direct ray tracing because it allows to easily select the minimum number of rays to be traced. The FMM is also amenable for parallel execution. In particular, in the present work the Fast Iterative Method has been implemented on GPU.
Moreover, the FMM has been accelerated by introducing a tree data structure. The tree allows to manage the mutual interactions between multiple scattering surfaces and the parallelization of the ray tracing step.
The method has been numerically tested on simple canonical cases to show its performance in terms of accuracy and speed. Then is has been applied to the evaluation of the Aperture Field phase required by the reflector diagnosis.

Collaborations

Osservatorio Astronomico di Capodimonte - Istituto Nazionale di Astrofisica(INAF-OAC) - Ing. Pietro Schipani

4. Products

Conference Papers

Capozzoli A., Curcio C., Liseno A., and Savarese S.,
"Accelerating Fast Marching for Geometrical Optics"
Applied Computational Electromagnetics Society Symposium-Italy (ACES), 2017 International. IEEE, 2017.

Capozzoli A., Celentano L., Curcio C, Liseno A., and Savarese S.,
"Optimized Near Field with an Optimized Controller"
12th European Conference on Antennas and Propagation (EuCAP 2018) - submitted