AUV – The main Challenges and possible Solutions

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Abstract

This paper gives the description about an AUV (autonomous underwater vehicle) and its challenges. An AUV is a robot that travels beneath the water without any input from the operator. Maintaining a position with an underwater robot is a difficult task. In the case of an Autonomous Underwater Vehicles (AUVs), not only the underwater conditions, but also the environmental effects off the surface need to be considered. This paper deals with the solutions to the challenges faced while travelling under the water.

Keywords: Autonomous underwater vehicle, AUV depth control, response robotics, underwater navigation, ID control.

1. INTRODUCTION

Marine autonomous systems, including submarine gliders and Autonomous Underwater Vehicles, are revolutionizing our ability to map and monitor the marine environment [1][2]. Although truly autonomous systems are typically deployed from a research vessel, they are not tethered to the vessel and do not require direct human control while collecting data [3]. They therefore provide opportunities for data acquisition imparts of the ocean previously inaccessible to vessel-based instruments, e.g. beneath ice sheets in Polar Regions [4] [5], and are improving the spatial and temporal resolutions of a broad spectrum of marine measurements. Marine autonomous systems also have an increasing range of applications in the defense, industry and policy sectors, such as geo hazard assessment associated with oil and gas infrastructure [6].AUV stands for autonomous underwater vehicle and is commonly known as unmanned underwater vehicle. AUVs can be used for underwater survey missions such as detecting and mapping submerged wrecks, rocks, and obstructions that can be a hazard to navigation for commercial and recreational vessels. An AUV conducts its survey mission without operator intervention. When a mission is complete, the AUV will return to a pre-programmed location where the data can be downloaded and processed [7].

The University of Washington was the first one to develop the AUV in 1957, by Stan Murphy and Bob François. Later in 1970 MIT also developed an AUV. Hundreds of different AUVs have been designed over the past 50 years or more. But only 10 companies sell AUVs in the international market. One of the main challenges of (underwater) robotics is how an autonomous robot can adapt to the environment, identify and localize themselves. For example, an underwater current or drift can easily relocate an AUV in the water. To design a solution for position keeping problems, one should reckon with not only the underwater conditions, but also the interactions above the water. Potentially useful sensory input includes any measurable data indicating the stream, the wind speed or drifts. With a proper sensor-fusion algorithm and adjoin process control, an AUV is able to keep its position and depth. There are various types of sensors such as gyroscope, camera, accelerometer, and pressure sensor etc. that can be used for underwater applications.

1.1 Basic Architecture

The vehicle is a free flooding type AUV, having an external hull made of fiber glass, and three aluminum made pressure vessels inside: the main vessel, the maneuvering vessel and the thruster (Fig. 3). Those in vessel carries the computer units, motion sensors (rate-gyro, compass and inclinometers), depth and liquid level sensors, lithium polymer batteries, communication and power electronics. The maneuvering vessel includes the servo systems for moving the control surfaces and the thruster electronic driver. The thruster vessel carries a 150W DC motor, which moves a polyurethane propeller made by a rapid prototyping manufacturing system. Microcontroller based boards are used for the implementation of control units in the embedded system. Particularly for most of the functions to be implemented, the ARM7 family of microcontrollers is used. The navigation is implemented in the ARM9 microcontroller, since this function requires a more powerful Unrelated to the implementation of the Extended Kalman Filter (EKF) algorithm for sensor fusion. USBL (ultra-short baseline, also sometimes known as SSBL for super short base line) is the method used for underwater acoustic positioning. The topside unit (computer) calculates the position from the ranges and bearings measured by the

USBL

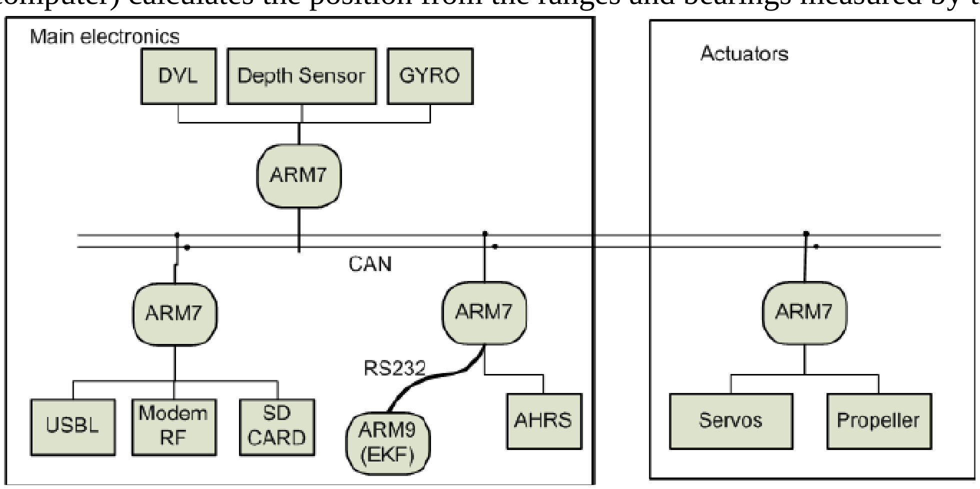

Fig:-1

2. AUV- MAIN CHALLENGES AND SOLUTIONS

2.1 Control problem

There are several ways to control an underwater vehicle [8]. During a field mission, an AUV would encounter interactions, such as drifts, buoyancy forces or streams. Many of these are unknown, with non-linear [9] effects, so they cannot be included directly in the motion equations. However, these forces take effect on the AUV, and influence its motion. Magnetic sensors are susceptible to external magnetic fields, such as the one generated by the thrusters. Furthermore, these magnetic fields can interfere with the communication link between other electrical components. To avoid this, the electrical parts which are able to disrupt the communication during a mission must be insulated from other parts. AUVs are specifically crowded devices(regarding their interiors), so electronics measurement systems should be shielded and designed properly to keep the measurement error between known intervals and minimize them as much as it possible.

2.2 Position keeping problem

Position keeping is a process, which is used to enable an underwater vehicle to keep orientation and depth, based on sensors and actuators. The position keeping can be separated into orientation and depth keeping. Both of them are supposed to be kept relative to a baseline. The base value can be the magnetic North (for orientation) and the output of the pressure sensor (for depth), or an initiated value which is set when the system starts, such as an Inertial Measurement Unit (IMU). When employing an IMU, the system must reckon with the inaccuracy of the measurement, because usually these values should be filtered. One of the most popular controller systems used by industry and academia is the historical PID controller, which can be adequate for the solution as well, where a proper depth and orientation keeping is presented with error minimization regarding the measurement errors of the sensors.

2.3 PID control

The PID controller is a closed loop controller. It consists of three main elements: P (proportional), I (integral) and D (derivative). A PID controller deals with cumulated errors, which are derived from the difference of the system measured output value from a predefined set point. All three PID parameters have significant influence on the system. With a high P value, the control system will be fast, but on the other hand, an extremely high parameter selection will lead to instability or oscillation. With I term added, a faster error elimination can be reached, but in the meanwhile, there will be larger over-shoots. A larger Parameter will decrease the overshoot, otherwise slows the response of the system. It is a linear controller; however, the underwater systems are non-linear because of the non-linear effects that can influence them. Popular approach to solve this is the use of adaptive process controllers.

2.3.1 Adaptive process control

The adaptively means that the P, I or D parameters are changing relatively to the error during runtime. In case of the depth keeping the mentioned value is the output of the pressure sensor, and as for the orientation keeping, that is the output of the compass sensor. The adaptive process control is a good approach to control a non-linear system with a linear PID controller. It keeps changing the parameters of the controller relatively to a function. A compass sensor should be used in order to solve the orientation keeping problem in one degree of freedom; furthermore, a gyroscope module is needed in order to compensate the error during the measurement. On the other hand, in the case of the depth keeping, a pressure sensor can be used combined with another sensor to increase its effectiveness. A variety of algorithms can be used to filter the acquired signals for more precise measurement, such as an adaptive, median filter, extended Kalman filter [10].

3. CONCLUSION

"The trouble with our times is that the future is not what it used to be." –Paul Valery. AUVs are now at an early stage of acceptance. However, by working on the cheap and efficient solutions to the environment based challenges like position keeping and orientation by using an adaptive PID controller, the orientation- and depth keeping problems (under limited conditions) for the AUV's design, their operational acceptance and number can grow on commercial level.

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