15th August 2013

THE HINDU

S & T » Science

How the heart of AUV was developed

R. Prasad

The control and navigation algorithms and guidance strategy for DRDO's 1,500 kg Autonomous Underwater Vehicle (AUV) was developed by the Department of Engineering Design, IIT Madras. The AUV is undergoing sea trials at about 100 metres below sea level. Photo: Special Arrangement The Hindu

The Autonomous Underwater Vehicle (AUV) is undergoing sea trials at about 100 metres below sea level

The heart of a nearly 1,500 kg robotic vessel that travels inside water — Autonomous Underwater Vehicle (AUV) — was developed by the Department of Engineering Design, IIT Madras.

The Defence Research and Development Organisation's (DRDO) underwater vehicle is currently undergoing sea trials at about 100 metres below sea level. The four-metre long, 1.4-metre wide, flat fish-shaped vehicle can travel at a speed of about 7 km per hour at depths of up to 300 metres below sea level.

Heart of the vehicle

The control and navigation algorithms and guidance strategy are the three most challenging aspects of an AUV, and all these together are considered as the heart of the vehicle. They were developed by a team led by Prof. T. Asokan of the Department of Engineering Design, IIT Madras.

The AUV has already passed the first stage of DRDO's project level testing. There is now a proposal to expand the AUV project to a major development programme.

The project level testing is basically to prove that technological integration of the software developed by IIT Madras with the hardware is possible, and the integrated system works as a whole.

Further elaborating on the significance of the development programme, Prof. Asokan noted: "It is for multiple applications like transport and surveillance. There must be a separate AUV variant for each operation." In the case of variants, only a fine-tuning of the algorithms and strategy is needed.

The robotic vehicle is fully pre-programmed — in terms of algorithms and strategy, and mission requirements — and piloted by an onboard computer. There is no control of the vehicle once it is released into water. "This is one of the biggest challenges," he said.

The limited communication with the vehicle cannot be put to use for regular operation. It is reserved for emergency communications like aborting a mission or activating a vehicle recovery mechanism. Most of the AUVs are built with positive buoyancy that tends to bring the vehicle towards the surface, in case of any system failure.

In the case of the AUV that is being tested by DRDO, the positive buoyancy is 15 kg. The vehicle moves at 0.3-0.4 metres per second speed when it comes to the surface due to positive buoyancy.

"The AUV will require fool-proof navigation, control and guidance systems on board to meet the mission accuracy requirements," Prof. Asokan said. "Even if one system fails, the mission will have to be abandoned and the vehicle recovered.

The control algorithm ensures that the various performance parameters of the vehicle, like speed and acceleration are achieved. Guidance strategy, on the other hand, is about planning a certain path to avoid obstacles and maintaining a required trajectory.

A navigation algorithm continuously monitors the location of the vehicle with respect to the desired location and corrects for any errors. The guidance strategy works in combination with navigation to maintain the pre-planned trajectory.

When the vehicle deviates from its intended path, the guidance and control systems activate the propellers (technically called 'thrusters') and control planes to ensure that the vehicle returns to the original trajectory and continue moving along the desired path.

The propeller configuration can be changed depending on the mission requirements. Movements in six different directions — upward and downward, forward and reverse, and left and right (port and starboard) — can be achieved by propellers placed suitably. Besides propellers, rudders and stern planes can also be used.

Simulations

Prior to developing the algorithms, Prof. Asokan and his team had to develop a dynamic model — mathematical equations of the robotic vehicle and payload. "Using the model we conducted many simulation studies to understand the performance and dynamic behaviour of the AUV," he said.

For instance, the simulation studies helped the team to understand how a particular thrust given to the vehicle changed the performance parameters like acceleration and turning rate. "Once we understood the normal operating behaviour, we started developing the controllers for desired performance," he explained.

Keywords: DRDO, Autonomous Underwater Vehicle, IIT Madras, AUV design