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Design of Interactive Simulation System and Graphical User Interface for Underwater Vehicle Control and Navigation

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ABSTRACT

This paper provides an overview of the development of an interactive simulation system and Graphical User Interface (GUI) for an underwater robotic vehicle. Computer simulations and graphical interfaces are effective ways for studying the behavior of a system well before it is developed and deployed. It allows lot of flexibility in the design and greater scope for improvement without major financial commitments. The underwater vehicle and its sub-system properties, control inputs (parameter adjustments, maneuvers, etc), and the underwater environment are graphically represented on an user interface that can be easily accessed by the user for modifications. The interface provides convenient means to evaluate vehicle performance by means of animations, dashpot and time history plots of engineering variables of interest. The dynamic model and control algorithms, developed using standard tools are used at the back-end of the program to model and simulate various control behaviors of the vehicle. The environment conditions, parameter variations, disturbance forces etc. can be simulated using the back-end algorithm. The simulation results can be visualized using the GUI and various control strategies, navigational algorithms and path planning can be easily tested using the interface program. Few examples showing how the simulations can be used to identify design changes that can improve underwater vehicle dynamic and control performance are also provided.

KEY WORDS: Underwater vehicle dynamics; vehicle control; graphical user interface; simulation;

INTRODUCTION

An Autonomous Underwater Vehicle (AUV) is a robotic device that is driven through the water by a propulsion system, controlled and piloted by an onboard computer, and maneuverable in three dimensions. This level of control, under most environmental conditions, permits the vehicle to follow precise preprogrammed trajectories wherever and whenever required. In the last few years we have seen an increased attention paid to research and development of AUVs. The reasons for considering the use of AUVs are their ability to gather information, manipulate physical objects, requires little or no support from a surface vessel, and the limited human capacity for direct, long-duration exploration of the ocean.

Testing and verifying the control architecture and control algorithm of an AUV is not an easy task. It requires real-time testing and monitoring of the vehicle, data acquisition and analysis and is a costly process. It is always desirable to use simulation tools to replace real-time testing and evaluation. This paper discusses such a simulation system developed for "JUBILEE" – a test-bed AUV being developed at IIT Madras. The simulation test-bed may also provide an advanced user interface to represent the numerical results as closely to real world results as possible. The purpose of the user interface is to facilitate interaction between the application and the user. Both the underwater environment and the vehicle are accurately modeled using a well designed simulation test bed. MATLAB Simulink is used to develop the mathematical model of the vehicle and LabVIEW is used to design the graphical user interface.

SIMULATORS FOR AUV

Over the years, several underwater vehicle simulators have been developed with the objective of simulating vehicle behaviors. A virtual reality based interactive simulation system for underwater robotic tasks (T.Asokan et al., 2004) was developed to evaluate the design, and performance of seven degrees of freedom manipulator mounted on an underwater robotic vehicle. The simulation program was written in C using World Tool Kit (WTK). Here the dynamics of the vehicle or the arm was was taken into account in the simulation studies..

A MATLAB based Simulation for Autonomous Navigation of Unmanned Surface Vehicles (Ali Eydgahi et al., 2006) was developed at the University of Maryland. A fuzzy logic based obstacle avoidance was simulated here.

A real-time graphical simulator with capabilities for on-line, hardware in the loop and hybrid simulation was developed by Ridao (P.Ridao et al., 2004). It uses MATLAB Simulink and Virtual Reality Modeling Language (VRML) simulation for simulator development.

A portable simulation facility for the design of autonomous underwater vehicles (G. Hackett et al., 1998) was developed at space and subsea robotics laboratory at University of Victoria, Canada. The graphics