The Use of Active Control on Human Powered Vehicles

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Abstract: There are many considerations that go into the design of a human-powered submarine, but the two most important are speed and control. The speed of the submarine is determined by the mechanical efficiency of the drive system and the drag. The controllability of the submarine results from the design of the control surfaces and the control actuator. In a one-man sub, both of these systems are at the mercy of the pilot. It is very difficult for the pilot to concentrate on peddling at the correct rpm and make directional corrections at the same time. In many cases the pilot will stop or slow peddling in order to make control changes. This results in a decrease in the forward velocity of the sub. A better solution to controlling the submarine is to decrease or eliminate the need for the pilot to control the direction of the sub. This is the approach that was adopted last year at Virginia Tech.

Last year pressure transducers and microcontrollers were used to determine and maintain the depth of the sub. This was a very basic system requiring each microcontroller to be programmed using assembly language. This was very time consuming, but it was effective. This system effectively reduced the control demand on the pilot by 50%. It showed that it was possible to build a safe and reliable electronic control system and most important it was a good starting point to implementing a more fully automatic control system.

This year the system is fully autonomous. In addition to the pressure transducers, a magnetic compass was added. The digital compass has a resolution of 0.1°, which results in a maximum error of 6" in 100 yards. The microcontrollers were replaced with a PC/104 computer and the control program was written in LabView. This allows for quick changes to the control program and allows for analysis on any computer. The entire system was mounted in a waterproof box as shown in Figure 1.

The control system can maintain the depth to within 6". Both the depth control and the directional control are better than what can be maintained, much less perceived by the pilot. The pilot has the ability to override the system using a joystick, which uses rotary encoders to determine the desired control surface angle.

Competition results have shown that 2-person (1 control, 1 propulsion) subs perform just as well as most 1-person subs, even though they are larger. One can conclude that this is due to the fact that the peddler is not distracted by the control needs. The autonomous control system gives the same result, without the need for a larger sub with greater mass and greater drag. This system completely removes the need for pilot control and allows the pilot to concentrate fully on propulsion.

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