Investigation on the Embedded Training of Submarine Emergency Manipulation

ZHOU Ying[1,a], HU Dabin[2], ZHOU Xiangyang[3,b], XIAO Jianbo[4,c]

[1]College of Power and Engineering, Naval University of Engineering, Wuhan, 430033, China

[2]College of Power and Engineering, Naval University of Engineering, Wuhan, 430033, China

[3]NVH Performance Development Department, Great Wall Motor Company Limited HAVAL R&D center, Baoding, 071000, China

[4]College of Power and Engineering, Naval University of Engineering, Wuhan, 430033, China

[a]email: 287071270@qq.com, [b]email: 654103940@qq.com, [c]email: xjbo1984@126.com

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Abstract. The embedded training of submarine emergency manipulation is one of new maneuver control training method, which enhances submariners' operational capacity and improves the navigation security of submarine. The development survey of submarine emergency motion model, training of emergency manipulation and embedded training in internal and overseas were summarized, and the related current problems were expounded. The intending development direction of embedded training of submarine emergency manipulation is high integration, strong pertinence and broad adaptability.

Introduction

Since the 21st century, the oceans become the focus of world attention, as a major naval power to protect maritime safety and marine rights and interests, and its increasingly prominent position. Features submarine covert strong, flexible, and in recent years has been to develop attention and navies, more and more used in high-tech submarine. How to give full play to their own advantages submarines, submarine operators to improve the technical level, to enhance the combat effectiveness of the submarine, has become an important research topic States Navy submarine development [1].

Although driven by modern science and technology, submarines automation, information technology level has been significantly improved, but the submarine accident is still frequent, single boat accident rate is much higher than surface ships, causing huge casualties and property losses [2]. Security remains one of the important factors played a submarine combat. Submarine maneuvers are all submarines in surface and underwater navigation manipulated collectively are key determinants of the submarine safety. Therefore, the study of submarine maneuvering control training model to ensure training quality and efficiency are the main way to improve the security of the submarine.

Currently, the submarine training maneuvers mainly in two forms: the real boats and shore-based training simulator training [3]. Shore-based simulator training refers to the state of motion and manipulation in the submarine simulation by computer simulation technology, training purposes. This training method is not only safe, easy to carry out training, can also simulate various conditions of training, relatively low cost. However, limited by the accuracy of the simulation model and not enough realistic training equipment, shore-based simulator training of trainers unable to provide realistic training environment, training is ineffective [4]. Training is a real boat by operating actual equipment on a real boat maneuvering control training methods, training environment closest to the real environment, training realistic and effective. But the high cost of training, the training time is limited and high risk, cannot carry out the manipulation of training under fault conditions [5].

Submarine underwater voyage due to operator error, mechanical failure and combat system

damage and other reasons, the submarine will trim dangerous loss of buoyancy and emergency rudder failure [6-7]. When an emergency occurs, the submarine operator to quickly take effective measures to properly maintain the vitality and submarine combat until the submarine returned to normal, a process known as submarine emergency operation. Emergency training is embedded manipulated using simulation training program simulated emergency conditions and to install a sensor on a real boat transport by manipulating the data to new forms of training simulation manipulation is an effective and safe means of submarine combat capability [8]. This form of training is not only secure and flexible, high fidelity, but also can simulate a variety of training conditions and good training effect, low cost, not only combines the advantages of two traditional training methods, but also to make up for their deficiencies, it is a more ideal form of training, will become the future development direction of navies maneuvers training [9].

Based on a large number of domestic and foreign literature, the emergency motion model submarine, submarines operated emergency training and research status of embedded training were reviewed, and pointed out the existing problems and the future direction of research.

Submarine Emergency Motion Model

Submarine motion model based on the theory of fluid dynamics, kinematics and dynamics, will be regarded as the submarine motion rigid body motion in the fluid obtained Submarine six degrees of freedom motion equations. In the 1960s, the movement of the submarine States to study and have proposed different forms of the equations of motion, which is the most representative of the United States naval vessels Taylor Research and Development Center in 1967, Gertler proposed equations and in 1979 the correction equation. Equation coordinates, symbols and hydrodynamic coefficients unified, comprehensive impact submarine propeller load and speed changes on the boat hydrodynamics, it is possible a complete description of the movement of submarines [10-11]. Submarine Voyage in the normal state and the state of emergency are six degrees of freedom motion equations can be used to describe the space, is the key to solving the equations for solving the hydrodynamic equations and the additional force of 108 parameters. Since the submarine movement under the state of emergency has obvious non-linear, non-linear theory Naval Postgraduate School submarine emergency motion analyzes [12-14].

Submarine motion model equations of motion in six degrees of freedom submarines, space-based, mostly concentrated in the simplified model and simulation experiments. Literature [15] by studying the submarine force, the equation of motion and obtained a submarine near the water emergency motion model at infinite large deep standing water. Based on this definition of the hydrodynamic coefficients sensitivity index, and exclude some sensitive index of smaller hydrodynamic coefficients by manipulation of experimental measurements, to achieve a simplified model of the submarine movement. Literature [16] aim to submarine emergency classification model, considering the damage location and size and other factors, the establishment of a submarine cabin damaged water model. And high-pressure blow-off and discard ballast and other heavy anti-submarine emergency steering process modeling, simulation experiment proves accurate and reasonable model. Literature [17] construction of a complete mathematical model submarine emergency ascent, including submarines damaged water compartments additional force calculation model, the angle of attack submarines in six degrees of freedom motion is too large, the model and the main ballast tanks high pressure blowing system model. By submarine ballast tanks of the pneumatic blowing system and dynamic process research in addition to using MSC.EASY5 power system modeling and simulation software to establish a high-pressure gas tank blowing system, stop and lift the mathematical model of the whole process and the simulation results were compared with the real boats. Literature [18] on the basis of the establishment of the submarine damaged water emergency steering model using Delphi compiled submarine damaged water emergency steering control simulation software for the submarine force operated emergency training provides a powerful help.

Submarine Emergency Training

Submarine emergency steering in recent years by experts and scholars attach great importance to the emergency motion analysis, manipulation methods of emergency, emergency Security has made many achievements. Literature [19-20] using the friction pipe flow theory, when the emergency steering in submarine compartments damaged water mathematical model, the simulation can be achieved through accurate forecasting of emergency ascent process, and to study at low speed when the loss of buoyancy submarine emergency steering. Literature [21] on the basis of research submarine equations of motion on the establishment of submarine maneuverability forecasting systems, both for each submarine Maneuvering to predict, but the assessment of the implementation of personnel operating the boat through the system. Literature [22] focus on the 206U submarines by the Lubeck engineering company's in West German blowing main ballast tanks in emergency ascent experiments are introduced, the submarine emergency ascent course study, discuss the mechanism modeling and identification modeling two kinds of submarines Dynamic modeling and analysis of advantages and disadvantages of PID control, pointing out that the submarine emergency ascent direction of development of automatic control algorithm. Literature [23-24] analyzed the submarine emergency ascent procedure, the small angle of attack and high angle of attack power coefficient calculated separately for the water to give the submarine motion parameter variation in different emergency procedure. Based on this research submarine rolling motion equations, a number of factors that affect the roll for proposed submarine roll control means, to avoid manipulation of the emergency submarines produced during rolling, "leaves" and other adverse conditions. Literature [25-26] for the current state of the submarine emergency motion parameters mutation prediction error is larger issues such as the use of Laval nozzle flow model, the first submarine in the tail in different locations damaged water and emergency manipulation process in motion study, get safe water limit line manipulated to provide a theoretical basis for the emergency operator to take a different programs operated submarine damaged water. Literature [27] on the state of the submarine hull and sea water pipes damaged different system analysis, the difference between the water area, water depth and navigation mode, will affect the "car, rudder, gas and water" and other factors into account to give more specific submarine damaged water emergency manipulate the model. Literature [28-31] for the Submarine Voyage concealment and safety, it defines the depth of the submarine navigation safety zone, the propeller cavitation work at high speed and the depth of the stern, respectively, as the depth of the elevator card to restore the security zone depth, the lower limit is proposed safety zone principles and methods determined. At the same time on the basis of reason and aft elevator card model analysis on a variety of emergency steering simulation comparison, propose the best conditions in the emergency steering policy, and to improve the traditional cross-shaped stern elevator technology to effectively improve the security of the submarine. In addition, the actual situation of the literature [32-33] binding reversing, parking and full rudder submarine safety studies, the establishment of emergency to restore submarine model are met safety speed and depth indicators, and manipulate programs and the best characteristics of the submarine discussions.

As the number of submarine accidents increased significantly, major naval powers come to realize the importance of submarines operated emergency training and troubleshooting, the main measures taken from three aspects [34]. The first is the emphasis on personal training, country, Canada, New Zealand developed a strict code of crew training and personal protective equipment worn in training described in detail, stipulates that those who did not complete the training mission personal alone can’t be operated submarines and troubleshooting. The second is the establishment of professional training institutions, since the 1950s, Western countries since the beginning of the establishment of emergency response training institutions, schools and other damage control, including its military bases in the United States Navy has 78 emergency training related to the school, the Turkish Navy and the British Royal Navy We have set up a damage control submarine escape training center. These institutions offer courses related to simulation training, and hire professional trainers’ guidance and management of daily training equipment. The third is to increase research on training simulators and training platform. Some countries have detailed plans in

submarine emergency training and the development of appropriate training platform, closer to actual combat support training, a substantial increase in their ability to maneuver emergency crew. Located in Portsmouth, UK Royal Naval Artillery School and Raleigh sailors school are equipped with "Damage Repair Instruct Units (DRIU)" training simulators provide real submarine cabin model for the training of personnel, the simulator can simulate the operating environment even when operated during emergency training can be made to render the atmosphere of smoke and noise, high fidelity training environment. British Navy Devonport naval base in “Nuclear-powered Underwater Ship Control Training device (NUSCOT) simulation training, the coach is on the "Trafalgar" class attack submarines console accurate model, based on six DOF hydraulic platform to provide training for personnel operating the boat. Not only can the entire training simulators provide realistic training environment, but also for emergency breakdown training to improve the crew's ability to maneuver emergency. Hamm 2002 Havre Collingwood training school has installed two full-mission bridge simulator and supporting the linkage of two operating rooms and two navigation chambers, to fully simulate the actual layout of the bridge of the destroyer, and is equipped with all real ship as instrumentation and equipment. Computer Sciences Corporation is responsible for manufacturing simulator. At the same time, the simulator is generated by nine Christie Matrix 3000 projectors external analog visual effects. It can achieve the various compartments of different brightness and different smoke level visibility, high fidelity training environment. While coaches can be set by the bridge equipment failure, such as an engine failure, rudder failure, gyroscope failure, control failure, the emergency crews to manipulate conduct training [35].

Embedded Training

Embedded training has a long history, dating back to the 1950s, the United States and Western military powers developed virtual signal generated by sophisticated hardware technology and provides training by displaying the virtual target for the training of personnel. However, the initial design simple embedded training. Virtual single signal can only implement a training function [36]. 60-70 years, with the rapid development of computer technology, as well as simulation technology, laser technology, virtual reality technology, the introduction of high-tech R&D staff developed a number of powerful, highly integrated embedded training systems, such as the US Army Multifunction integrated laser engagement simulation system. From the beginning of this period, the Western military power will shift from the traditional focus on training simulation training to the embedded training, research and development in the embedded training a lot of manpower and material resources, for the rapid development after lay a solid foundation for embedded training [37].

Into the 1990s, embedded training achieved rapid development. A large number of embedded training systems and equipment successfully developed and equipped. The most typical is the Canadian company CAE Integrated Platform Management System (Integrated Platform Management System, IPMS), the system automatically ship information collection, processing, display, crew provide an integrated information management platform [38-40]. It is mainly integrated device state maintenance and detection system (Condition Based Maintenance System, CBMS), battle damage control system (Battle Damage Control System, BDCS), the real ship Training System (On-board Training System, OBTS) and the like. Real ship training system is embedded in the real training module on board, and established a comprehensive training environment on ships. Training system simulates the real ship navigation environment and failure that may arise, provide rich content for the training of trainers. At the same time, training personnel in real practical operation of the equipment on board, the background model simulation program by solving real-time display in the display unit training conditions, high fidelity training effect is remarkable. US DD-21 land-attack destroyer, Germany K-130 class small frigates, the British Type 45 destroyers are all equipped with a real ship training system, enabling man and the joint training [41-43]. 2001 US Simulation Training and control center in order to development needs of both

equipment that should not break the existing structure and equipment, and improve the training effect, to ensure safe training in Abrams tanks and Bradley fighting vehicle weapon install embedded training systems [44-45]. Italian Aermacchi company to achieve the installation of an embedded training simulation system on the M-346 advanced trainer, the system is built into a target area terrain databases, after starting the system, the database in real-time simulation training environment, receiving ground radar transmit signal according to the motion state of virtual for trainers to create a realistic flight scenarios [46-47]. Individual training device embedded virtual deduction America RBD developed and M2A3 "Bradley" infantry fighting vehicle embedded training system, the use of network communications and computer technology to provide targeted training to build training through simulation training environment for the training of personnel [48-50]. In addition, the Dutch National Aeronautical Laboratory and Locke Martin has for the successful development of the Royal Netherlands Air Force F-16, F-35 and other models embedded training system, which enables the training data and the interface between the planes share offers the best solution for the multi-joint tactical flight combat training [51-52].

In recent years, a number of research institutions and universities in training simulators and embedded training systems are set up a special research team. Those researches fruitful for the rapid development of embedded training provided a powerful impetus [53-57]. Some experts and scholars through research on advanced simulator was developed aimed at fighting vehicle simulator, ship handling simulator, monitoring radar simulator and other training simulators. These simulators individually designed interface bus, and connected with the installation of specialized training equipment interface that initial realization of simulation training, but the training function is simple to maneuver, and the frequent failures such as poor connections, and there are shore-based simulation training a large gap. Based on the Armored Force Engineering Institute of the Environment and tank fire ballistic issues, the establishment of a complete model of the shooting, described by tanks aim to hit shots from the whole process of design of embedded tanks shooting training system that can simulate shooting environment, high accuracy of the model, complete with tanks existing operating equipment for training. At the same time, the system can judge the results of the shooting hits, improving the quality of training [58-62]. Naval University of Engineering and Shanghai ship transport research institute, etc. according to the simulation training platform functional requirements, through mature foreign ship embedded training system and its design, the submarine power platform for embedded training simulation system overall structure design, software system design, system hardware interface design, training evaluation system design, build real-time simulation module and model library, and study design of the main propulsion system consisting of an embedded training [63-67].

In summary, the embedded technology is still in the theoretical and experimental phase, the future is still a long way to go. Many foreign outstanding embedded research as well as mature domestic simulator technologies provide reference and help for the future development of our embedded training.

Embedded Training of Submarine Emergency Manipulation’s Problems and Development Direction

Embedded Emergency operated submarine training research the main problems currently facing the problem of contingency model accuracy, embedded technology issues between trainers and training equipment communication problems. Current researches on submarine models are mostly for emergency motion modeling a given state, for example, elevator malfunction, cabin damaged water, and emergency floating like variables in the model is limited. Submarine voyage occurs in an emergency situation, to be affected by the weather, sea conditions and its own equipment, and many other factors, too many model parameters. It is difficult to achieve high-precision motion under emergency submarine simulation. Our country is still in the stage of development of embedded technology, embedded training simulation module in existing submarine monitoring system, and through the installation of a sensor in the control device to achieve the purpose of training still need to break through the technical bottleneck. Since the equipment and training the trainer to take a

different system platforms and communication protocols, so communication with each other on the need to consider many factors, including the interface type, the number of threads, with or without feedback.

In the future, embedded training of submarine emergency manipulation will toward to high integration, targeted, and wide application field. First, training is no longer just for the submarine maneuvers, but also the main propulsion, weapons, navigation and other systems together, for joint training of the whole ship. Secondly, the training system is a high degree of intelligence, to differentiate the advantages and disadvantages of the different training for trainers' technologies, while using neural network modeling method, based on the theory of fuzzy mathematics, the submarine emergency motion model is more accurate. Finally, manipulate embedded emergency training to adapt to different types of submarines, in order to achieve our submarine training manipulate the popularity of embedded Emergency.

Conclusion

Submarine emergency motion model, emergency training and manipulate paper reviews the research status at home and abroad embedded training, describes the submarine emergency manipulate embedded training current problems and the future direction of development. Increase research submarine emergency manipulate embedded training, solve the model accuracy, embedded backward technology, communications hardware is not reliable training problems towards integration, differentiation, the popularity of the training direction, is to improve submarine maneuvering an important way to control the quality of training to ensure the safety of the submarine.

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