MAS 03 A simulation-based study of the effects of underwater communications on the control of Marine robots

MAS 03.1 People

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MAS 03.2 Overview

Communication plays an important role in the design of collaborative systems. If teams of marine robots involve AUVs (Autonomous Underwater Vehicles), and we want to enable them to have communication without surfacing, underwater communications are a requirement. Acoustic channels suffer from significant attenuation, dependent both on frequency and distance. There is extensive time-varying multi-path, motion-induced Doppler distortion as well as an introduction of delays due to the low speed of sound – something not easily noticeable in radio or optical communication mediums. This severely limits the available bandwidth as well as varies the communications performance with distance.

MAS 03.3 Approach and System Description

To know how information provided via an acoustic communication link, affects the performance of the controllers of the ASV, we conducted simulations to study this effect by providing localization of the ASV via an acoustic channel while its station-keeping controller described in [2] was used. Fig. 4 shows this scheme. In particular we looked at the effect of Packet Error rates, the effect of communication delays, the joint effects of Packet Error Rates as well as those due to the transmission bandwidth and the effects of wind.

Figs. 2, 3, 4, and 5 show results from MATLAB simulations of our vehicle model from [1]. In Fig. 2, we can observe that the mean-positioning error is not affected by packet loss until this loss becomes large, on the order of 0.7. We believe this is because the communications bandwidth is still stays high enough as compared to the dynamics of the ASV.
Fig. 4 shows the joint effect of both the error-rate and the transmission delay acting simultaneously. This effect is much more pronounced than either effect alone taken singularly. We see that even modest packet error-rates coupled with modest delays leads to much larger mean-positioning errors. Delay also shifts the transition point for when increases in the error-rate cause an “exponential” increase in the positioning error.

As explained in [1], the effective transmission bandwidth is range-dependent. To make up for bandwidth-loss due to range, it might be necessary to compensate by reducing the resolution of the data. We performed studies to test the effect of transmission bandwidth which we performed by adding quantization to the position-feedback in the packets.

**MAS 03. 4 Results and Accomplishments**

Figs. 2, 3, 4 and 5 show some of the simulation results obtained through extensive simulation experiments we conducted. These results highlight the fact that underwater communications are indeed a significant challenge. We can conclude that our control system can be significantly affected by the errors, delays, bandwidth and wind-related effects due to acoustic communications. However, when these errors are low, their effect is filtered out by the slow dynamics of the vehicle.

**MAS 03. 5External Research Partnerships**
The robotics group at the University of Cassino, Italy (current).