

Department of Computer Science
University of Salzburg

PS Natural Computation, SS 2005

Evolutionary Optimization of Radar Antenna Arrays

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1 Introduction

The modern level of remote sensing systems makes possible to solve the wide scope of problems beginning from object detection and finishing by object recognition. The further development of such kind of systems requires special antennas with small size and weights for airborne location and with high spatial resolution.

The approach is to obtain image using sparse array with quality similiar to quality that could be reached by systems with filled array with a considerable gain in the quantity of antenna array elements.

Therefore we seek a sensor layout that yields the smallest sidelobes in the array beam pattern. Any emissions not in the main interrogation beam are referred to as side lobes. The technical background is based on a paper from Nicholas K. Spencer (Cooperative Research Centre for Sensor Signal and Information Processing, AUSTRALIA), where non-uniformly spaced linear arrays (NLAs) are optimized.

2 Milestones

- Due date: 16.03.2005: settling-in period: get information, read paper from Nicholas K. Spencer (Cooperative Research Centre for Sensor Signal and Information Processing, AUSTRALIA)
- Due date: 06.04.2005: working with JEvolution, compile and test the code composed by Helmut Mayer - first test runs, create a project page, discuss further work
- Due date: 13.04.2005: try to find fitness function for maybe a faster computation
- Due date: 20.04.2005: design a graphical output for the antenna array beam pattern
- Due date: 27.04.2005:
- Due date: 04.05.2005: implement a graphical user interface to enhance usability
- Due date: 11.05.2005:
- Due date: 18.05.2005: get the sparsed phase antenna array more flexibel, which means: allow to change length of the array and number of used sensors
- Due date: 25.05.2005: compare our results generated with the new implementations to the results of Spencers paper
- Due date: 01.06.2005:
- Due date: 08.06.2005: Finish our project paper

3 Progress Of Work

3.1 Week 1, Wednesday, 16.03.2005

The first week was our settling-in period and it consists of some small parts. The first part was getting some information about sparse antenna arrays. Therefore we organized some literatur like Radar Signals (Nadav Levanon and Eli Mozeson, Wiley 2004). We read the paper from Nicholas K. Spencer (Cooperative Research Centre for Sensor Signal and Information Processing, AUSTRALIA)

3.2 Week 2, Wednesday, 06.04.2005

We got JEvolution and the programcode from Mr. Mayer to work. Therefore we used the building tool Ant, because it makes testing much easier and its build file is extensible if necessary. For presenting our progress we created a project page <http://student.cosy.sbg.ac.at/mmes-sner/natural/>, where our weekly tasks and new ideas will be shown.

3.3 Week 3, Wednesday, 13.04.2005

This week we concentrated on the fitness-function implemented in the evolutionary finding process for the antenna structure. To our surprise we found out, that the problem to minimize the sidelobes and maximize the mainlobe could probably be solved by implementing a weighth-function like the Blackman or the Hamming-window.

3.4 Week 4, Wednesday, 20.04.2005

To make our common work less redundant we divided responsibilities among us as follows:

- search for eventually new fitness-function and research in weight-function for sidelobe supression
- implement a visual output for the array beam pattern - will be probably done with a Java applet
- write a Graphical User Interface to enhance usability
- implement and test new ideas; try to find optimal settings like number of arrayelements and sensors

This goals should be realized within the next few weeks.

3.5 Week 5, Wednesday, 27.04.2005

Because the textual output of the data produced by the evaluation was not very satisfying we designed a Java Applet for graphical output. It is now much easier to recognize, if a evaluation was more or less successfull.

3.6 Week 6, Wednesday, 04.05.2004

To provide a easier way for changing the variables we implemented a simple but effective GUI.

3.7 Week 7, Wednesday, 11.05.2005

During our reseach it ocured to us, that the use of a full phase antenna array without sensorgaps would provide a very strong mainlobe and minimize the sidelobes because of the phase overlay. To get proof of this idea, we decided to evaluate a complete 55 sensor array with a sensor at each position. To our disappointment the result wasn't as satisfying as we thought. The reason is unknown until yet and has to be researched.

3.8 Week 8, Wednesday, 18.05.2005

For many uses is would be insufficent to have a array with fixed length and a number of 16 sensors determined. Often it would be useful to work with a bigger oder smaller array because of the variance of the wave length used for different tasks. For this reason (and surely because of the main goal - to minimize the sidelobes and increase the power of the mainlobe) we got the sparsed phase antenna array more flexibel. Which means, that now it is allowed to change the length of the array and the number of the used sensors.

3.9 Week 9, Wednesday, 25.05.2005

Thanks to our last weeks work it was possible to generate easy and very flexibel many generations of antenna arrays. These arrays vary in length, number of used sensors or both at the same time. Within many runs we experimented with a different number of sensors in arrays with varying length. With length we mean the total number of spots where a sensor could be placed. Our very interesting results will be found soon in our project paper.

3.10 Week 10, Wednesday, 01.06.2005

Finally we finished our evaluations and test runs and started writing our project paper.

3.11 Week 11, Wednesday, 08.06.2005

4 Subproject responsibilities

Auracher Michael:

- implement a visual output for the array beam pattern - will be probably done with a Java applet
- write a Graphical User Interface to enhance usability

Lugstein Wolfgang:

- implement and test new ideas; try to find optimal settings like number of arrayelements and sensors

Messner Markus:

- testing the existing programm and new features
- compare our results and those from the paper

Schiefer Thomas:

- theoretical background radar antenna arrays
- search for eventually new fitness-function and research in weight-function for sidelobe supression

5 JEvolution

Author: Helmut A. Mayer from the Department of Computer Science, University of Salzburg.

For the development of our strategy, we use the framework JEvolution. It is an optimization tool which works with EA (Evolutionary Algorithms). It is very easy to use, but not only for novices. Also expert can use this tool for optimization and finding a solution for a problem. The software has many possibilities to configure the algorithm for selection and mutation.

6 Links

- Our site: <http://student.coby.sbg.ac.at/~mmessner/natural/>
- JEvolution framework: <http://www.coby.sbg.ac.at/~helmut/Teaching/NaturalComputation/proseminar.html>