

Theoretical Approach of Development of Tracking Module for ARPA system on Board Warships

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Abstract : The maritime industry is expanding at an alarming rate and as such there is a perpetual need to improve situation awareness in the maritime environment using new and emerging technology. Tracking is one of the numerous ways of enhancing situation awareness by providing information that may be useful to the operator. The tracking system described herein comprises determining existing states of own ship, state prediction and state compensation caused by random noise. The purpose of this paper is to analyze the process of tracking and develop a tracking algorithm by using α - β - γ tracking filter under a random noise or irregular motion for use in a warship. The algorithm involves initializing the input parameters of position, velocity and course. The actual positions are then computed for each time interval. In addition, a weighted difference of the observed and predicted position at the n th observation is added to the predicted position to obtain the smoothed position. This estimation is subsequently employed to determine the predicted position at $(n+1)$. The smoothed values, predicted values and the observed values are used to compute the twice distance root mean square (2drms) error as a measure of accuracy of the tracking module.

Key words : Tracking module, warship, α - β - γ filter, state matrix, state compensation, smoothing, prediction, stable condition

Contents

- 1, Introduction
- 2, Objectives
- 3, α - β - γ Tracking Filter Equations
- 4, Simulation Results and Analysis
- 5, Conclusion

Objectives

- To Develop a Theoretical Tracking module that continuously computes and updates a maneuvering vessel's position.
- To test the performance of the tracking module by use of the 2drms error measurement.

Introduction

Tracking as used in the maritime industry is the continuous computation and updating of the various parameters that are important to be known by the operator. This is achieved by utilization of a tracking filter which reduces the noise observation hence improving the estimations of the measured parameters.

α - β - γ Tracking Filter Equations

The tracking filter considered for this paper is the α - β - γ filter since it is easy to implement as it has less computational load. In addition, its design enables tracking of a maneuvering vessel with high accuracy. The following equations describe the tracking process using the α - β - γ filter;

$$P_s(n) = P_p(n) + \alpha(P_o(n) - P_p(n))$$

$$V_s(n) = V_s(n-1) + t a_s(n-1) + \frac{\beta}{t}(P_o(n) - P_p(n))$$

$$a_s(n) = a_s(n-1) + \frac{2\gamma}{t^2}(P_o(n) - P_p(n))$$

$$P_p(n+1) = P_s(n) + t V_s(n) + \frac{t^2}{2} a_s(n)$$

the subscripts o, p and s denote the observed, predicted and smoothed positions respectively.
 t: is the time interval between steps
 n: is number of steps
 The smoothing parameter for position is determined as follows:

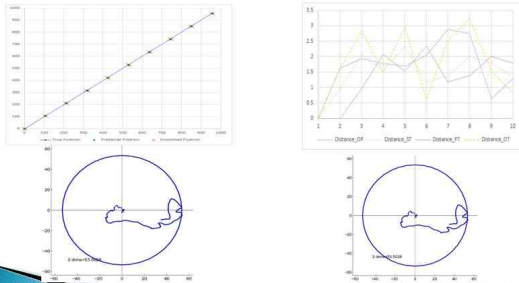
$$\frac{2(2n-1)}{n(n+1)} < \alpha \leq 0.6$$

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Simulation Results



The following simulation tests were performed in order to evaluate the performance of the α - β - γ filter algorithm;
i. No input noise



Result Analysis

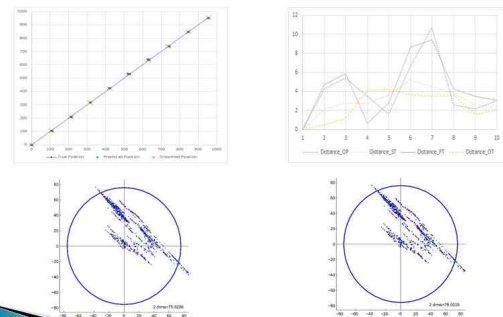


- The residual and prediction errors were computed by calculating twice the root mean square from the true positions to the observed, smoothed and predicted positions of the circle containing 95% of the respective 1000 positions. These radial distances were then used to compare the tracking filter performance among the three cases.
- The radial distances were larger in the two cases that had noise input than in the noise free simulation.
- The residual errors were lower than the prediction errors.

Simulation Results



ii. Varying course



Conclusion

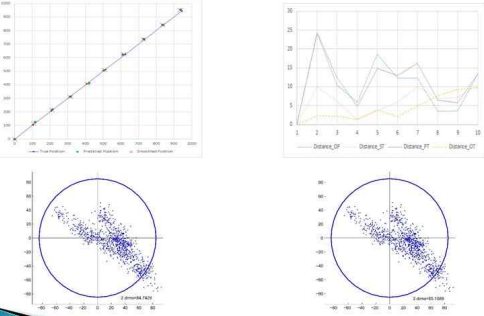


- ✓ The performance of the tracking module developed was satisfactory.
- ✓ Better estimates of position measurements were obtained after smoothing which led to near accurate predictions of position.
- ✓ The noise-free situation out-performed the simulations with noise input. However, practically the simulation environment must be designed to allow for noise input.

Simulation Results



iii. Varying course and velocity



Recommendation



Future development of this research recommends determination of the optimum values of α , β and γ parameters required to improve the performance of this tracking module.

In addition, the authors recommended application of the tracking module to a real time environment in order to test its performance.