The Application of Artificial Intelligence in Ocean Development : In the View of World Expo 2010

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***Abstract*—Under the background of global ocean development, artificial intelligence has increasing importance which urges the improvement of traditional research and exploration methods. Marine applications of artificial intelligence have been further practiced and expanded by Shanghai World Expo, which reflect in at least three major areas: firstly, the foundations of technical thought kernel, network expansion and intelligent navigation are laid in "Maritime Internet of Things"; secondly, in the field of far-reaching sea exploration, unmanned probe (deep-sea robot) relied on artificial intelligence technology has gradually become a major force in international competition; thirdly, as an ocean information and management comprehensive integration platform, "digital ocean" is applied to crack ocean information solitary island, jumbled information and other difficult problems through cooperation development, function integration and affinity services, enhancing the public ocean consciousness.**

Keywords-artificial intelligence; Shanghai World Expo; maritime internet of things; far-reaching sea exploration submersible; digital ocean

I. INTRODUCTION

Ocean development is common focus of global attention, especially the second geographical discovery which focused on the ocean strategic resources further enhanced the importance of ocean strategy. As ocean science and technology constantly toward the great science and high technology system, AI(AI) that one of the core technologies has become the important support for many fields' further improvement. More than half a century, the world expo has always been important platform of intelligent technology. The Shanghai world expo not only showed the current AI achievements, but also provided wide space for AI applied to ocean development, which at least reflect in the following aspects.

II. APPLICATION I: NEW EXTENSION OF "MARITIME INTERNET OF THINGS" TOWARDS OCEAN

As an important part of the new information age, "Internet of things" has become the key areas of AI integrated application. However, the "Internet of things" currently still exist poor properties, limited application, safety risks and some other problems. As the emerging trend of "Internet of things" development, "maritime Internet of things" grows rapidly, and gradually extends from inland and coastal waters to the ocean, leading the "Internet of things" overall development. Through the Shanghai world expo, "maritime Internet of things" has been further improved and promoted.

A. Living Organisms Philosophy: the Core of "Internet of Things"

living organisms philosophy is an important breakthrough of Shanghai World Expo, which is the new understanding of people-city-earth relationship that the three are of interdependent equality and should get well along with each other. As the Shanghai world expo showed, cities are not only organisms connected by pipes and transportation systems, but are bodies of structure and soul supported by the development of Internet of things and AI technology [1].

Accordingly, living organisms philosophy has become the new thought core of the Internet of things, and intelligence has a great contribution to cities becoming "wisdom organism" of perception and adaptive ability. For example, a variety of sensor equipment applied in Expo built the neural network foundation of urban bodies, including monitoring sensors of submarine optical fiber cable which have adaptation to complex ocean conditions provided remote support for World Expo submarine cable.

B. The Frame Construction of "Maritime Internet of Things" and Its Expansion in Expo

As the "Maritime Internet of Things" developed rapidly in China, the basic frame of world's largest "Maritime Internet of Things"—China shipping automatic identification system (AIS) network has covered almost all coastal waters and advanced course above inland waterway's four level, and all the 264 base stations and AIS national data center achieve interoperability. Meanwhile, through ship-borne equipment and shore-based networking system, it is possible to realize mutual recognition and information exchange of ship-ship and ship-shore, w/hich further improve navigation efficiency and reduce accident probability, making the comprehensive benefit amount to $ 12 billion[2-3].

At present, as the third regional center system of global AIS shore-based network, China AIS system has realized data exchange with Denmark, South Korea and other countries. What's more, the core technologies of China AIS shore-based system have been brought into the international standards by International Association of Lighthouse Authorities. "Maritime Internet of Things" ensures a leading position in the development of "Internet of things". Shanghai World Expo will further integrate AIS system to GPS system and ECDIS (electronic chart), establishing "ship dynamic monitoring system" which become part of "information platform of Expo passenger safety supervision".

C. Wisdom Navigation: the Important Trend Towards the Ocean Century

As the 21 century is the ocean century, the importance of navigation will further highlight. Regarded as the world economic barometer, navigation recovers more than 90% of the global trade[4], and its technologies have become indispensable key means of defending national marine rights and interests. However, the information technology equipment of navigation is very popular currently, demands of more intensive global navigation networks are still not meted in ocean century.

Therefore, relying on the maritime Internet of things, AI ships and other key technologies, it is of great significance to promote the navigation industry transfers from the traditional navigation to electronic navigation (E-NAV), then the intelligent navigation (I-NAV). Compared with the electronic navigation, intelligent navigation mainly has the following advantages: firstly, the interactive communication of ships, beacons and shore ensures the high-density navigation safety; secondly, the implementation of autonomous navigation and collision avoidance reduces manmade accident; thirdly, active analysis and warning for objects on sea improve the ship security ability; fourthly, it is possible to conduct robot rescue under extreme environments; fifthly, dynamic monitoring of ships' anti-pollution can be done, and so on[5]. In recent years, intelligent navigation has achieved breakthrough development, take China for an example, intelligent search and rescue system, automatic collision avoidance systems, digital ports and three-dimensional ocean charts are orderly conducted and "digital navigation mark" has begun to take shape.

III. Application II: New Breakthrough In The Far-Reaching Sea Exploration Submersible

Under With the ocean development expansion continually from the shallow waters to the far-reaching sea, the "Integrated Ocean Drilling", "Sea Floor Observatory Network" and other far-reaching sea global projects are carried out. Because of the complicated environment in far-reaching sea, detection technology equipments are facing great challenge. In this case, far-reaching sea exploration submersible especially unmanned detector (i.e., far-reaching sea exploration robot) has gradually become the main base of far-reaching sea exploration. Therefore, AI technologies that satisfy the specific exploration robot and exploration environment become one of the research focuses. As the Shanghai World Expo showed, independent judgment and reasoning and other thinking abilities of intelligent robots have improved greatly, which make it possible that the intelligence programs can not only receipt and feedback environment information in high quality way, but also be able to complete difficult and delicate movement based on comprehensive environment. At present, the far-reaching sea exploration robots mainly consist of two types: Remote Operated Vehicle(ROV) and Autonomous Underwater Vehicle(AUV):

A. The Intelligence Support for Far-reaching Sea ROV

With advantages of long operation time, convenient operation, ROV gets energy, transmission data and control commands by umbilical cables resources exploration and is widely applied to resources exploration, the laying of submarine cables, marine scientific research and so on. The United States, Russia, Japan, Britain, France and other major maritime powers in the world have developed a variety of ROV applied to different tasks and work depths, including the Japan KaiKo ROV which set the world record of arriving at the bottom of the Mariana Trench by diving 10,975 m (Table 1).

TABLE 1: ROV'S OWNED BY MAIN WORLD OCEAN EXPLORING INSTITUTIONS AND THEIR WORKING SYSTEMS[6]

Institutions (manufacturers）	**Name and model of ROV**	**Maximum diving depth（m）**
Japan JAMSTE（EMS）	Kaiko	11000
French Ifremer	Victor6000	6000
American WHOI	Jseon 2/Medes	6000
Canada Institute of Marine Science （ISE）	Alvin	4500
American MBARI	Tiburon	4000
Japan JAMSTEC(EMS)	Dolphin 3K	3300
Japan JAMSTEC(EMS)	Hyper-Dolphin	3000
American MBARI(ISE)	Ventana	1850

Although the ROV is supported by the mother ship on ocean surface, AI are still needed in special circumstances. For example, the underwater ROV oriented system is hard to orient accurately by cameras under the influence of the insufficient illumination or turbid water quality, which make it easy to collide. Therefore, plans of ROV tracks and avoiding obstacles in three dimensional space based on the fuzzy control method have achieved good results[7].

B. Intelligent Support for the Far-reaching Sea AUV

ROV and HOV are the most important tools for marine research and development at present, but the umbilical cables of ROV limited the scope of activities and diving depth. Therefore, AUV shows great potential. (Table 2) AUV can enter in a complex structure without relying on a large water surface support. It has advantages of small space and low operation and maintenance cost[8], but related AI technology of current AUV remains to be further improved.

TABLE 2: PART OF AUV DEVELOPED IN RECENT YEARS[9]

Name	Depth/m	R&D unites
AUTOSUB	1600	SOC, United Kingdom
CARIBOU	4500	MIT, USA
CETUS	4000	MIT, USA
HUGIN3000	3000	Kongsberg, Norway
HUGIN1000	600	Kongsberg ,Norway
R2D4	4000	Tokyo University, Japan
REMUS	100	WHOI, USA
SAUVIM	6000	University of Hawaii, USA
ANTHOS	3000	MIT, USA

Control system is the core of AUV intelligent components, and currently there are dozens of intelligent software system of AUV with different features[10]. Software systems can be broadly classified into high level task planning module and the lower control modules, and the former based on detecting needs to navigate and make decision; The latter based on sensor information and navigation/decision to produce control instructions to drive implementation, which needs enough robustness to deal with uncertainty of the model and current environmental interference[11].

IV. Application III: The expansion of "Digital Ocean" towards intelligence

At present, the main maritime countries have poured much resource into the construction of "digital ocean" system. For example, the "Neptune" plan of United States and Canada; ARANA program of Japan has initially completed, 25 African coastal countries also jointly set up the African offshore resource data and network information platform. However, due to the strong dynamics, extensive synthesis and large quantities data and other characteristics of marine information, forecast and preview are faced with a number of challenges. Therefore, the deep combination of AI, information technology and remote sensing to improve the capacity of system analysis and stimulation has become an important trend.

A. Construction of Trans-regional Cooperation

Because of the complexity and wholeness of ocean, systematic observation and research tend to be cross-regional and cross-border. Since the middle of 1980s, the marine science and technology gradually entered the new stage of the alliance, general cooperation, large regional [12], and a series of international unite or regional large marine experiments and research plan gradually expand in China. (Table 3).

Table 3: part of influential International joint research scheme

Joint research scheme	Time	Major parties
WOCE	1990-2002	30 countries jointly completed
Tropical Ocean and Global Atmosphere program, TOGA	1992-1993	Completed by multinational cooperation
Joint Global Ocean Flux Study, JGOFS	1993-2003	Germany, Norway and other countries
Global Ocean Observing System, GOOS	Launched in 1991	IOC WMO
Coast Watch	Launched in 1987	NOAA
North East Asian Regional-Global Ocean Observing System	Launched in 1995	China, Japan, South Korea, Russia and other countries and regions

As for China, because the marine information data is short of specifications and unified standards for a long time, different regions use different data formats based on their business needs. Therefore, there is a phenomenon of "Marine Information Islands". In general, offshore survey developed counties is 5~10 years or so, while this cycle of China is close to or more than 20 years [13]. In 2003, "comprehensive marine survey and evaluation of China's offshore sea" special program ("908 special progect") implemented, and information infrastructure of "digital ocean" as an important project launched in 2006. This program is promoted by 24 Marine Administration and provincial nodes, and Shanghai as a demonstration area has been initially achieved information sharing and transparency of offshore node.

B. Double Convergence Development of Function

Faced with "Islands of information" and management segmentation problem, it not only needs coordinating work but also requires convergence of different functions and business areas to meet the needs of integrated ocean management and development. Therefore, the AI play a vital role in the extension of "digital ocean" promotion to implement the "horizontal" and "vertical" double convergence of function.

"Horizontal convergence" is to establish an integrated system platform which integrated independent function modules such as management of sea management, marine environment management, marine law enforcement surveillance, marine fisheries management, coastal zone management and e-government construction to realize marine integrated and coordinated management[14]; While "vertical integration" is on the basis of in the horizontal integration to use the extraction, mining, assimilation, analysis and convergence technology of multiple sources and multi-temporal data to realize imitation, forecasting and prediction[15].

C. Affinity Services of Public Platform

Application of AI technology in marine development is often for the needs of professional sector and its high-end and complex characteristics make it hard to close to the public. However, due to the urgent need of the whole people's awareness for national ocean development, the convenient and affinity-integrated construction of high-end platform is generally obvious.

Visualization is the direct ways of affinity expression. As the visual platform of marine information integrated services, the prototype system of "Digital Ocean" is of significance. At present, based on "Digital Earth" system (Table 4), most "digital sea" prototype systems have many functions such as digitalization of sea coastal area and islands, visualization of elements and simulation of natural phenomena.

TABLE 4. "DIGITAL EARTH" SYSTEM BASED ON THE SPHERE MODEL OF THE EARTH

name	country	R & D units
Google Ocean	USA	Google Inc
World Wind	USA	NASA
Skyline Globe	USA	ESRI Corporation
Visual Earth 3D	USA	Microsoft Corporation
LVE	Switzerland	Leica Geosystems
Geo Globe	China	Wuhan University
prototype system of "Digital Earth"	China	Institute of Remote Sensing Applications Chinese Academy of Sciences

For example, on the basis of "Google Earth", Google Inc launched the sea bed browsing tool—"Google oceans" in 2009 which is currently the world's most popular marine information platform covering about 5% of the world ocean data. As another example, the world's first four-dimensional "digital ocean" prototype system which is made by China has two versions-management edition and public edition. Among the two, the public version has a large-scale marine basic geographic data, thematic data integration, renewal of ocean monitoring, forecasting information in real time, public information inquiry and publication of information products and knowledge[16]..

V. CONCLUSION

AI has become an important support for ocean development, whose significance lies in injecting thinking abilities of forecast and simulation, urging the improvement of traditional research methods, giving composite capacity of ocean stereoscopic development in greater scope, more complex environment and more diversified main- bodies' involvement. Marine applications of AI have been further practiced and expanded by World Expo 2010.

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