TARGET TRACKING ENHANCEMENT USING A KALMAN FILTER IN THE PRESENCE OF INTERFERENCE

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ABSTRACT

In this paper we present a new target tracking enhancement system that uses a Kalman filter in the presence of interference. If the radar (seeker) is affected by different types of interference, this will affect the missile trajectory towards the target and may cause inaccurate tracking. In the new system a six-state Kalman filter is utilized to perform the tracking task and to carry out smoothing to the corrupted trajectory. This also provides good information about the target velocity in three dimensions which is very important information about the target.

A three dimensional scenario between target (with high manoeuvre) and missile is used to illustrate the performance of the system in the case when (i) no interference is present and (ii) interference is present. The performance of the filtered trajectory using the Kalman tracker will be assessed for different guidance methods: including (i) proportional navigation (ii) pure pursuit and (iii) constant bearing. The Kalman improvement for the tacking for the three guidance method will be analysed.

1. INTRODUCTION

Monopulse seekers are commonly used in target tracking because of their angular accuracy [1]. These types of seekers provide a better angular accuracy and less sensitivity to fluctuation in the radar cross section (RCS) of the target compared with other types of tracking radars (such as sequential lobbing and conical scan) [2]. Historically, monopulse seekers (or radars) employ two separate feed horns on a single antenna element in order to generate two receive beams that are slightly offset in azimuth (or elevation) angle. Sum and difference outputs are formed by summing and subtracting the two beam outputs, respectively. The ratio of difference to sum output voltages, called the error voltage, is then used to determine the degree of correction necessary to realign the beam axis with the target. With the introduction of phased array technology, it became unnecessary to employ special hardware for monopulse processing, since the array itself can electronically form the multiple beams needed [3,4]. A typical conventional monopulse processor for phased array radar is obtained by appropriately phasing the individual array channels to obtain sum and difference outputs. The ratio of difference to sum outputs provides the measure by which the angle offset from the beam axis (i.e., look direction) is determined. The updated angle measurement is used to compute phases for the channels so as to realign the beam axis with the target. The radar (seeker) is affected by different types of interference [5]; this will affect the missile trajectory towards the target and may cause inaccurate tracking. Using a Kalman filter performs the tracking task and facilitates smoothing of the corrupted trajectory. This also provides good information about the target velocity in three dimensions.

2. GENERAL KINEMATIC EQUATIONS OF MISSILE TARGET ENGAGEMENT

The mathematical algorithm, that describes the target-missile engagement, uses a kinematic modelling method, in which the missile is assumed to be a massless point and the equations describing its motion are derived without considering the causes to this motion. In this algorithm a time step update for both the target and missile velocity and position in the three dimension space are calculated according to the ideal bonds equations (equations of the law of guidance).

3. KALMAN FILTER ENHANCEMENT ON THE MISSILE TARGET ENGAGEMENT

A six-state Kalman filter is utilized to perform the tracking task and perform smoothing to the corrupted trajectory. For each time step during the missile target engagement, the unfiltered position of the target is filtered through a Kalman filter before putting it again into algorithm to get the responding missile position.

4. SIMULATION

For all the simulations algorithms, we consider 3-dimensional motion between the missile and the target. Then we apply the kinematics equations in three cases when (i) no interference is present, (ii) interference is present, and (iii) The performance of the filtered trajectory using the Kalman tracker

5. CONCLUSION

In this paper we have described the effect that interference has on the missile seeker. Introducing interference into the tracking radar system decreases the tracker ability to determine the exact target position. From the radar point of view it will corrupt the target location and consequently drive the missile to an incorrect location for the three guidance methods and this leads to target miss tracking.

The Kalman filter as a linear estimator was used in this paper to minimize the mean squared error of the LOS tracking angle due to interference. It is not a method to decrease or cancel this interference, but makes successive improvement of the missile's ability to keep tracking the corrupted target trajectory until the LOS distance reaches the fusing distance (hit the target). In our future work we will focus on how to minimize or cancel this interference especially resulting from clutter and terrain scattering interference.

6. REFRENCES

[1] Richard Klemm and Ulrich Nickel, "Adaptive monopulse with STAP" in *IEEE International Conference on Radar* 2006.
[2] Merrill I. Skolnik, *Radar Handbook- Second edition*, McGraw-Hill, Inc., 1990.
[3] Arnold D. Seifer, "Monopulse-radar angle tracking in noise or noise jamming" in *IEEE Transactions on Aerospace and Electronic Systems*, vol. 28, pp. 622 - 638 , 1992.
[4] Hamish Meikle, *Modern Radar Systems- Second edition*, Artech House, Inc., 2008.
[5] Yaron Seliktar and E. Jeff Holder and Douglas B. Williams, "An adaptive monopulse processor for angle estimation in a mainbeam jamming and coherent interference scenario" in *IEEE International Conference on Acoustics, Speech and Signal Processing,*1998.