Autopilot For A Personal Watercraft

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The objective of this thesis was to develop an autopilot for a personal watercraft (PWC) – popularly known as a jetski – that is capable of maneuvering both in calm and rough waters.

The Swedish Sea Rescue Society (SSRS) is a voluntary organization focused on saving lives at sea and participate at approximately 80 percent of all sea rescue operations in Sweden. With a variety of vessels used in these operations, one of the more important one is the RescueRunner. The RescueRunner is a PWC designed by the organization *Safe at Sea* in cooperation with the SSRS to be used in search and rescue operations, due to their quickness and agility.

Like all PWC, a RescueRunner can be exhausting to drive for long distances, particularly in rough conditions. Since SSRS's main vessels are too small to carry a RescueRunner, an autopilot is to be developed such that the RescueRunner can follow the lead boat autonomously to the rescue site.

At Chalmers, several previous projects have worked on the RescueRunner. Among these, [2] and [3] were helpful to this project. The aim of this project was to develop an autopilot [1] such that it can handle calm and rough water alike. To achieve this, the following steps were taken:

- Modelling of the PWC.
- Modelling of the environmental disturbances (wind, waves and currents).
- Control strategy for following waypoints.
- Control strategy for dealing with disturbances.

A common method of controlling naval craft is by controlling the velocity and heading independently, meaning one separate controller for each. This was also done in this project. For the PWC to follow the lead boat, coordinates of the lead boat (waypoints) are sent out to the PWC. By comparing the waypoints (desired position) and the current position the appropriate velocity and heading are calculated.

In rough waters where environmental disturbances are more prominent, things become more difficult. Waves were the largest concern and presents the biggest challenge. The challenge is further exasperated by the lack of human aboard, which takes away valuable weight and stabilizing influence from body-movements. This makes a PWC even more vulnerable to being "thrown around" by the waves. Due to the uncertain and unpredictable nature of the waves, developing control strategies from a simple wave-model would not be viable in real-life applications. Instead, the control strategies were modelled on maneuvers assumed to mimic experienced PWC-drivers in a set of different scenarios. For instance, if waves were coming from a certain direction, how would an experienced driver handle that? Whilst these strategies certainly do not guarantee stability, they are deemed to give the PWC a viable chance of moving towards its desired position without capsizing in rough waters.

A series of simulations were performed with the model. Following a leadboat between waypoints is easy enough in simulations. With ocean currents pulling the PWC resulting in reduced or increased resistance was countered by the use of integral action in the controller. Drifting was countered by continuously recalculating the course heading.

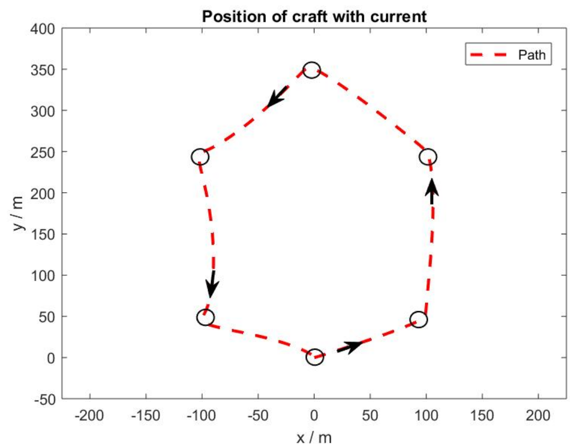

Figure 1. Path of a PWC during a hexagon movement with sea currents (from the right).

In terms of waves, simulations were made was to examine the feasibility of a "zig-zag" maneuver in situations when waves were coming from the sides. This maneuver entails staying in course (towards the desired position) and only turning towards the waves (head on) when they are about to hit. The point of the simulations was to examine whether a PWC can turn fast enough to face the waves head on and then quickly getting back on course. The result for this specific maneuver was not very promising when the waves come in rapid succession, since the craft had precious little time to turn and face the wave. There is however a lot of room for improvement that might make this maneuver more compelling. The hope is that the control strategies given in this project can be a good basis and are built upon in future works.

References

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