Where Should The Sensors Go?

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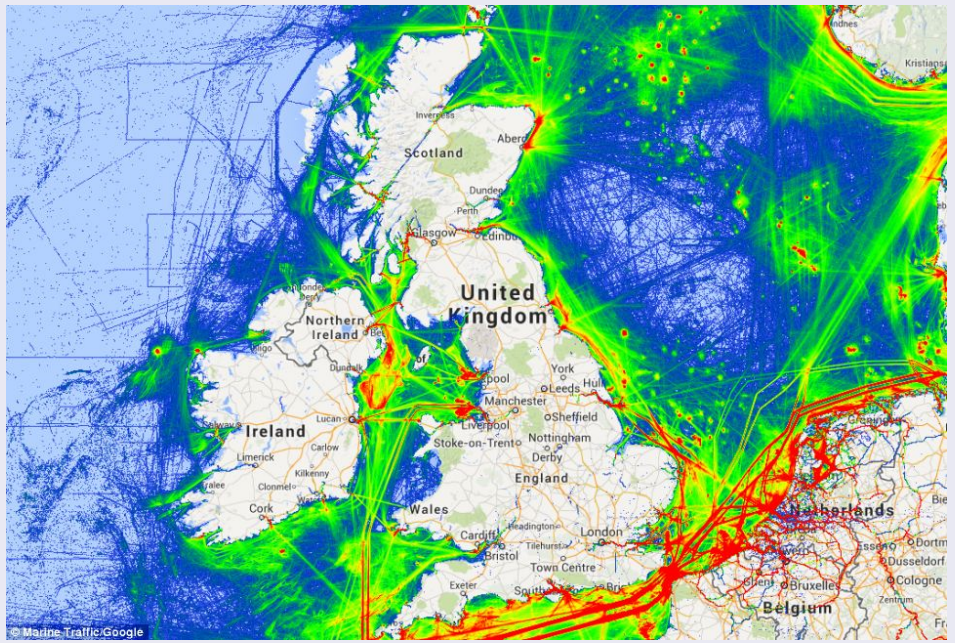
Outline

The problem

We have some data on where ships go.
Using this, where should we place the sensors to minimise the error on the estimated ship position?

UK maritime activity



Model of the sound emitted by ships

- A sensor at position x_s hears a sound y emitted by a ship at position x according the the following model

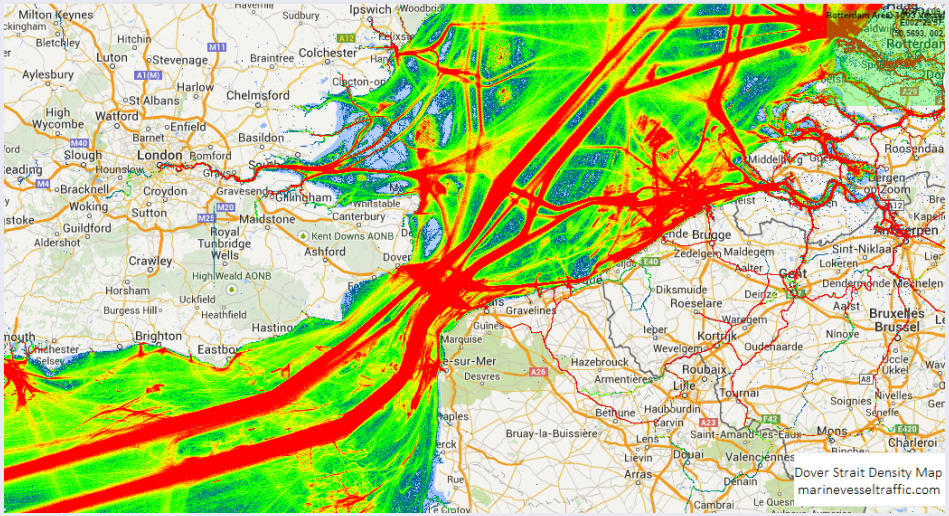
$$y = h(x) + \zeta \tag{1}$$

where $\zeta \sim \mathcal{N}(0, \sigma^2)$ and

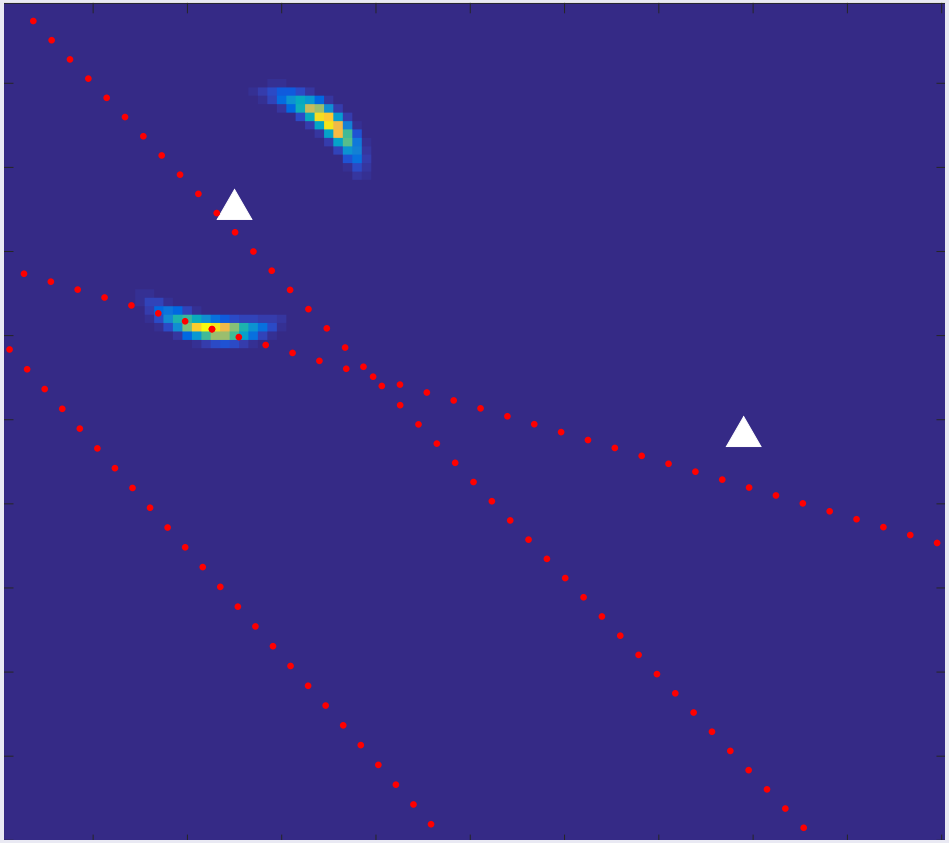
$$h(x) = \rho - 10 \log_{10}(||x_s - x||) \tag{2}$$

Shipping lane model

Shipping lanes through the channel



An ingenious model



Objective

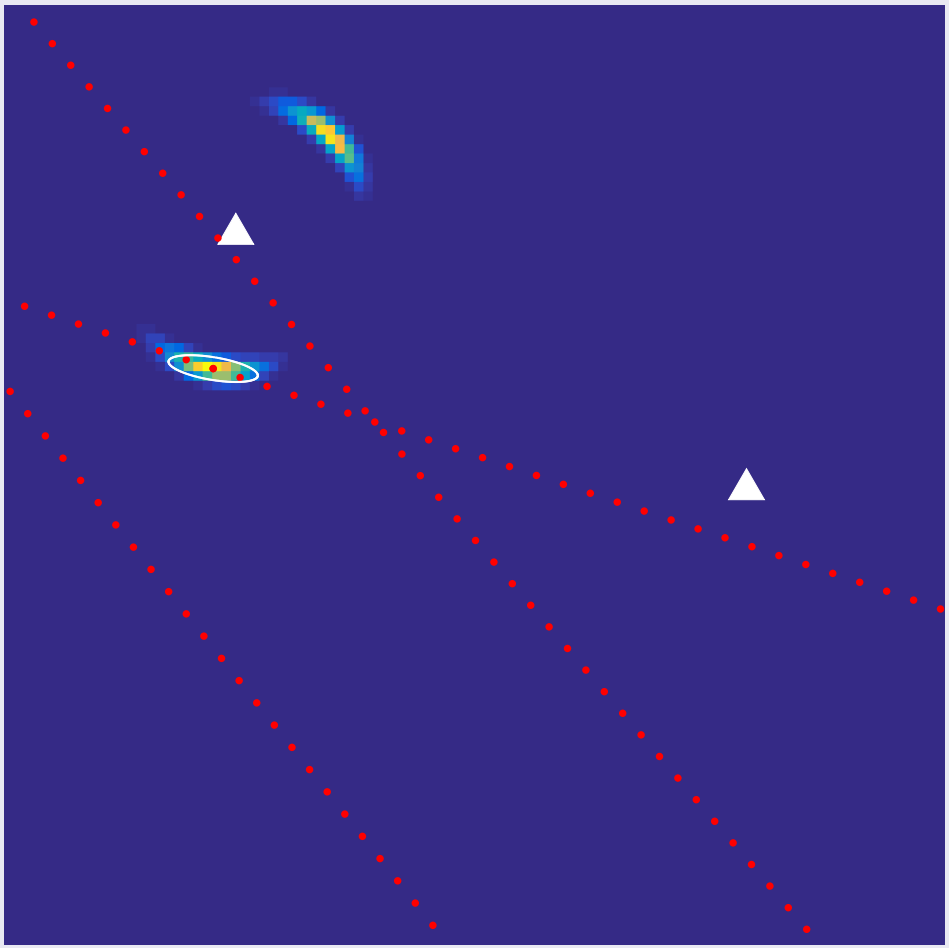
The objective

Determine

$$\theta_{\min} = \min_{\theta} \int_{\gamma} \mathrm{Tr}(\mathrm{cov}(P(s,\theta)))ds \tag{3}$$

where θ represents a sensor configuration, $P(s,\theta)$ is *the covariance of the posterior*, and γ is some number of arclength parametrised curves each representing a shipping lane.

An ingenious model

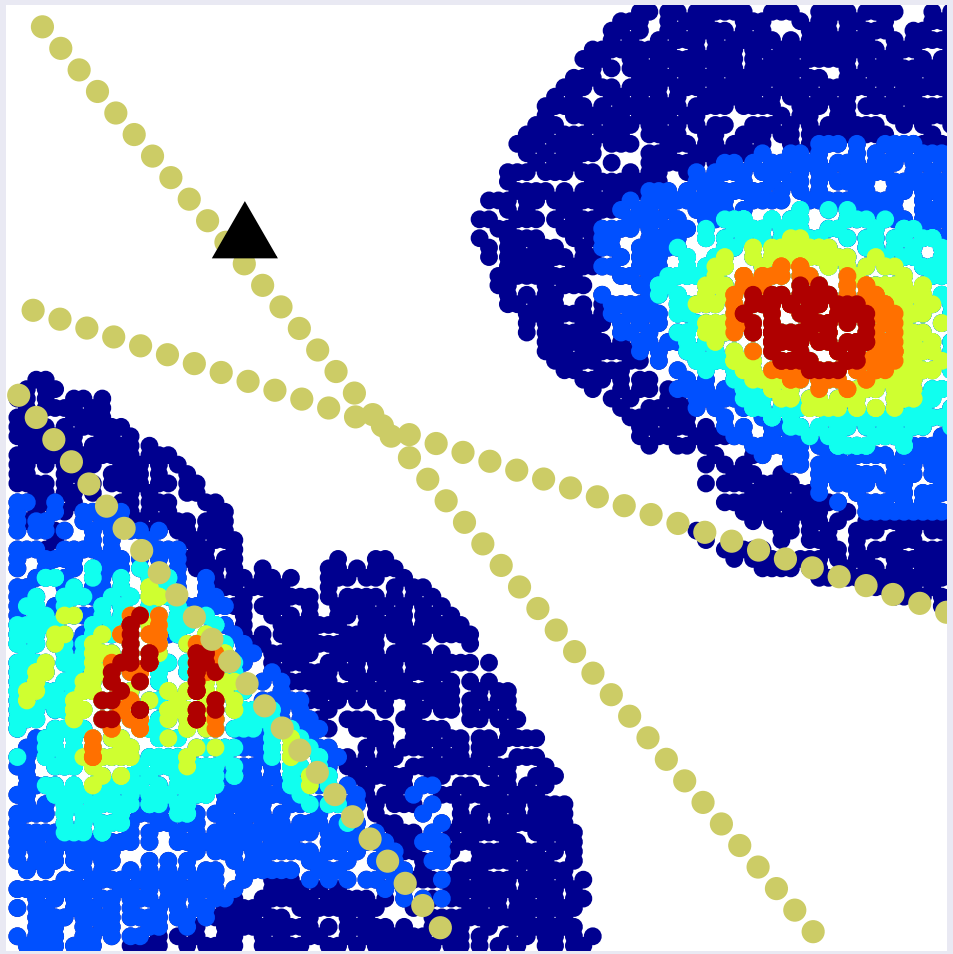


Optimal sensor placement

Finding a good initial sensor configuration

(1) Place one sensor at random
(2) Place the second sensor at the best position given the position of the first
(3) Place the third sensor at the best position predicted given the positions of the first two
(4) Proceed recursively

Given a single sensor in the sea, where should we place the next?



Further work

Refining a good initial sensor configuration

Move sensors around according to some sort of MCMC algorithm like simulated annealing

Include more ships

Instead of a minimising the error on a single ship, minimise the error on a chain of ships, each .

Incorperate ship position into the prior

We believe ships are more likely to be in shipping lanes than not.

Constrain sensor positions

It may be forbidden to place sensors on shipping lanes or land

Reference I

Paul Zarchan; Howard Musoff (2000).
Fundamentals of Kalman Filtering: A Practical Approach.
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