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Adaptive Algorithm of AUV Meander Pattern Trajectory Planning for Underwater Sampling

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ABSTRACT

The algorithm of autonomous underwater vehicles /AUVs/ trajectories planning for mapping of oceanographic data is considered in the paper. The problem of this research consists in adaptive data sampling by single AUV or group of vehicles for further high-precision mapping of environment parameters under restriction of whole given area covering. For simulation a bathymetry scalar field was considered, which is given by a digital elevation model. Some simulation results of considered algorithm operation are supplemented.

KEY WORDS: adaptive sampling, trajectory planning, AUV.

INTRODUCTION

Consider the problem of 2D distributed oceanographic scalar field mapping like temperature in horizontal plane or bathymetry. Traditional sampling methods using vessels and towed sensors are in general expensive and do not provide detailed aquatic area coverage. Using this technology, area of interest is covered by nets of tacks. However, this method can take much time if the purpose of research is a detailed survey of inhomogeneous underwater environment. In this case it would be more appropriate to use an AUV with according algorithms of trajectory planning, designed for more fast and precise solution of this problem. It is obvious that AUVs are able to map the environment adaptively, acting as a smart mobile sensor.

The problem can be resolved by taking more samples in fast-changing data areas and few samples in slow-changing data areas. Our task consists in an algorithm designing, which builds such adaptive trajectory for AUV that covers the aquatic square without gaps.

The basic idea is to build a trajectory, consisting of meander patterns of different "levels". Patterns of larger level use smaller step between tacks. An AUV control system has to make a decision if the current meander level should be changed according to measured data.

A simulation was performed to verify of considered algorithm efficiency. Scalar bathymetric field, provided by digital elevation model /DEM/, was used for survey. Algorithm effectiveness was estimated by time of operation and resulting map precision for used bathymetric field. Ordinary kriging algorithm was applied for data interpolation and kinematical AUV model was used for trajectory calculation. The results of simulation are discussed in the final part of the paper.

PREVIOUS WORKS

Adaptive sampling is a research problem not only for marine engineers, but also for wide mobile robotics community. The information-theoretic and stochastic methods are widely used for these tasks.

The adaptive sampling algorithms are discussed in Fiorelly, Bhatta, Leonard and Shulman (2003). The adaptive sampling techniques with application to gliders were developed as a part of AOSN and AOSN-II projects. Fiorelli, Leonard, Bhatta and Poley (2004) described the results of experiments in Monterey Bay. They considered cooperative formation control for a library of algorithms, such as gradient climbing, "hot-spot" sampling, etc. They used objective analysis for error map to calculate sampling performance. The measured field was considered as realization of stationary stochastic process with Gaussian autocorrelation function. Adaptive sampling as mixed integer linear programming problem for AUVs is stated in Yilmaz, Evangelinos, Lermusiaux and Patrikalakis (2008).

In Low, Dolan and Khosla (2011) the information theoretic approach for the problem of sampling in extended rectangular area is considered. A uniform grid is used on the area of interest. Sampling trajectory is produced as a solution for optimization problem, maximizing stated information metric. Other adaptive sampling solutions, based on information-theoretic approaches can be found in Bin Zhang and Sukhtame (2007) and Low, Dolan and Khosla (2008).