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Design and Test a Robust Bearing-Only Target Motion Analysis Algorithm Based on Modified Gain Extended Kalman Filter

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Abstract : Passive sonar is a method for detecting acoustic signals in the ocean. It detects the acoustic signals emanating from external sources. With passive sonar, we can determine the bearing of the target only, no information about the range of the target. Target Motion Analysis (TMA) is a process to estimate the position and speed of a target using passive sonar information. Since bearing is the only available information, the TMA technique called Bearing-only TMA. Many TMA techniques have been developed. However, until now, there is not a very effective method that could be used to always track an unknown target and extract its moving trace. In this work, a design of effective Bearing-only TMA Algorithm is done. The measured bearing angles are very noisy. Moreover, for multi-beam sonar, the measurements is quantized due to the sonar beam width. To deal with this, modified gain extended Kalman filter algorithm is used. The algorithm is fine-tuned, and many modules are added to improve the performance. A special validation gate module is used to insure stability of the algorithm. Many indicators of the performance and confidence level measurement are designed and tested. A new method to detect if the target is maneuvering is proposed. Moreover, a reactive optimal observer maneuver based on bearing measurements is proposed, which insure converging to the right solution all of the times. To test the performance of the proposed TMA algorithm a simulation is done with a MATLAB program. The simulator program tries to model a discrete scenario for an observer and a target. The simulator takes into consideration all the practical aspects of the problem such as a smooth transition in the speed, a circular turn of the ship, noisy measurements, and a quantized bearing measurement come for multi-beam sonar. The tests are done for a lot of given test scenarios. For all the tests, full tracking is achieved within 10 minutes with very little error. The range estimation error was less than 5%, speed error less than 5% and heading error less than 2 degree. For the online performance estimator, it is mostly aligned with the real performance. The range estimation confidence level gives a value equal to 90% when the range error less than 10%. The experiments show that the proposed TMA algorithm is very robust and has low estimation error. However, the converging time of the algorithm is needed to be improved.

Keywords : target motion analysis, Kalman filter, passive sonar, bearing-only tracking
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