Research on Autonomous Grasping of an UVMS with Model-known Object
Based on Monocular Visual System

Qifeng Zhang¹ Piliang Gong¹,² WeiCai Quan¹,² Aiqun Zhang¹
¹ State Key Laboratory of Robotics, Shenyang Institute of Automation, Chinese Academy of Sciences
Shenyang, LiaoNing, China
²Graduate School of the Chinese Academy of Sciences
Beijing, China

ABSTRACT

This paper has proposed a method of grasping a model-known object autonomously for an Underwater Vehicle-Manipulator System (UVMS) using monocular vision. The distance between the vehicle and the object is estimated by extracting the pixel radius of the ball-like object, and the vehicle’s depth and orientation angle are used to keep the vehicle’s station while the manipulator is performing the grasping actions. Other key techniques, including station keeping and grasping strategy, thrust allocation and vehicle control are also presented. Pool experiments demonstrate the validity and practicability of the method.

KEY WORDS: UVMS; underwater vehicle; station keeping; underwater vision.

INTRODUCTION

In recent years, underwater vehicles become an increasing interest of research community and offshore industries. Today, it is common to use manned underwater vehicles to accomplish missions at sea bottoms, but it is of enormous cost and risk in such dangerous environments. Scientists wish to perform underwater missions in a completely autonomous way, so one research focus of this field is the autonomous Underwater Vehicle-Manipulator System (UVMS), which are supposed to accomplish scientific exploration and light-working task underwater or under ice autonomously. Whereas it is difficult to realize the entirely autonomy nowadays, some semi-autonomous UVMSs are developed, e.g. Bowen et al (2004), Yuh et al (1998). Being different from autonomous UVMS, this kind of system has an optical fiber that can be used to monitor or control the vehicle’s working process, and thus most key autonomous working techniques can be validated on semi-autonomous UVMS platforms. Since Hawaii University started to develop a semi-autonomous underwater vehicle for intervention missions in 1997, the vehicle has been experimented times and great success has been achieved in several key techniques, including precise location in short range and underwater cutting based on vision systems. Besides, many other institutes have explored relative autonomous operation related techniques, such as control, motion planning and object localization. Professor Antonelli (2003) investigated problems such as inverse kinematics resolution to find suitable vehicle/joints trajectory that correspond to a desired end-effector, adaptive tracking control and interaction control. Zhang (2007) discussed the motion planning, coordinated control and integrated experiments on motion planning and control of an autonomous UVMS. Li (2008) developed a simulation system to grasp a feature point using multi-sensor fusion.

Our main work is to research several specific problems in grasping a model-known object autonomously on the UVMS developed by Shenyang Institute of Automation, Chinese Academy of Sciences. Pool experiments are conducted to demonstrate the validity of our system and strategy. The remainder of this paper is organized as follows. The UVMS experiment system is described and the method of relative distance estimation using monocular vision is proposed. Then the design of the vehicle controller and thrust allocation is presented. The autonomous grasping strategy is introduced and pool experiment results are given at last.

UVMS EXPERIMENTAL SYSTEM

Fig. 1 shows the UVMS experiment platform, which consists of an underwater vehicle and a four-function underwater electric manipulator. To grasp autonomously, station keeping is necessary. The vehicle has the following sensors to supply the station keeping information, a depth sensor for vehicle’s depth, an IMU (Inertial Measurement Unit) for the vehicle’s orientation angle and a CCD camera for relative distance between the vehicle and the object. The control system of the platform has two parts: the surface console and the underwater electronic cabin, with a cable connected between each other for power transmission and data communication. The vehicle has two work modes: remotely operated mode and autonomous working mode. There are six thrusters for the vehicle to realize 6DOF