Student Autonomous Underwater Challenge - Europe

The Student Autonomous Underwater Challenge â€“ Europe (SAUC-E) is an annual event providing an opportunity for student-led teams to design and build a small autonomous underwater vehicle (AUV) to compete over a variety of challenges. The University of Southampton team (Figure 1) â€“ the winners of SAUC-E 2007 â€“ are aiming to retain their title at the 2008 edition to be held from 7 to 11 July at IFREMER in Brest (France). A new vehicle is in the latter stages of development for this yearâ€™s challenge to try to emulate the achievements of its predecessor.<P>

The Student AutonomousUnderwater Challenge – Europe (SAUC-E) aims to encourage new generations of engineers to focus on the advancement of underwater technologies by providing a real-world environment in which new ideas can be developed and tested. These aims are being achieved through the development of an annual competition in which credit can be gained across a range of categories. These categories include subjective measures such as design, innovation and build quality, and objective measures such as vehicle weight and performance. The performance is measured using an underwater test course consisting of a number of tasks including - identifying and navigating through gates, locating optically and/or acoustically active targets, marker dropping and arena mapping.

Previous SAUC-E Competitions

The first two SAUC-E competitions attracted a range of entrants from institutions based in France, Germany, Spain and the UK. There has been a wide variety of vehicles developed, ranging from hydrodynamically shaped AUV-style vehicles to open-frame ROV-style vehicles. In addition, a range of technologies has been implemented including biomimetic propulsion systems and even using everyday household objects.

The first SAUC-E competition was held at Pinewood Studios in 2006 (Figure 2). The University of Southampton team achieved a creditable third place finish behind teams from Universitat de Girona and Heriot-Watt University. A significant upgrade of the 2006 vehicle was undertaken to improve the propulsion system and the autonomy and control of the vehicle. These upgrades led to victory in the 2007 competition, held in the Haslar Manoeuvring Basin at Qinetiq in Gosport, ahead of teams from the University of Cambridge and ENSIETA. The robust, lightweight and manoeuvrable design scored well in the subjective categories, as well as exhibiting the best performance over the test course.

University of Southampton’s 2007 Entry

The 2007 vehicle (Figure 3) was 1.3m long and incorporated a pair of central pressure vessels: one containing the electronic systems and one containing the batteries. The pressure vessels were mounted onto a lightweight aluminium frame and were enclosed within a hydrodynamic carbon-fibre fairing designed to reduce vehicle drag. The vehicle was equipped with two wing-mounted thrusters and two vertical tunnel thrusters to provide control over the surge, heave, pitch and yaw motions. The particular thrusters chosen were 70-mm diameter rim-driven thrusters offering symmetrical performance and good low-speed control. In addition, four stern-mounted fixed control surfaces enhanced the stability of the vehicle.

Sensors and Control

The sensory equipment onboard included a pressure sensor, an inertial measurement unit (IMU), a three-axis magnetometer and three cameras, which provided data to the control software, developed in Matlab, run on a Mini-ITX board. The control software was written using a software agent approach, that is, the components of the control system are split into separate modules that run simultaneously and share information via a database. Examples of these individual modules include a module with responsibility for the overall mission control, a module with responsibility for processing the images from the cameras and a module with responsibility for the low-level control (thruster control).

Navigation and Guidance

The navigation and guidance of the vehicle was undertaken using the simultaneous localisation and mapping (SLAM) approach, which correlates the information on the relative motion of the vehicle from the sensors with the images recorded by the cameras. These images are processed to identify objects or features thus allowing the vehicle to build up a map of the arena to aid in navigation and decision-making. For the competition, the cameras are also used to identify specific targets in the arena, which are of known colour and shape.

Aims of the SAUC-E 2008 Vehicle

The 2008 vehicle has been designed by a group of undergraduate students to embrace the new challenges introduced for the 2008 competition whilst drawing on the experience gained in previous years. More specifically, these new challenges include salt water of greater depth than the previous vehicle was capable of operating in. The new vehicle retains the lightweight and hydrodynamic design approach, and aims to improve on the manoeuvrability and control performance of the 2007 vehicle. A further aim for the 2008 design is to develop a testbed for postgraduate research into the propulsion and manoeuvring of underwater vehicles.

Vehicle Layout

The 2008 vehicle has a torpedo shape with an elliptical nose, parallel midbody and tapered tail section. The parallel midbody section is formed of a pair of cylindrical pressure vessels in a similar arrangement to the 2007 vehicle. The tail and nose sections are floodable with

outer fairings constructed using a vacuum-formed plastic. To combat the difficulties of operating in salt water, the vehicle is primarily constructed from engineering plastics, using perspex tubes for the pressure vessels and Delrin for the end caps and attached nose and tail frame structure.

Propulsion and Actuators

The 2008 vehicle is over-actuated with a ducted thruster at the vehicle stern for primary propulsion and four tunnel thrusters – two horizontal and two vertical – in addition to two pairs of actuated control surfaces mounted on to the duct in the race from the stern thruster. This over-actuation provides multiple options for undertaking the manoeuvres required for the competition tasks but also facilitates research into the control of underwater vehicles throughout the entire speed range including the transition between high-speed (survey) and low-speed operation.

Control Developments

The sensors onboard the 2008 vehicle are similar to those used on the 2007 vehicle with superior cameras to enhance the autonomy and control. The 2008 vehicle also has a sonar system to provide greater mapping capabilities. Matlab Simulink has been chosen for the control software. This provides a pictorial and interactive environment for developing the control algorithms and facilitates simple adjustment and fine-tuning.

Lessons from Previous Experience

The design, manufacture and testing of vehicles for the SAUC-E competition has furnished the team with considerable experience in the development of small, low-cost AUVs. The key lessons learnt from these competitions are that the vehicle needs to be robust for the environment that it is intended for, including an awareness of its operation and maintenance at the design stage; and that an integral factor in the development of a good control system is the amount of practical testing undertaken with the vehicle to enable the controller to be tuned to the specific responses of the vehicle.

The new vehicle is registered to compete at the 2008 SAUC-E competition in July. The team hope that the experiences gained from the previous competitions and the time and effort spent developing the new vehicle will enable the University of Southampton to retain their title.

The University of Southampton team would like to thank their sponsors Kongsberg Maritime, Kontron, Reap Systems, Scorpion Vision Software, Seacon (Europe) and TSL Technology.

More details about the University of Southampton team and the development of AUVs for the SAUC-E competition can be found at website 1.
More details about SAUC-E in general, including details of the 2008 competition, can be found at website 2.