Investigating the convergence of algorithms for Radar Resource Management

Due to improvements in hardware and software, radar systems are getting more and more degrees of freedom. Some examples are the rise of phased-array antennas, digital beamforming (DBF) and digital waveform generation. This led to so-called multi-function radar (MFR) systems. In the past, a radar was usually used in a single mode and multiple radar tasks often needed to be performed successively or by separate radar systems. Nowadays, MFRs are able to execute many functions jointly and practically in parallel, especially due to the possibility of very quick changes in the direction of the beam by the use of phased-array antennas.

A big problem for the control of MFR systems is that its resources, especially the sensor time, are limited. Therefore it is common for a radar to work in some kind of overload situation where it cannot give all objects the same amount of attention. Due to the fact that MFRs are supposed to handle many different tasks in parallel, those limited resources have to be distributed to the different tasks according to their importance. Radar Resource Management (RRM) is usually not a simple scheduling problem, because the length of the tasks can be adjusted according to the importance of a target.

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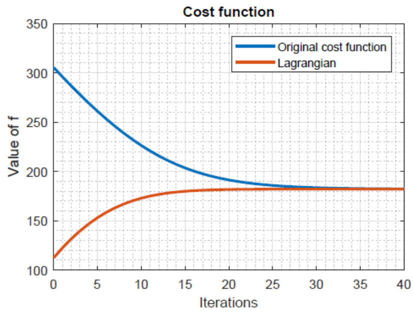

Our approach is the combination of a constrained Partially Observable Markov Decision Process (POMDP) and Lagrangian relaxation. The POMDP framework will be used to implement a non-myopic RRM, which means that future time steps are going to be taken into account when a decision is made about the next best action. By applying Lagrangian relaxation, the optimization problem can be simplified by including the constraints into the objective function and decoupling the overall problem into smaller optimization problems, one per task.

In order to find an optimal solution with Lagrangian relaxation, iterative algorithms need to be used that recursively find the optimum for the Lagrange multipliers. Some possible algorithms are for instance the subgradient method, the Nesterov accelerated gradient descent or the proximal algorithm.

The project will consist of several parts:

- Understand the background of RRM and study some possible approaches [1][2][3].
- Study certain aspects of convex optimization theory and Lagrangian relaxation [4][5].
- Review different iterative methods to solve constrained convex optimization problems [6][7].
- Apply the found methods on Lagrangian relaxation in a typical RRM framework (for instance assigning sensor time to different targets in a tracking scenario).
- Investigate the influences of different input values for the algorithms (for example the initial guess or the step size) and how multiple algorithms can be combined for improved performance.

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References:

[1] P. W. Moo and Z. Ding, Adaptive Radar Resource Management. Academic Press, 2015.

[2] A. O. Hero and D. Cochran, "Sensor Management: Past, Present, and Future," IEEE Sensors Journal, vol. 11, pp. 3064-3075, Dec 2011.

[3] A. O. Hero, D. A. Castanon, D. Cochran, and K. Kastella, Foundations and Applications of Sensor Management. Springer Publishing Company, Incorporated, 1st ed.,2008.

[4] S. Boyd and L. Vandenberghe, Convex Optimization. Cambridge University Press, 1st ed., 2004.

[5] D. Bertsekas, Convex Optimization Theory. Athena Scientic, 1st ed., 2009.

[6] Bertsekas, Dimitri P. (2015). Convex Optimization Algorithms. Belmont, MA.: Athena Scientific. ISBN 978-1-886529-28-1.

[7] Sébastien Bubeck (2015), "Convex Optimization: Algorithms and Complexity", Foundations and Trends in Machine Learning: Vol. 8: No. 3-4, pp 231-357. http://dx.doi.org/10.1561/2200000050