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A New ROV DP

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Abstract

This paper will introduce SeeTrack Offshore. A new DP system for ROVs that helps Offshore Contractors reduce their training and operating costs. SeeTrack Offshore automates the ROV control process.

It saves time over conventional systems making operations quicker, safer and easier. With SeeTrack Offshore the ROV pilot can truly control the ROV: forward means forward. The ROV efficiently maneuvers through a mission automatically compensating for the effects of currents. The ROV can keep a stable ROV hover without holding onto structures or landing on the seabed, allowing the operator to take excellent video pictures from a distance. SeeTrack Offshore is a simple retro-fit, which interfaces to a Doppler and the ROV joystick.

SeeTrack Offshore is the outcome of a several years of research and two years of focused product development, including various trials and offshore demonstrations in the West of Shetland and the Gulf of Mexico. The results from these trials and demonstrations will be shared with the audience.

Introduction

The offshore industry is experiencing a global shortage of qualified and experienced people. Young people are now less inclined to undergo technical or scientific training and the strain on the industry has been considerable. This resource challenge is particularly applicable across the ROV industry, where young pilots struggle with the steep learning curve, while experienced pilots are few and far between. Amidst this skills shortage the ROV industry has been growing in importance and new systems have been commissioned industry-wide, to maintain the pace of offshore operations. SeeTrack Offshore, the subject of this paper, has been designed to simplify the training needs of pilots by automating the ROV control process. The core technology behind SeeTrack Offshore is the outcome of a long program of research and development of Autonomous Underwater Vehicle technology (the interested reader should refer to [1]). This ongoing program resulted in the development and trial of the world's first offshore autonomous ROV riser inspection. Enhanced automation provides a platform that is intuitive to maneuver and allows the pilot to concentrate on the actual mission, thus improving his situational awareness. The use of this advanced Dynamic Positioning engine has also been found to make ROV operations safer, more stable and easier to operate. This paper describes the technology behind SeeTrack Offshore and provides telling results on the performance improvement expected through the use of the system.

Overview

SeeTrack Offshore has been designed using a modular architecture with an interface layer that can be adapted to fit different ROV systems. It can therefore be retrofitted to any existing ROV and it does not require changing any of its parts. The interface layer referred to as the "personality card" interfaces the surface unit to both the ROV control unit and the navigation sensors that must include a Doppler Velocity Log (DVL), a heading sensor and a depth sensor. The position of the ROV is estimated by the Navigation sensors and the estimates can be further improved if other sensors are also made available. The output from the Navigation module is used by the Autopilot module to control the ROV as requested by the operator through the Display module. Each of these modules are explained in more detail below.

The data from the navigation sensors is smoothed by the Navigation module in aid of Dynamic Positioning during dropouts of sensor data (such as Doppler outages). It integrates data from various sources and fuses it to provide position, velocity, attitude and attitude rate vectors at 5 Hz updates.

Conventional navigation solutions estimate the optimal position for the ROV which is not desirable for DP control, as updates from accurate absolute position references could result in the ROV "jumping" to a new position as it reacts to new estimates of its own position. This could result in erratic piloting which is potentially dangerous, therefore the Navigation module inside SeeTrack Offshore only uses the absolute references to update the coordinates on the display and any errors on the estimates of velocity and attitude rates, is left to the pilot to correct for position errors. The ROV will maintain a stable hover or will carry out a manoeuvre as originally planned and will not react to new position fixes. More accurate navigation sensors will improve the navigation performance, but conventional DVL systems operating at 300 kHz and a single-axis FOG have been shown to provide suitable performance, as illustrated in the results section.

The Autopilot module monitors vehicle position and responds to pilot requests, by calculating the necessary thruster settings to achieve new positions. The module processes requests with a 5 Hz update rate. This rate can be improved but has been sufficient for all observation- and work-class ROVs fitted to date. The Autopilot module provides a very smooth, accurate and efficient level of vehicle control, and is markedly different to that produced by a human ROV pilot.

The Display module is a key feature of SeeTrack Offshore. It has been designed through careful and prolonged consultations with ROV pilots. The outcome is a simple, highly intuitive interface that allows even novice pilots to carry out complex operations. The Display module links to a mouse for point-and-click control of the ROV and to a standard ROV joystick for a conventional flight. The pilot can command the ROV to move to positions using existing vector charts as a reference and see the sonar data from compatible sonars displayed in real-time. The Display module provides control inputs to the Autopilot module and is able to display the position of the ROV in real-time. It can also read survey strings and display the position of up to 2 other ROV systems, 3 TMS or garages and a vessel; therefore the operator is able to operate with a significantly improved picture of the ROV's environment.

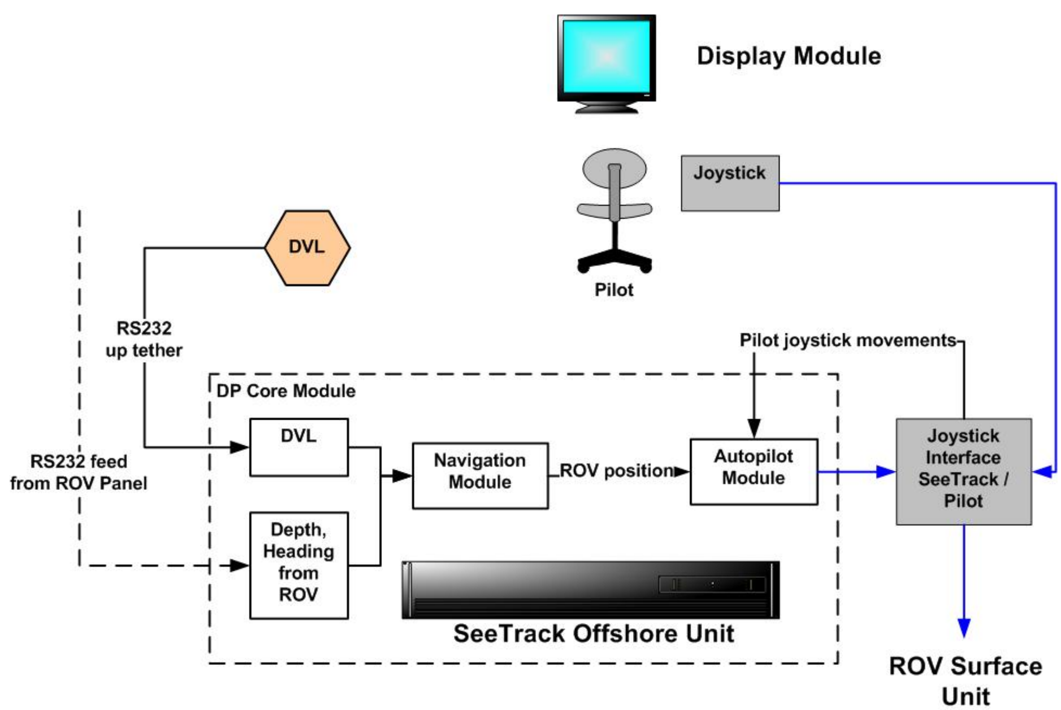

Figure 1: SeeTrack Offshore Architecture

Flight Modes

The flight modes were also designed after in depth consultations with the ROV pilots to ensure a safer and more efficient control. The flight modes essentially provide the operator with different levels of automation. Each level of automation simplifies the control of the ROV, but the operation can revert to manual control immediately when and if required, by using an emergency stop button. The flight modes are as follows:

- Manual: In Manual mode, the SeeTrack Offshore disengages from the ROV and it flies as a conventional ROV would. The Autopilot module does not alter the ROV joystick commands. The Display and Navigation module provide an estimate of the ROV position for the benefit of the pilot.
- Hover: In Hover mode, the ROV keeps station in a fixed position and compensates for tether effects and currents and ignores all joystick inputs.
- Auto-hover: In Auto-hover mode, the ROV is flown manually as a conventional system, but when the joystick is released the ROV enters hover mode automatically and keeps station. If the joystick is used again then the Autopilot module is disabled.
- Auto-Fly: In Auto-Fly mode, the Dynamic Positioning engine is constantly in charge. All modules are operating and forward using the joystick means forward, SeeTrack Offshore automatically compensates for tether effects and currents. In this mode the pilots can also use the popular point-and-click interface to move the ROV easily and efficiently.
- Cruise: The Cruise mode has been designed for surveys and the ROV cruises at a set speed and heading. In this mode the joystick is ignored.

The system can be disabled at any point through the emergency stop button irrespective of the flight mode. The emergency stop button completely disables the SeeTrack Offshore unit and when activated the ROV joystick will breakout from the SeeTrack Offshore surface unit. If the system looses Doppler lock or its heading and depth references, the ROV will also return to manual operation.

Results

SeeTrack Offshore has been extensively tested and has been used in operations in the West of Shetland and in the Gulf of Mexico. Tank tests have demonstrated that it can withstand significant currents, outperforming typical pilots, and in offshore tests, the system has been operated with currents of up to 1.6 knots, in depths of up to 500 meters and with 4 to 5 meters of heave. Recent offshore tests showed that positional performance is significantly more stable than a typical pilot, see Table 1.

	Typical Pilot	SeeTrack Offshore
Forward (m)	0.60	0.05
Lateral (m)	0.10	0.01
Depth (m)	0.40	0.40
Heading (º)	6.00	1.80

Table 1: Positional Performance

Figure 2 shows a typical response for the system. It typically displays a small overshoot and no offset when it settles.

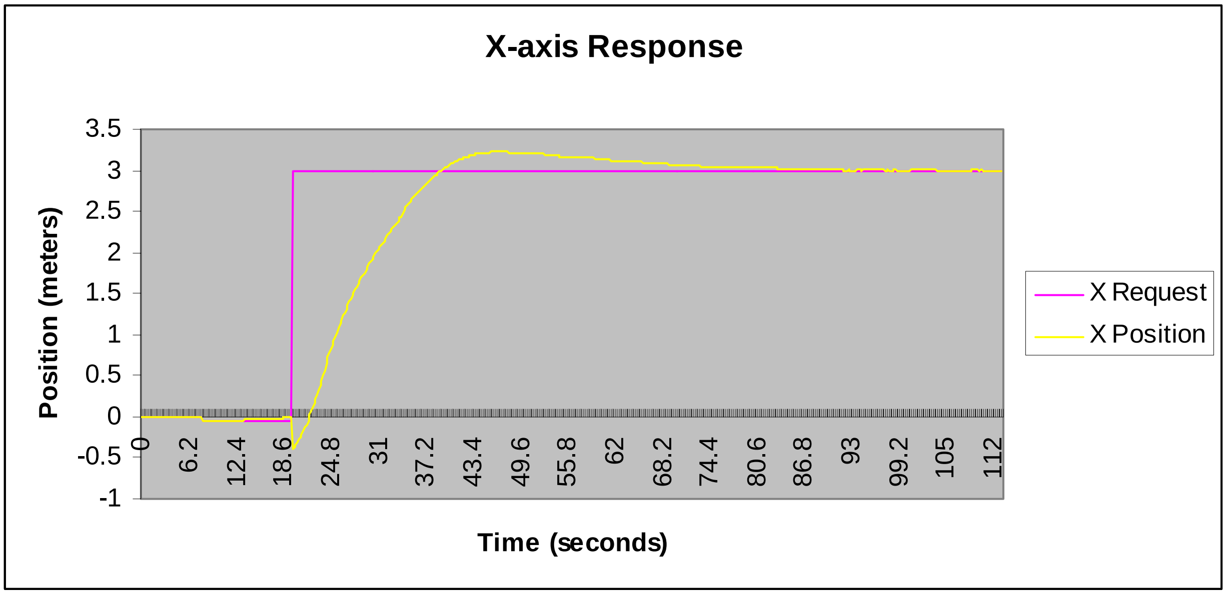

Figure 2: Typical Response to a request to a new position.

A different set of tests examined the performance improvement that resulted from running three different missions (see Table 2).

In the first mission, the pilot was instructed to transit to a target, identified in the sonar screen, 17 meters away from the ROV. The pilot simply chose the desired position for the ROV to transit to in SeeTrack Offshore's screen and clicked on it. When operating the ROV manually without automatic assistance the pilot would be required to re-observe the sonar screen at various intervals to ensure that the ROV is on the right course. Experiments proved that using SeeTrack Offshore was quicker.

The second mission involved a complex manipulator task. The pilot was asked to attach and tighten a shackle to an underwater structure. The complexity of this task is such that ROV pilots do not normally attempt it. The pilot was able to complete the task quickly and safely, outperforming a pilot flying the ROV without automatic assistance.

For the final mission the pilot was instructed to dock to the ROV garage under a 4 to 5 meter heave. The pilot using SeeTrack Offshore was able to expediently dock into the garage, see Figure 3. The pilot could simply hover close to the cage and wait for the ideal conditions to reverse into it and perform the docking procedure.

	Typical Pilot	SeeTrack Offshore
Transit 17m	50 sec	120 sec
Manipulator	120 sec	1200 sec
Docking	120 sec	300 sec

Table 2: Operational Performance

The results have demonstrated the clear advantages of SeeTrack Offshore over conventional operations. These advantages are available to any ROV with a DVL, a heading reference and a depth sensor.

Figure 3: ROV docks into garage using SeeTrack Offshore

Future Work

SeeTrack Offshore has now been retrofitted to two different types of Observation-Class systems (the Falcon and Lynx both manufactured by Seaeye) and three different types of Work-Class systems (including Subsea7's Hercules and Oceaneering's Maxximum). The use of a single common interface has made training and operations easier. One of our aims in the near future is to extend the umbrella of compatible systems.

The system will be further improved through the addition of new modules. Many of these modules have already been trialed in prototype form as part of the AUV work program. Initially SeeTrack Offshore will be enhanced through the addition of target-relative station keeping. Using an acoustic camera SeeTrack Offshore can be enabled to automatically track a target and subsequently maneuver the ROV around that target. The prototype form of this module has been used in a tank trial demonstration, see Figure 4, and to run Riser inspection missions in West of Shetland operations. The new modules will be trialed in the Gulf of Mexico and should allow for station-keeping in mid-water without Doppler lock. Future modules will be made available through the outcome of current programs of work being carried out for world recognized oil operators in the civilian sector and allied navies. These will include automatic target recognition and autonomous docking.

A new set of trials will commence on the 24th of September that will characterize the system for conventional drill support operations through repeated daily exercises over a three month period.

Figure 4: Automatic orbiting around a vertical target

Conclusions

SeeTrack Offshore will be the core platform necessary to incorporate a careful plan of enhancements. The paper has shown that substantial benefits can already be obtained from using the system. Through the delivery of proven technology, users will eventually become ROV-mission observers and new benefits will be available to the SeeTrack Offshore user community. The plan is to make 3D and reactive mission planning the accepted standard, and provide enhanced awareness to enable the ROV to follow its mission. In the future, running an ROV mission will be a painless task where the ROV will follow its pre-identified route and react automatically to planned events, such as taking a closer look at any potential features, and deal with any unplanned events, such as avoiding obstacles in a dynamically changing 3D world. The technology will also make the ROV aware of its own status. Failure of system components will clearly influence the way the ROV must operate and act. The ROV will be able to plan and re-plan vehicle actions in highly unstructured environments, taking into consideration not only changes in the environment and in the perception that the vehicle has of the environment, but also changes to the vehicle itself. All of these technologies are currently being developed and de-risked by SeeByte.

The current program of work detailed in this paper shows the current benefits of advanced Dynamic Positioning and the potential for future automated missions.

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