Active Learning for Level Set Estimation

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Problem

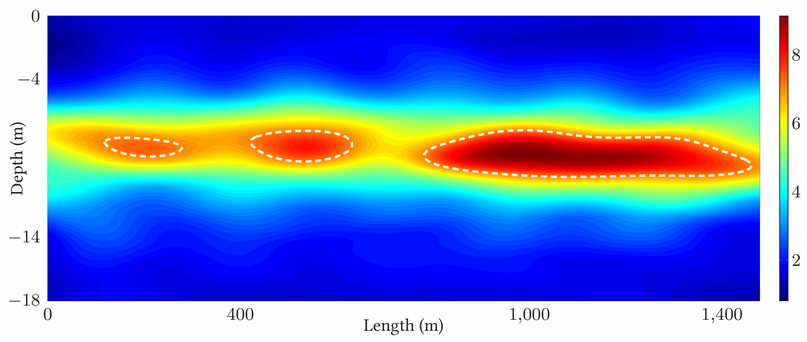
We would like to determine the regions where the value of some unknown function lies above or below a given threshold level.

The above can be posed as a classification problem (into super- and sublevel sets) with *sequential* measurements, which are assumed to be *expensive* and *noisy*.

Example applications

Environmental monitoring

Estimate regions of a lake transect where algae concentration is “abnormally high”.



Geolocating internet latency

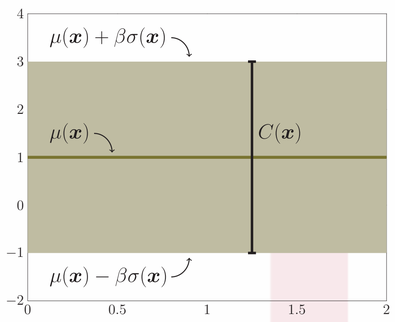
Estimate regions of the world with “acceptable” latency to our PC, e.g. for trouble-free online gaming.

Gaussian processes

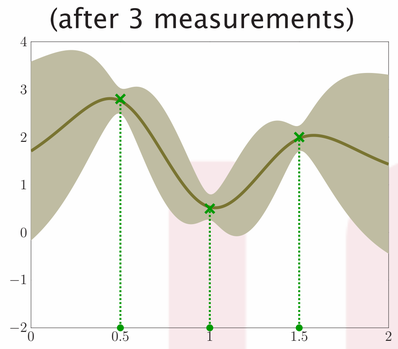
Estimation

Given some measurements, GPs provide *mean and variance* estimates of the unknown function, allowing us to construct *confidence intervals* at each point.

Prior

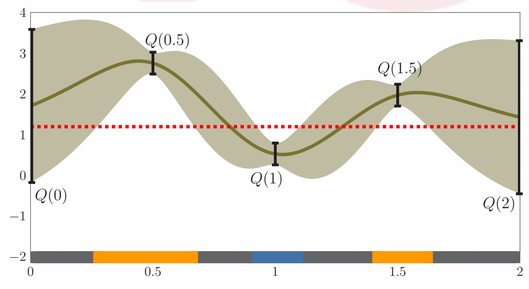


Posterior
(after 3 measurements)



Classification

For each point, we use the GP-derived confidence intervals to either classify it into the super- or sublevel sets, or leave it unclassified.



Measurement selection

To obtain informative measurements w.r.t. the problem at hand, at each iteration we select the most *ambiguous* point among the yet unclassified to be measured.

Intuitively, ambiguity quantifies our difficulty in classifying a point w.r.t. the given threshold level.