Adaptive RC Sailer Interface Design Notes

Overview: Typically, radio-controlled model sailboats are operated by two joysticks; one to position the sails (in or out); and another joystick to control the rudder position (left and right). In general, quadriplegics rely on mechanical/electrical adaptations to control their environment. Various adaptive devices include momentary on/off switches (sip & puff), gravity sensing switch (head tilt), voice recognition systems, and electronic sensors which detect low voltage neurological impulses (muscle and brain wave signals). The Adaptive RC Sailer Interface incorporates the popular Arduino micro-controller to monitor, interrupt, and translate the adaptive inputs from momentary contact switches into compatible RC system inputs.

Description: Normally, the joysticks are attached to the rotatable shaft (called the wiper) of a potentiometer (variable resistor) which is similar to the analog volume control on a stereo system. As the joystick moves left & right or forward & backward, the wiper rotates and creates a voltage divider between the stationary high and low voltage terminals of the potentiometer. The varying voltages are picked off the wiper and are applied to the circuit which creates time spaces between the transmitted pulses that are subsequently demodulated into control signals by the receiver. Substituting an *electronically controlled digital potentiometer* for the mechanical potentiometer attached to the joystick provides the key to building an adaptive system. An *electronic digital potentiometer* can be adjusted by various means. A very simple way is to click a switch for lesser resistance (rudder left) and to click another switch for greater resistance (rudder right). The Arduino micro-controller monitors the number of clicks and directs the digital potentiometers to alter their resistive values. Similarly, two additional switches can be used to winch the sails in or release the sails out.

Implementation: Besides the adaptive switches that are already familiar to quadriplegics, the Adaptive RC Sailer Interface consists of the following components:

an Arduino UNO micro-controller,
two X9C103 digital potentiometers,
https://www.renesas.com/cn/en/document/dst/x9c102-x9c103-x9c104-x9c503-datasheet
printed circuit board (Vero Stripboard) with an 16 pin DIP socket and three 3.5 mm stereo jacks.

These components can be obtained from various on-line sources such as Digi-Key, Mouser, and others. The Arduino source code .ino can be downloaded from GitHub
https://github.com/adaptivercsailing/adaptivercsailing,
as well as a copy of these design notes along with a copy of the simplified wiring diagram.

Notes and Caveats:

1. This modification requires opening the RC transmitter and disconnecting two joysticks from the motherboard. However, no other modifications are required for either the RC receiver or the sailboat itself. Connections to the interface box are via 3.5 mm stereo cables, which in most cases, are directly compatible with existing adaptive switch devices.

2. Since there are no readily available sources for the various joystick/motherboard connectors, the replacement connections must be improvised.

3. The prototype was based on a 5 VDC radio system (HiTec LASER 4). If your system incorporates 3.3 VDC (for example, the FlySky i6X), then the circuit board needs to be rewired to use the Arduino's 3.3 VDC supply pin rather than the 5 VDC supply pin.

4. The feasibility demonstration prototype PCB board wiring color scheme and layout differ slightly from the updated Fritzing diagram, but is nevertheless functionally the same.

5. If control reversals occur, they can be accommodated by using the *Control Reverse* feature of your radio system; by interchanging the adaptive switch cable positons on the interface control box; or by rearranging the increment/decrement commands in the .ino source code.

6. *Trim Control* can be accomplished in software, by hardware, or by a combination of both. The feasibility demonstration prototype incorporates the trim function in the Arduino .ino software (by setting the "center" values as well as the maximum and minimum excursion values). "Trim pots" could have been added to the Arduino Interface Control box in order to manually tweak the quiescent values. Depending on the radio system, the organic trim system might still be available.

7. The Surrogate Adaptive Switch Simulator box was a development tool that served as a substitute for actual adaptive switches. It is not required for implementing the Adaptive RC Sailer Interface. If you need to debug the system, simply grounding the SailsIn & SailsOut and the RudderLeft & RudderRight pins will accomplish the desired task.

8. Hopefully a significant number of people will be inclined to fork this project and develop approaches which use various other adaptive input devices as mentioned above (especially the voice recognition and the brain wave sensor) as well as an approach that injects a PPM signal directly into the RC transmitter's PPM port.