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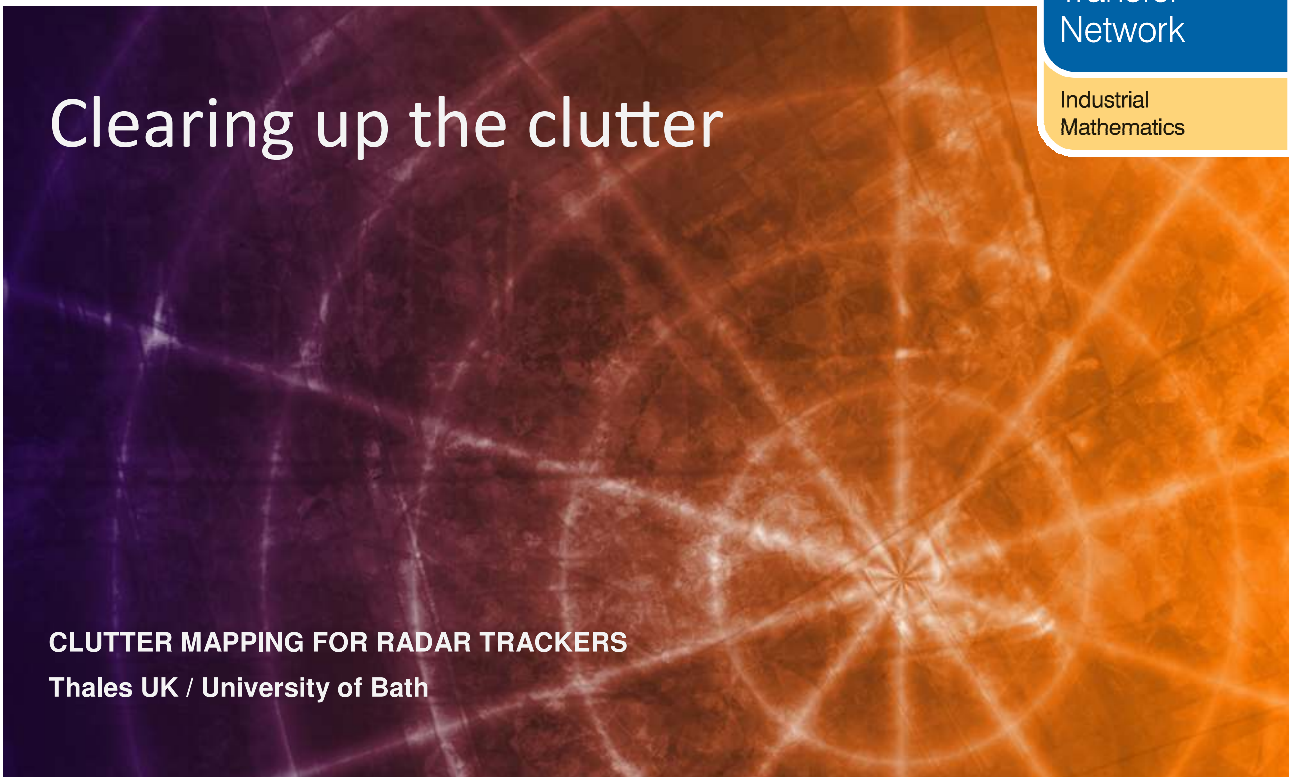

# Clearing up the clutter

**CLUTTER MAPPING FOR RADAR TRACKERS**

**Thales UK / University of Bath**

## The need

Surveillance radars detect and locate objects of interest, or 'targets', but also produce unwanted detections from other physical entities called 'clutter'. Separating targets from clutter requires having an accurate estimate of the clutter density. The challenge is harder when there are discontinuities in the clutter, such as at the boundary between sea and land.

A 'tracker' identifies combinations of data having similar characteristics to real targets. It uses a track score to distinguish between targets and clutter. The estimate of clutter density is used to update the track score as part of this process. It is particularly important not to underestimate this density, to avoid false tracks being declared as targets.

## The outcomes

This project enabled Thales to construct a clutter density estimator that is accurate, data-driven and operable in real time, even in the presence of discontinuities.

The new method has been implemented in MATLAB using a model problem. It incorporates a boundary-detection algorithm, based on Delaunay triangulation, which avoids the problems that grid-based methods have in dealing with discontinuous clutter densities.

The benefit of more accurate clutter density estimates will be improved sensitivity of trackers in identifying targets. This in turn will provide better automation of the entire procedure, with reduced operator workload.

Thales has benefited from the ability to explore, in depth, fields of research that were not previously considered. The research will be continued by applying the method to real radar data that contains more complex physical features.

The student has developed insights into the way that research and business are conducted at a large international company, and an understanding of how mathematics is used and needed in radar systems technology.

*"We have found the internship mechanism to be an effective tool for advancing our understanding of the topic. The interaction between the project team and KTN has been particularly stimulating, and we would welcome similar opportunities in the future."*

**Glen Davidson**
**Thales UK**

## Technical summary

The naïve approach to estimating clutter density partitions the domain into a grid, and finds the density in each grid cell. However, unless the grid cells are aligned with the boundaries of the discontinuities or somehow capture the physical features of the data, this approach has limitations.

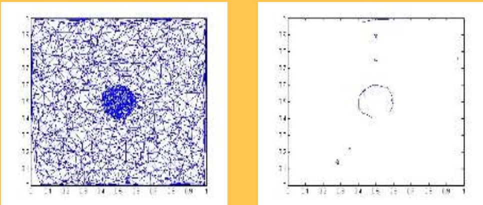

*Figure 1: Delaunay triangulation of data points (left) and boundary extraction (right)*

We instead used a data-driven approach, combining boundary extraction with density calculation. The core of the boundary extraction is *Delaunay triangulation* (Figure 1), which captures the local proximity of points and is used to identify the boundaries of discontinuities. Note that randomness in the data means that some 'false edges' remain after the boundary extraction.

Using the extracted boundary, the density at every point in the domain is estimated (Figure 2). For each point, we identify the nearest 100 neighbouring points that do not lie on or across the boundary, and use the triangulation to find the area that covers these points. A sample size of 100 gives an expected error of approximately 10%. Errors in the implementation were consistent with these expectations, even at points near the boundary. We also determined numerically the percentage of false edges generated by the boundary extraction method, and these were also found to be in agreement with theoretical predictions.

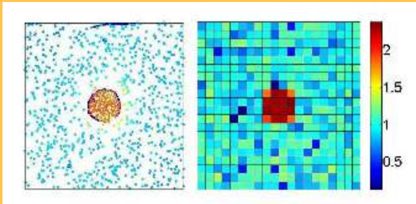


*Figure 2: Density estimation using our method (left) and the grid-based approach (right)*

In contrast, the alternative, grid-based approach is largely unsuccessful in estimating clutter density, and suffers in particular from a systematic bias at cells on the boundary.

*"The internship has given me an invaluable insight into the use of mathematics in industry. From it I will take away a wide range of experience and technical skills. I would recommend such an opportunity to any mathematics PhD student with an interest in pursuing a technical career in industry."*

**Sean Buckeridge**
**University of Bath**

*"Seeing some of the mathematical tools developed and studied in academia being used in real-life applications is an important measure for the success and impact of our work"*

**Rob Scheichl**
**University of Bath**

This internship was part of the Underpinning Defence Mathematics programme, a joint initiative of the UK Ministry of Defence and the Knowledge Transfer Network (KTN) for Industrial Mathematics. The KTN works to exploit mathematics as an engine for innovation. It is supported by the Technology Strategy Board, in its role as the UK's national innovation agency, and the Engineering and Physical Sciences Research Council, in its role as the main UK government agency for funding research and training in the physical sciences.

EPSRC
Engineering and Physical Sciences Research Council

## Project Details

**Partners**
Thales UK
University of Bath

**Project investment**
£15,000

**Intern**
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