

Reduction methods for grid cover problem used in radar applications

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Modern radars are highly flexible and can dynamically perform adaptive covering to operational constraints. Set covering is an efficient formulation for optimizing radar search patterns [1], as displayed in Figure 1, but is known to be NP-hard to solve [2]. In practice, computation time is directly dependant on the problem size, i.e. number of variables (columns) n and number of constraints (rows) m . In case of grid covering by rectangles, the number of variables is usually quadratic in the number of constraints: $n \sim m^2$

Removals of rows and columns is a common preprocessing step in solving covering problems [3]. A column is redundant if another column covers the same constraints for equal or inferior cost. A row makes another row redundant if the covers of the former are all covers for the latter. Naive removal of redundant rows is performed by comparisons of all pairs of columns in $O(n^2m) = O(m^5)$, and similarly, naive removal of redundant rows is $O(nm^2) = O(m^4)$.

Exploiting the geometrical properties of rectangular covers, it is possible to perform exhaustive removal of columns in $O(m^2)$ and removal of rows in $O(m^3)$. In practical cases, row removal does not make such a difference a computational time, as the number of constraints is usually low to begin with (within a few thousands), but column removal can lead to a significant speed-up as the number of variable can be high (up to several hundred thousand), allowing real-time optimization of adaptive radar search patterns in operational situations.

References

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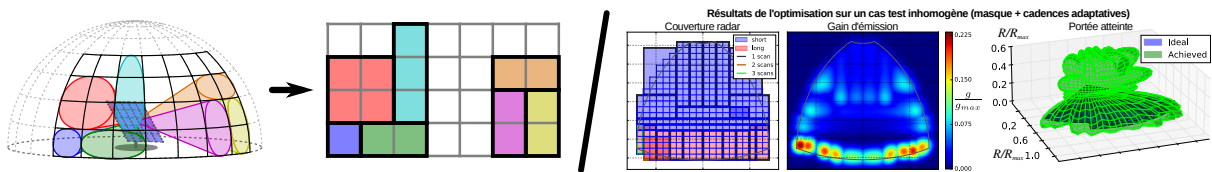


Figure 1: Radar search pattern representation as grid cover (left) and simulation example (right)