On-line Modeling of AUV’s Maneuvering Motion in Diving Plane Based on SVM

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ABSTRACT
Support vector machines have been validated as an efficient artificial intelligent algorithm for solving classification and regression problems on account of their simple model structure, good generalization and global optimal solution. However, their on-line performances are not yet widely used. A simple on-line algorithm named incremental least square support vector machines is put forward by analyzing the kernel function matrix and is employed to identify the maneuvering parameters of autonomous underwater vehicles in diving plane. Zigzag-like maneuver with 5º fin angle is simulated based on the mathematical model, and the viscous hydrodynamic coefficients are then on-line identified by using the proposed method. The comparison between the identified parameters and the standard derivatives demonstrates the validation of incremental least square support vector machines. This study is useful for maneuvering study and model-based control for underwater vehicles.

KEY WORDS: underwater vehicles, support vector machines, on-line modeling.

INTRODUCTION
Autonomous underwater vehicles (AUV) are intelligent robots employed to accomplish some risky and fatigued undersea work such as pipeline maintenance, oceanographic survey, underwater rescue and mine hunting. To successfully achieve these targets, AUV should possess perfect performance in each aspect from shape design to intelligent planning and decision making. Generally speaking, the main goal is to achieve given position and accurately finish specific task with minimum resources and least time. For this situation, it is apparent that good maneuverability is of great significant.

Regarding the research of AUV’s maneuverability, the pivotal problem is to precisely determine the mathematical model based on a series of hydrodynamic derivatives including inertial and viscous ones. On consideration of inertial hydrodynamic coefficients, captive model test by using planar motion mechanism (PMM), empirical estimation and theoretical or numerical calculation would be efficient. With respect to viscous hydrodynamic coefficients, there are four commonly-used methods, i.e. captive model test, empirical estimation, computational fluid dynamics (CFD) method, and free-running model test or full-scale trial with the addition of system identification (SI). With the development of SI theory and experiment measure techniques, the fourth method for determining the hydrodynamic derivatives are widely studied and implemented.

System identification theory for maneuvering modeling of marine vehicles has been put forward for decades. Petrich et al. (2007) identified the model parameters by using least square method (LS) for Virginia Tech 475 AUV. Tiano et al. (2007) obtained the hydrodynamic characteristic by using observer Kalman filter identification (OKID) method. Mahfouz and Haddara (2003) predicted the hydrodynamic parameters by using neural network (NN) from certain standard maneuvers. Luo and Zou (2009) verified the validation of a novel approach, i.e. support vector machines (SVM), in identifying ship’s hydrodynamic coefficients.

SVM method was first proposed by Vapnik (2000) based on statistical learning theory in the early 1990s, after which many researcher concentrate themselves on its improvement and application (Drezet and Harrison 1998, Gretton et al. 2001, Goethals et al. 2005). SVM methods include least square SVM (LS-SVM), ε-SVM, υ-SVM, C-SVM and so on. The algorithms contain batch algorithm and on-line algorithm. For batch method, some mature algorithms, even open softwares are available such as sequential minimal optimization (SMO) (Platt, 1998), LIBSVM (Chang and Lin, 2001) and SVM^light (Joachims, 1999). Meanwhile, Cauwenberghs and Poggio (2001), Laskov et al. (2006), et al. studied on-line SVM, but it has not been widely used.

This paper makes an effort on on-line modeling of AUV’s maneuvering motion by using incremental LS-SVM. The proposed algorithm is deduced from LS-SVM by means of transformation of kernel function matrix, and then it is used for on-line identification of viscous hydrodynamic coefficients for AUV in diving plane. This paper is arranged as follows: the first section is introduction, the second describes the mathematical model of AUV in diving plane, the