Adaptive Sampling Using Fleets of Gliders in the Presence of Fixed Buoys: a Prototype Built Upon the MyOcean Service

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In the last decade the use of fleets of gliders has proven to be an effective way for sampling the ocean for long-duration missions (order of months). In a previous study [1] a method for adaptive sampling the ocean using fleets of gliders based on the use of a clustering algorithm has been introduced. The key ideas were: i) build a 2D mesh grid over the synoptic uncertainty of the ocean field to sample with "knots" having density proportional to the level of the uncertainty; ii) group this set of knots using a clustering algorithm, i.e. the Fuzzy C-Means (a fuzzy variant of the well-known K-Means algorithm). The centroids are the next way-points for the gliders. However, that method assumed all-maneuverable assets. In this study we extend it by exploiting the existence of non-maneuverable assets, i.e. fixed buoys (a situation that frequently occurs in real scenarios) and by considering time-dependent uncertainty, i.e. aiming to reach the way-points at time *t* such that the uncertainty at future times is minimized.

The first essential idea is to consider the positions of fixed buoys as part of the centroids to obtain from the clustering algorithm: the remaining centroids to be computed will be considered as the next positions where to send each glider. By using the clustering algorithm described in [2], called "Partially Provided Centroids Fuzzy C-Means" (PPC-FCM), we have been able to exploit the presence of fixed buoys by sending the gliders in regions not already covered by the buoys/floats. This allows a better distribution (lower overlapping) of the sensing assets, with respect to the direct use of the standard Fuzzy C-Means, uninformed of the presence of the buoys. The second idea is to replace the synoptic uncertainty field by the field of mutual information between the way points at time *t* and a selected future time.

We have built a prototype of this novel adaptive sampling scheme for mixed assets (maneuverable and non-maneuverable) that automatically retrieves ocean forecasts (currents, temperature, salinity, etc.) from MyOcean services. In addition, the prototype comes with a graphical user interfaces that facilitates the selection of the region of interest for data download. Once the data have been downloaded with low efforts, the (PPC-FCM) algorithm is run to get the next gliders way-points. The procedure is then repeated any time new forecasts are available.

Our tool will be even more effective if MyOcean forecast products in future releases contain, other than the expected (mean) value of the field of interest obtained from forecasting models, a measure of the associated uncertainty, such as standard deviations. By including this uncertainty estimate, glider mission planners would have valuable information on where to send the assets in order to reduce the uncertainty as much as possible.

[1] Cococcioni, et. al., «SONGs: Self Organizing Network of Gliders for Adaptive Sampling of the Ocean», Maritime Rapid Environmental Assessment Conference, October 18-22, Lerici, Italy, 2010
[2] Cococcioni, «Clustering in the presence of partially provided centroids: a fuzzy approach», Technical Report, Department of Information Engineering, Pisa, 2014.