A TECHNOLOGY REPORT FROM ROV '91

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Abstract

The ninth annual international conference on Remotely Operated Vehicle (ROV) technology was held on 21-23 May 1991 in Hollywood, Florida, USA. This conference, sponsored by the ROV Committee of the Marine Technology Society, addresses all aspects of ROV intervention and technology. Technical papers and exhibits covered emerging technological areas form the viewpoint of operators, engineers, scientists, manufacturers, offshore corporations, government and military personnel. The conference had was attended by representatives from over 20 different countries, providing a world wide perspective on ROV technology. This paper will provide a report on the latest technology showcased at the conference and is comprised of material presented in the technical sessions and on display in the exhibition. More detailed information on the topics discussed herein can be obtained from the ROV '91 conference proceedings [1].

Technology Today

The advances made in undersea vehicle technology during the past 15 years have been tremendous. With the investment of the offshore oil companies in this technology, beginning in the late 1970's, it has progressed to a very reliable point, at least as far as relatively shallow water (3,000 to 6,000 ft) observation and work systems are concerned. The miniaturization of the electronics for command and control, communication and navigation has led this advance and helped spearhead the development of the now prolific Low Cost Remotely Operated Vehicles (LCROVs). And the 20,000 foot barrier for ROVs was not only broken, but exceeded twice within one week by the CURV vehicle (Eastport International) and the Advanced Tethered Vehicle (Naval Ocean Systems Center) [2].

The fact that many of the long standing problems faced by the ROV industry have been solved does not mean that there are no further challenges. The vehicles and equipment on display at the ROV '91 show in Hollywood, Florida provided a tremendous showcase of the technology which could lead one to believe that we have solved all the problems. In fact, there is a long way to go in technology development in addition to educating the public. For example, just prior to the conference the famous "Lost Patrol" was presumably discovered in the infamous Bermuda Triangle. After listening to a presentation on this discovery, seeing the exposition of high tech equipment and talking to others who have found undersea treasure, a reporter from one of the local newspapers asked me if there was still anything left to find in the ocean. The only logical answer was another question - "Have we found everything on land yet?" His question shows the naivete' of most people who don't realize the vastness of the ocean, it's boundless resources and energy, and it's effect on the rest of the world. It is also possible for a similar naivete' to exist among technologists when looking at the future of ROVs. Therefore, the primary intent of this paper will be to enlighten the reader concerning an area which is emerging as one of the most exciting and potentially beneficial aspects of technology to come along - "virtual reality."

The "Virtual Reality" of Tomorrow

Whether you desire to call it "remote presence," "telepresence," "virtual reality," or other similar terms, the goal is the same, to place the operator in a control room which makes him feel that he is sitting in the environment himself. The key technologies which are critical to achieving this include underwater manipulator design, manipulator control systems, micro-navigation techniques and the synergistic integration of various media presentation techniques. A brief overview of some of the important work ongoing in this area, as presented at ROV '91, follows.

Manipulator Design

The state-of-the-art of in underwater manipulator design can be represented by two systems being developed by Schilling and the Woods Hole Oceanographic Institution (WHOI), both in the United States.

The latest manipulator from Schilling, called ATLAS, incorporates force feedback and automatic end effector interchange in an all titanium arm with 6 degrees of freedom, and a 250 pound payload at a reach of 110 inches [3]. The miniature "master arm" which is used to control the manipulator is no longer than 16 inches at full extension and weighs only 3.5 lbs. The compact and accurate control system of this arm is not its only remarkable feature, the tool interchange system incorporates hydraulic quick-disconnects along with an inductive coupling which provides power to run tool electronics and passes telemetry data. This combination of designs will provide future operators with a significant added capability.

Manipulator development at WHOI is more research oriented, directing its application to the next generation of vehicles [4]. Their goal is to develop a manipulator with increased payload and dexterity while reducing the size, weight, complexity and power requirements. The initial efforts have been quite successful, especially while recovering over 50 objects from a Roman shipwreck in the Mediterranean Sea while using the arm on their JASON ROV. The importance of this work is that the manipulator is all electric, which will be critical to many future systems, and it's controls consider the entire system. This means that the control techniques being developed consider not only the manipulator and the hand, but also the actions of the vehicle. For a future "virtual reality" to exist, the actions and reactions of everything in the immediate environment must be taken into account.

Manipulator Control

The control of the manipulator in the operational environment while performing work is a critical portion of the overall task. This is being investigated by both GKSS-Forschungszentrum Geesthacht GmbH of Germany and Tecnomare of Italy.

The work being performed at GKSS uses a modified industrial robot which can operate down to 1100 m of seawater [5]. Their primary emphasis has been in the off-line programming and simulation of the system in an ambiguously structured environment. Their system uses a 3-D Computer Aided Design system to create solid models of the ROV handling system and the underwater environment, kinematic models to determine position and orientation of components and motion models to describe characteristics of moveable elements. This system can then be used to develop trajectory data which can be used to refine programs and can be presented on a graphical display. The program can then be tested out on the actual manipulator in a simulated environment prior to the actual operation. Future work calls for this system to be operated in conjunction with their DAVID vehicle.

Tecnomare is developing a supervisory control system for manipulators which can enhance task effectiveness, reduce operator fatigue and perform difficult tasks [6]. A key aspect of this work is the development of the "TV-Trackmeter" which can evaluate spacial coordinates of a scene through the use of a stereoscopic based TV camera and image processing system. This system can track a point selected by the operator on the screen or can acquire the workspace geometry by scanning the area. By combining this with graphical presentations of the workspace and manipulator, the operator can be shown the entire operational environment. After this environment has been established, the operator can change his position within the environment to view from different angles, rotate objects, zoom in, etc. Combining all of the portions of this system, the motion of the vehicle, manipulator and environment can be accounted for which will result in an "operator friendly" control system.

Micro-Navigation

One of the best applications of computer generated graphics was recently used in association with the JASON Program at WHOI. The SHARPS (Sonic High Accuracy Ranging and Positioning System), developed by the Marquest Group of the US, was combined with a graphical model of a sunken ship which they were working on [7]. With the 2 cm accuracy, at 100 meters, of the SHARPS system, the operator can accurately fly the vehicle without adequate visual coverage from the onboard televisions. This would be of substantial benefit in turbid water, which was often the case during this operation. Also, with this system, the operator can move himself about the graphical scene to obtain different views of what is going on far below the ship. None of the benefits of the technology discussed to this point will reach their full potential without a reliable and accurate micro-navigation system. If the operator doesn't know where he is at, then he will never be able to perform the task.

Virtual Reality

Regardless of the sensitivity and accuracy of the tools, manipulators, hands and other systems at the operator's disposal, if he can't get a "real world" feel for the working environment, he will still not be efficient. This is the goal of the Monterey Bay Aquarium Research Institute (MBARI), United States, and the Centre for Industrial Research, Norway, in their respective projects.

The work being conducted at the Center for Industrial Research seems to be going in the direction of "virtual reality" through their development of a "video-wall" [8]. The operator sits in an "egg-shell shaped" chair, which eliminates most of the control room clutter, and communicates with the underwater maintenance system using voice commands or mouse input. The video wall presents graphically the entire environment he is operating in while the real-time TV presentation is shown directly in front of him. As he moves the chair, the TV insert moves with him. The video wall, which is 2 by 2.5 meters, along with the "stress-less" chair, gives the operator a good start to feeling a part of the environment.

MBARI is developing a conceptual control room for their new ROV [9]. The room will incorporate what is called a "display wall" which incorporates presentations from six TV cameras, sonars, and sensors to provide the operator with a "wrap around" environment. They feel that with the application of advanced audio displays, touch screens and universal hand controllers, they will be able to approach "virtual reality" while operating in a dynamic, non-structured environment.

Conclusion

What should the operator of tomorrow expect? Will he use computer interactive "data gloves" to reach out and touch the point in his computer generated graphic environment where the manipulator is to go? Will he relax in comfort, using voice commands while the computer tells him the status of data he requires? Probably all of the above. The good thing for the underwater industry is that they are not alone in developing much of this technology, especially the visual presentation of material. Therefore, the cost of developing such advanced systems will be somewhat reduced. Exploitation of advanced technology has always been a way of life for those working undersea, because if it can't be done on land, it probably can't be done underwater. Thus, the technology which is often being developed in the aerospace and other robotic industries first, will aid undersea technologists significantly in the quest for the perfect operator environment. Through technology transfer and the dedication and vision of today's technologists, "virtual reality" will eventually reside in the undersea operator's control room.

References

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