# Control of Mini Autonomous Surface Vessel

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***Abstract—*** *This paper presents an initial development stage of mini Autonomous Surface Vehicles (ASVs). The ASVs named Drosobot is being developed for hydrographic survey on lakes. The paper also explains the factors influencing the conceptual model, the selection of shape, the parameters influencing the control in the design, the practicalities encountered in navigational issues and mechanisms of communication amongst a group of these ASVs based upon the Drosophila's optimal swarming movements.*

*Keywords: Autonomous Surface Vehicles, Drosobot.*

## I. INTRODUCTION

The use of ASVs for oceanographic observations could result in sea surface measurements that have higher spatial and temporal resolution than the current methods[1]. Based on our survey, this kind of mini ASVs swarming platform being developed by Charlesa *et al.* [2], concentrates on the problem of finding an optimal navigation path through regions of coastal bioluminescence while maintaining covert status of the operation. Meanwhile Mahacek, P. *et al.* is currently developing multi ASVs using cluster space control approaches [3]. In contrast, our study addresses the problem of finding the best mechanical design to be integrated with the optimal navigation path searching of Drosophila or the fruit fly in the marine environment.

## II. BACKGROUND

To exhibit the practical benefits of this approach, we are constructing a group of five simple ASVs. This work is focused on the research and development of a portable, high-performance, mobile surface platform to provide both port security navigation aid as well as environmental and oceanographic measurements. The Drosophila Robot (DrosoBot) is designed to be cylindrical (38cm in diameter) in shape, so that it would be able to move in an omni directional manner, based on the motion behavior of the Drosophila. The system is able to communicate in real-time with swarming intelligent capabilities may be deployed for underwater floor mapping and water quality sampling applications.

## III. MODELLING AND CONTROL

The basic principle of the ASV must comply with the basic ship theory. However, in the case of the ASV, due to the lightness in weight of the ASV, total dependence on the ship theory cannot be made. The most challenging phase of this work is determining the maneuvering stability. In this work, drift angle handling and reduction is of main concern since these two parameters have paramount importance in determining the stability of the ASVs. Mass distribution is always represented by mass of inertia. The top priority to be considered would be the yaw mass of inertia since it will directly affect the heading direction of the ASV. Roll and pitch direction mass of inertia are meaningful when vibration in vertical direction is significant. SolidWorks is used to compute the moment of inertia.

Fig. 1: Actual platform on the field test.

## IV. RESULTS AND DISCUSSIONS

The Solidworks design of the ASV is analyzed using Matlab. In practical, the ASV might not achieve the desired position and direction at the same time.

### a. Simulation

Due to the fact that the sampling time is 4 seconds (NMEA Combiner), the ideal PID cannot be achieved. Thus, the program is made to turn a smaller angle over time in order to prevent overturning. Maintaining the rudder angle for 4s might yield unpredictable turning. Through such an arrangement, despite the low sampling frequency and lack of speed control, the accuracy is within the tolerance of ±3m with the condition that the GPS gives steady readings. Besides that, measures to prevent overturning also readily reduce the drift angle. This will enhance yaw stability. Fig. 2 shows the ASV travelling from an origin with initial heading at North to (0,-8) at South. As the thruster does not allow double sided thrusting, this serves as a good testing condition. The ASV reaches (-0.300, 8.556) at 48s. The error is 0.6309m.

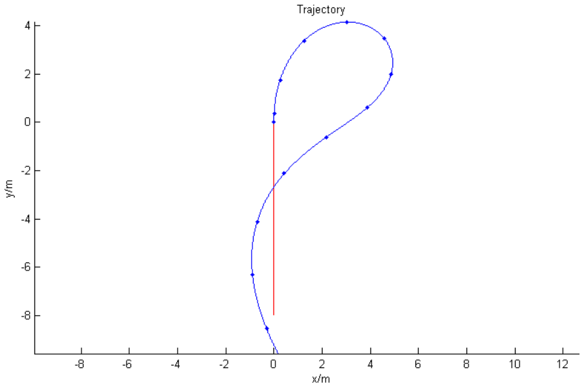

Fig. 2: ASV Trajectory at 180-degree Turning

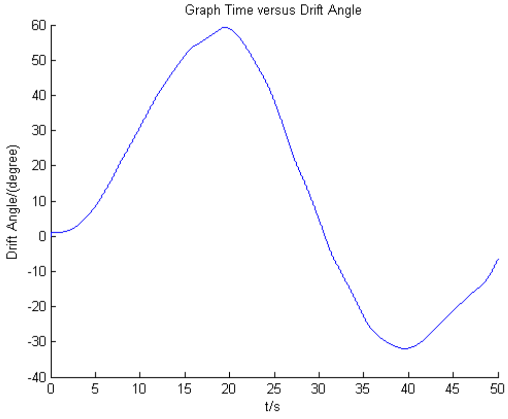

Fig. 3: ASV drift angle at 180 degree turning

Fig. 3 shows the drift angle of the ASV. Although the drift angle is large at the initial turning, the next peak shows a declining drift angle. However, as this case is the extreme case, this shows that the drift angle can only reach 60 degree at the most. For a 45 degree turning trajectory however, 22s is needed for it to reach the destination. There is enhancement in accuracy and the drifting angle is 28 degrees. Therefore, in order to maintain yaw stability, path planning is suggested to prevent sharp turning. Path planning should also include the option of allowing polygonal path rather than displacement path. Moreover, accuracy degrades as the turning angle increases.

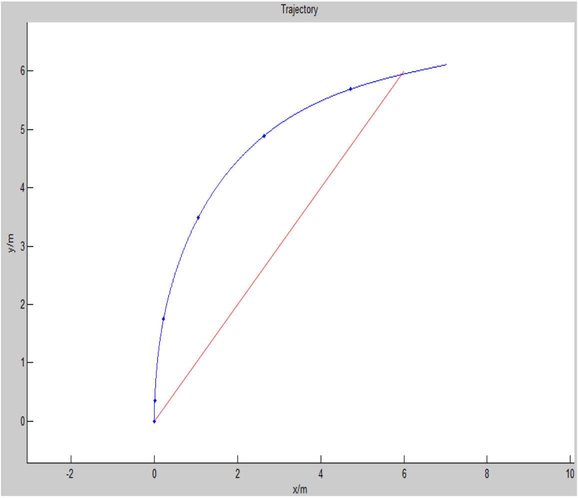

Fig. 4: ASV Trajectory at 45-degree Turning

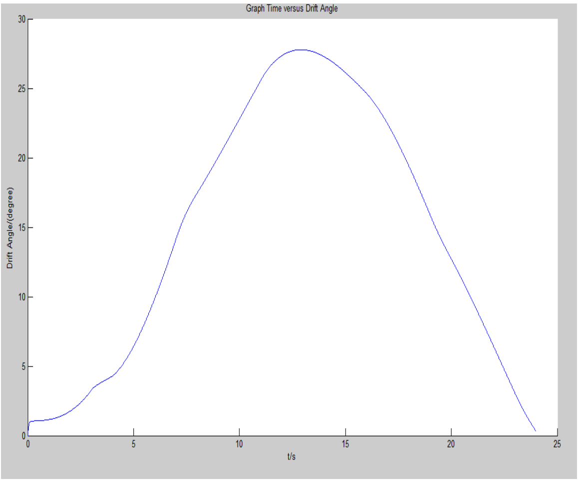

Fig. 5: ASV drift angle at 45-degree turning

Fig. 4 shows 45 degree turning trajectory. The destination was reached at 22s. Accuracy is much enhanced if compared to 180 degree case. Fig. 5 shows 45 degree turning drift angle. The drifting angle is 28 degree. Thus, it suggests that path planning should prevent sharp turning in order to maintain the yaw stability. It is also true that path planning should allow polygonal path rather than a straight displacement path. Moreover, accuracy degrades with turning angle increases.

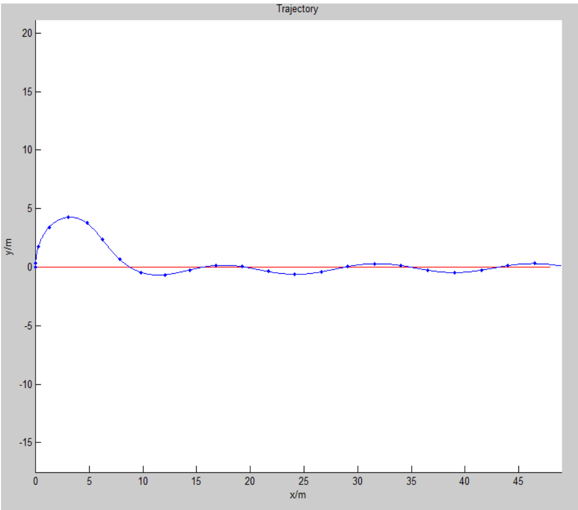

Fig. 6: ASV Trajectory at 90-degree Turning

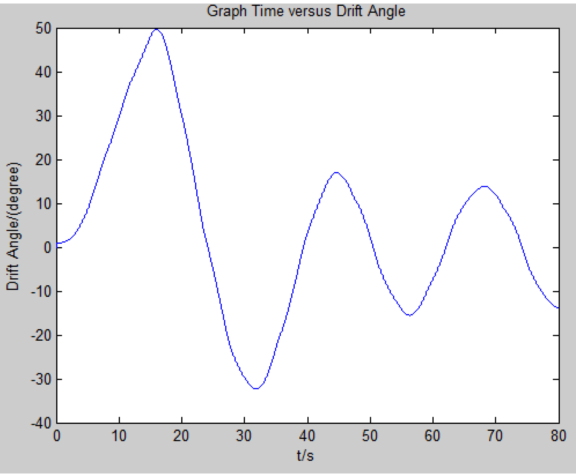

Fig. 7: ASV Drift Angle at 90-degree Turning

Fig. 6 reveals that the ASV can be deployed in omni-directional path. The error is tolerable since it is still within 1m while the ASV itself is 38cm in diameter. Fig. 7 also reveals that the drift angle settles down faster than the case of 180-degree turning. The ASV reaches maximum drift angle in 16s for 90-degree turning while it uses to 20s to reach maximum for 180-degree turning. Judge from Fig. 2 and Fig. 4 the ASV is capable to maneuver as long as the allowable turning radius is larger than 6m. Based on this consideration, the ASV swarm path planning system must allow the turning radius to be 8m to prevent any potential collision with obstacle. The distance in between ASV must also larger than 8m when these mini ASVs form a swarm.

### b. Pre experimental result

We performed a preliminary experiment to identify control performance and perform pool mapping (small swimming pool). Fig. 8 shows the underwater contour, plotted by using 5 units of DrosoBots in 15 minutes.

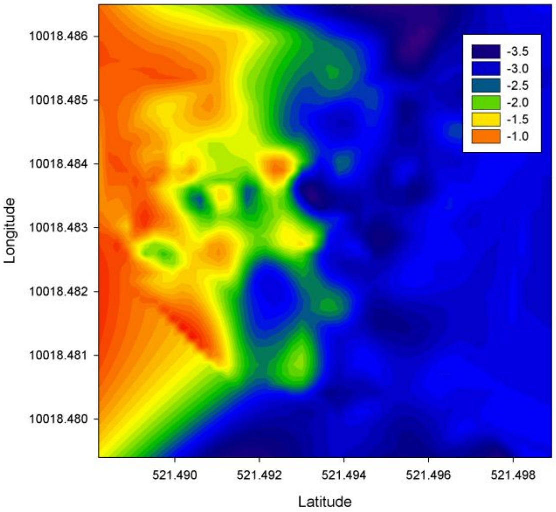

Fig. 8: Swimming pool contour

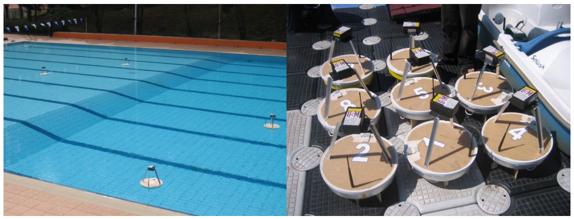

Fig. 9: Actual DrosoBots in action

The experiment shows that, DrosoBOTs could be used for collecting various marine data such as temperature, salinity, conductivity and eventually can identify the deepest location of that particular area as well. Currently we are also working on the numerical benchmark function of the Fly Optimization Algorithm for min-max optimal searching such as Sphere, Rosenbrock, Rastrigin, Griewank, Schwefel and Schaffer. This performance analysis will assist to gain a deeper understanding on the efficiency of the optimal searching algorithm as compared to the other animal inspired metaheuristic algorithms.

## V. CONCLUSION AND FUTURE WORK

The DrosoBOTs focuses in this works on the functionality of the swarm robotics dedicated for marine applications. It has been developed purposely for collecting a range of data in a short period of time. The simulation and trial results show that the ASV needs to be improved before their actual deployment on lakes and the coastal area.

## VI. ACKNOWLEDGMENT

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