

RoboSail Workshop 4

Objectives Students will:

- Create code that uses RC Transmitter to switch between autonomous and manual sail control
- Write/test/debug code for autonomous rudder control, tacking and gybing

Part I Learn/discuss how RC Transmitter can be used in Automatic Sail mode (30 min)

1. Discuss autonomous sail mode
 - a. The sail is now automatically controlled by the Arduino code. Is it useful to have autonomous sail all the time? Do you ever want to regain control?
 - b. The sail control lever on RC Transmitter is not used but the signal is still being read by the Arduino. How can it be used for switching between manual and automatic, or for another function?
2. Create code to switch between Autonomous and Manual Sail, test/revise
 - a. During regular sailing the sail is least often full-out. We can use this lever position to indicate Autonomous sailing.
 - b. Define lever position of > 1850 or so to mean use Autonomous Sail. Anything less than that is Manual Sail
 - c. The benefit of this strategy is that you can always take control back from the Arduino and bring the boat home without having to go chase down someone with a skiff to go rescue your boat.
 - d. Program this and test it out on the water. Call the program ManAutoSailSwitch.ino
3. Discuss future uses of the RC Transmitter when both sail and rudder are autonomous
 - a. Next step in programming is autonomous rudder. That leaves the Rudder lever available to send signals to the boat.
 - b. We can continue to use the Sail Lever as Manual or Autonomous as in the first exercise today. Later you can change it to anything you want.
 - c. Think of "Rudder Left" (< 1200) as signal "L" that can tell the boat to turn left by some amount. Similarly "Rudder Right" (> 1800) as signal "R" that can tell the boat to turn right by some amount.
 - d. Discuss how this might be done in code – then put it on hold until there are algorithms and code for autonomous rudder.
 - i. Need to check that lever has "returned to center" before initiating command

Part II Create code for autonomous rudder to hold a given Point of Sail (90 min or more)

1. Review frame of reference for sensors and actuators and practice on plastic sailboats
 - a. Make sure that kids can describe Points of Sail (windvane angles) as angles/numbers
 - b. Make sure that kids can describe Rudder positions as angles/numbers
2. Do exercise on sailing to a Point of Sail using a fan and a student
 - a. Blow fan from one direction. Define it as angle
 - b. Student turns to various points (beam reach, close haul, run, etc.)

- c. Move fan a bit to simulate shifting wind. Student should follow desired point.
 - d. Demonstrate how small steps are used for small adjustments and big steps for big ones.
 - e. Define the “error” between the actual wind angle and the desired wind angle or Point of Sail
 3. Develop algorithm and code for automatic rudder for a given Point of Sail
 - a. Use plastic boats to visualize and test
 - b. Define a starter Point of Sail (90° on the windvane is a good place to start)
 - c. Create pseudocode and share/discuss
 - i. Consider using $\text{Change} = (\text{DesiredAngle} - \text{WindAngle})$ to create a command for the rudder such as $\text{rudderCommand} = \text{change} * \text{scalefactor}$
 - ii. Make sure to constrain the rudder command to $\pm 60^\circ$
 - d. Create new code called AutoRudder.ino using ManAutoSailSwitch.ino code from the last exercise
 - e. Debug/Test/Revise in classroom. Use a fan to simulate wind and rotate boat by hand according to rudder. On water the boat will only sail to the Use
 4. Review ways to use Transmitter while in Autonomous mode.
 - a. Use sail lever to make a manual/automatic switch for rudder control. This code is created **next** and will be called AutoRudderPOSwithSwitch.ino
 - b. Use rudder lever to send cues to boat when in automatic rudder mode. Cues can be used to change direction. This code is created **later** and will be called AutoRudderPOSwithSwitchCue.ino
 5. Develop algorithm for an autonomous/manual rudder control switch (using the sail lever)
 - a. With the sail lever in the up position (autonomous), the boat will sail with autonomous sail and rudder control to a POS specified in the code.
 - b. With the sail lever in the down position (manual), the user regains control of the rudder and can pilot the boat to a different course. The sail control continues to be autonomous.
 6. Coding exercise 3: Create new code called AutoRudderPOSwithSwitch.ino using AutoRudder.ino code from the last exercise
 - a. Use a boolean variable such as `Auto = TRUE`
 - b. Debug/Test/Revise in classroom, then on the water
 7. Program the boat to gybe when appropriate (optional)
 - a. The first time through this exercise, the code likely causes the boat to tack to the specified POS, no matter what course it is on. Discuss ways to modify the algorithm such that it gybes when appropriate
 - b. Consider logic that sends boat to the desired position by turning the easiest way (less than 180 °)
 - i. If $(\text{change} > 180^\circ)$ then $\text{change} = \text{change} - 360^\circ$
 - ii. If $(\text{change} < 180^\circ)$ then $\text{change} = \text{change} + 360^\circ$