Chapter 21
Modeling and Visual Navigation of Autonomous Surface Vessels

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ABSTRACT

In this chapter, the authors address main issues of Navigation, Guidance, and Control (NGC) and vision system of Autonomous Surface Vessels (ASV). These issues compose research problems and related research findings in recent years. Related research results are reviewed first; then the hardware and subsystem of ASVs is introduced. For the typical rudder-propeller, three degrees of freedom horizontal underactuated model is presented. Visual ASV is applied more and more in complex and unknown environment with increasing demand of obstacles avoidance. Two examples of visual applications are demonstrated. One is riverbank identification using color segmentation and Hough Transform; the other is bridge detection using optical flow.

ROBOTICS AND MECHATRONICS

A robot is a mechanical or virtual artificial agent, usually an electro-mechanical machine that is guided by a computer program or electronic circuitry. Robot is able to execute dangerous tasks instead of people in complex environment or manufacturing processes for security and economic reason. Robot is playing a more and more important role in our life for various applications, including domestic, commercial and military (Cleary, K, 2006) (Niku, S. B. 2001). Modern robots include mobile robots, industrial robots, service robots, educational robots, agricultural robots, military robots and mining robots, etc.

Mobile robots mainly consist of UGV (Unmanned ground vehicle), UAV (Unmanned aerial vehicle) and USV (Unmanned surface vehicle), which are required to be able to move in the known or unknown environment autonomously or semi autonomously. According to the control way of sensing environment

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and action of robot, architectures of mobile robots are classified as deliberative control, reactive control and hybrid control (reactive + deliberative). In this chapter, the USV, also known as Autonomous Surface Vehicle (ASV) is introduced with prototype, hardware, modeling and vision based USV.

Various techniques have emerged to develop the science of robotics and robots, such as mechatronics, signal detection and processing, intelligent control and multi sensor fusion, etc.. The process of developing an autonomous vehicle is complicated. In the process to development of a vehicle can be separate into three parts, mechanical, electronic/hardware and software. The process starts with selecting an appropriate platform that refers to mechanical, and then hardware refers to electronics (integrating hardware and sensors), and software refers to computer programming. Hence, robotics is highly related to the technology of Mechatronics which was first proposed as combined technology of mechanisms and electronics by Tetsuro Mori in 1969.

After development of several decades, Mechatronics now is not only limited to mechanisms and electronics, but an interdisciplinary field of engineering including telecommunications engineering, control engineering and computer engineering. As a combination of multidisciplinary, it rejects splitting into separate disciplines. The main goals of Mechatronics are to bring out novel possibilities of synergizing and fusing different disciplines and to develop products, processes, and systems that exhibit quality performance in terms of reliability, precision, smartness, flexibility, adaptability, robustness, and economical features (Habib, M K. 2007).

Mechatronics is not only a technology, but also a philosophy that supports new ways of thinking, innovations, and design methodologies. As mentioned above, robotics is a complicated, multi subjects technology, so it is important to realize the synergistic between the different subjects. Mechantronics is potential interdisciplinary approach that capable of bridging the gap between each single discipline or profession. In the product development process, Mechatronics leads the interaction of different disciplines and improve the product design from technique level to system level. Based on these advantages, mechatronics have been applied in various fields, such as micro-Mechatronics, Opto-Mechatronics, Super-Mechatronics, Mechno-informatics, Bio-Mechatronics, Control-mechanics and Megatronics (Habib, M. K., 2012).

PROTOTYPE, HARDWARE, AND MODELING OF AUTONOMOUS SURFACE VESSELS

Prototype

Autonomous Surface Vehicles (or Vessels) (ASVs) which also are called Autonomous Surface Craft (ASC) or Unmanned Surface Vessel (USV), are designed to traverse relatively unknown environments with onboard sensing, guidance and autopilot capabilities, for challenging tasks without close supervision of human operators. Lots of ASVs are developed in the past decades for commercial, research and military applications.

Catamaran type ASV “Charlie” and “SESAMO” are developed by Institute of Intelligent Systems for Automation, Genova, Italy. M. Caccia discussed ASV modeling by self-oscillation identification method for heading controller tuning, and then designed I-PD controller+ Kalman filter as steering controller (Bibuli, M, 2008). The harbor experiment proved the satisfactory results. Caccia, M (2008) discussed

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