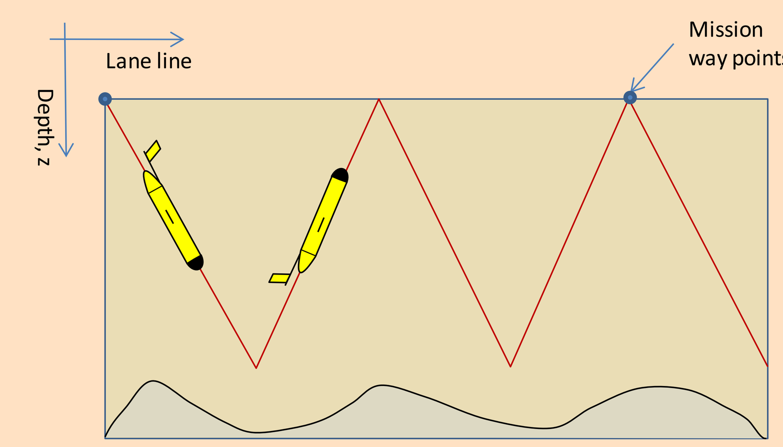
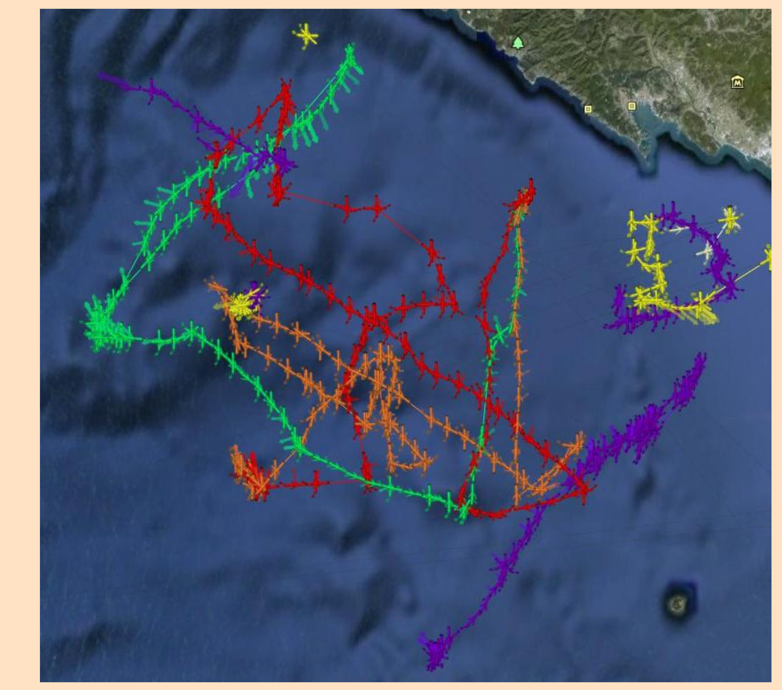
SONGs: Self Organizing Network of Gliders for Adaptive Sampling of the Ocean

M. Cococcioni, A. Alvarez, R. Grasso, D. Cecchi and C. Trees – NATO Undersea Research Centre, La Spezia, Italy

Abstract

NURC is continuously developing new techniques for adaptive sampling of the ocean using a fleet of gliders.
In this work a new heuristic method for obtaining next gliders' way-points is proposed.
The method first meshes the uncertainty distribution of the METOC variable under observation (sea surface temperature, significant wave height, etc.), than it detects the clusters of the knots provided by the meshing algorithm. The centroids of the detected clusters are used as next way-points.





1. Underwater Gliders

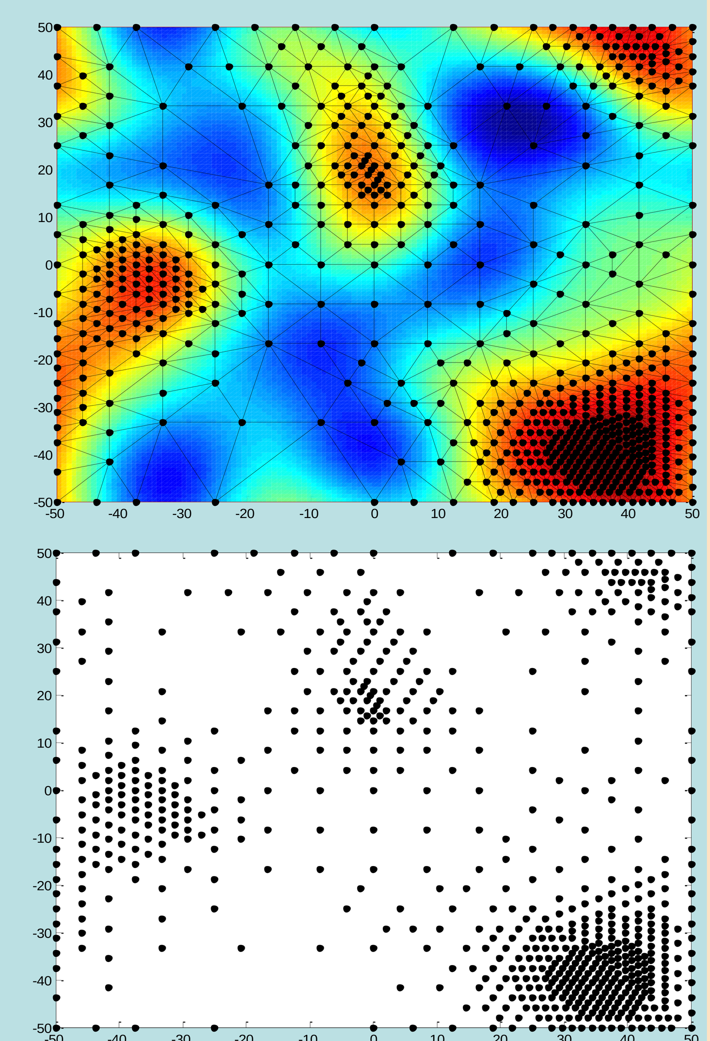
Underwater Gliders are a cost-effective technological solution to sample the ocean.

In highly dynamic areas, adaptive sampling is preferable to static sampling, in order to increase performance by optimally making use of a limited number of gliders.

The relatively low cost of these sampling platforms, is opening the door for many research institutions to purchase a fleet of gliders.

When a fleet of gliders has to sample for a long period of time in situ measurements like conductivity, temperature and depth, there is the need to continuously update the glider missions to take into account sampling needs.

2. Network of Gliders



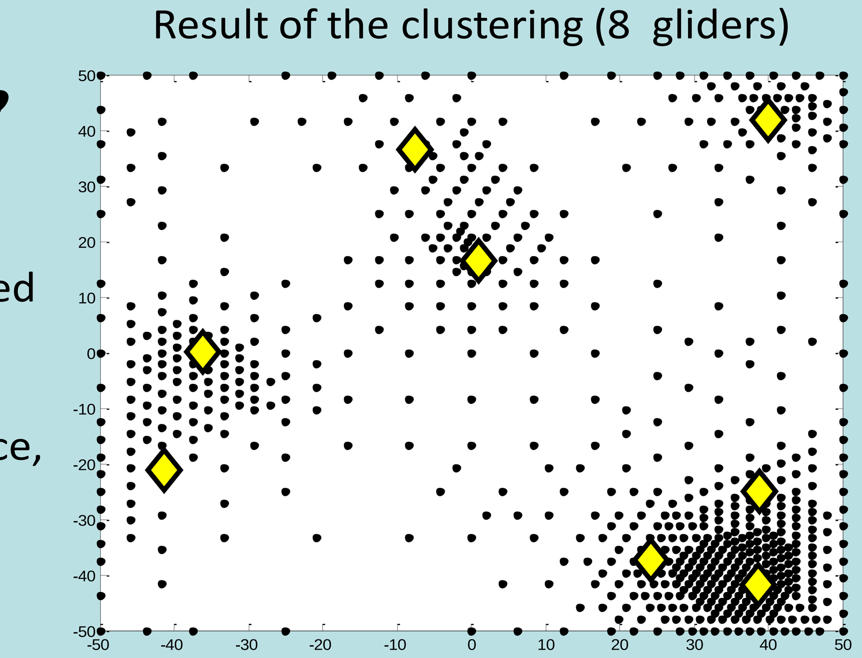
How to plan the paths of a fleet of gliders is the topic of this work.

Using a global cost function, we are able to mesh the area of interest in such a way that finer resolution is used on regions needing a more accurate sampling, while coarser resolution is used on the rest.

The global cost function can be both the expected prediction error or the expected uncertainty level.

3. Clustering the knots

Result of the clustering (8 gliders)

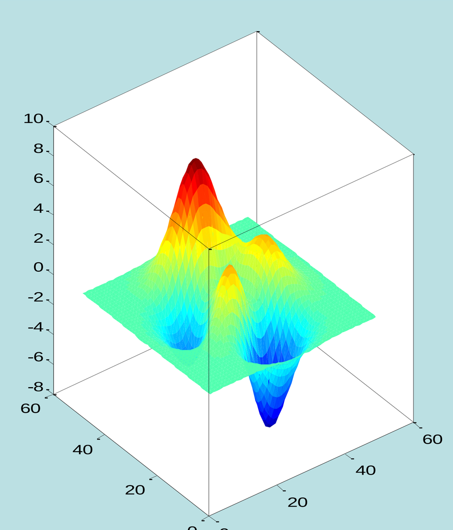


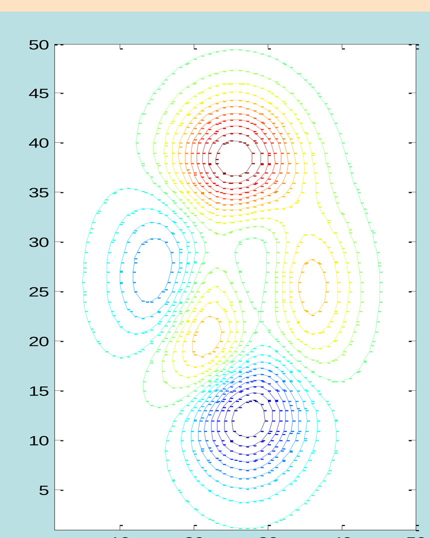
Once the mesh has been obtained using a meshing algorithm, the associated knots, considered as points in a two-dimensional space, give us an idea on how to adaptively sample the area.

This set of points can be fed to a clustering algorithm (like the fuzzy c-means algorithm) in order to get the position of the centroids, where the number of clusters is equal to the number of available gliders.

The centroids' positions can be used at the next surfacing points (way-points) for each of the associated gliders (a glider is associated to its closest centroid).

4. Advantages of meshing



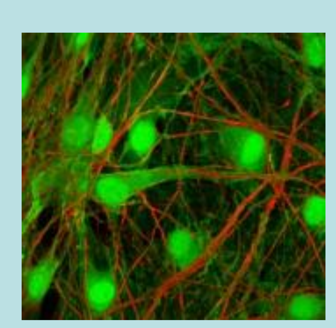


Theoretically, one could make use of a clustering algorithm based on a potential function, like mountain clustering and subtractive clustering, but it would introduce limitations on the suitable clustering methods.

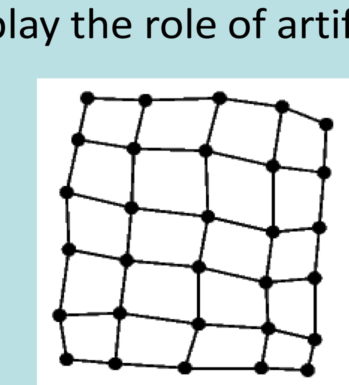
On the contrary, by using a meshing algorithm (thus producing a density of points proportional to the error/uncertainty), any clustering algorithm can be used, like:
- agglomerative and divisive hierarchical clustering;
- neural networks-based clustering (competitive learning and self organizing maps);
- partitional clustering (k-means, fuzzy c-means, ISODATA, etc), etc.

5. Analogy with neural networks

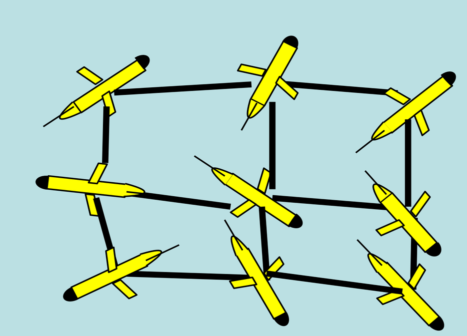
In the future, we have to exploit more in depth the parallelism between Self Organizing Artificial Neural Networks (SOANNs) and Self Organizing Glider Networks (SOGNs), where gliders play the role of artificial neurons.



human neurons



artificial neural network



network of gliders

Doing so, we can make use of advanced learning algorithms developed for SOANN also for SOGNs.

6. Summary and future work

A new methodology for auto-organizing a network of gliders has been proposed.

By introducing the use of meshing algorithms, any clustering algorithm can be used to compute next way-points.

A possible parallelism between artificial neural networks and networks of gliders has been proposed.

Next validation steps:

- validate the system using real METOC forecasts, but using virtual (i.e., still simulated) gliders;

- validate it using both real METOC forecasts and real gliders, in a real experiment at sea.

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