USING DATA MINING METHOD FOR ANALYZING OTS CAPTURE ZONE

Jinsong GAO 1 Longhe SUN 2 and Guangshan Lu 2
(1. Department of Electronic Engineering, Northwest Polytechnical University, Xi'an 710072, China
2. Electro-Optical Equipment Research Institute, Luoyang 471009, China)

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Abstract

After Over the Shoulder (OTS) fire control principle had been validated and simulated a few years ago [2,3,4,5,6], an issue that needs to be addressed is how to deal with simulation data, so as to explore the underlying mechanism of the OTS process. Data mining (DM) [1] is an effective and systematical approach for discovering knowledge from a vast amount of data. In this paper, the DM method is used to extract knowledge from a set of data of capture zone for an OTS process. By using this method, the knowledge about the OTS capture zone can be discovered. It is found that the most important factors that affect the OTS capture zone are that forward radar of a fighter can not track its own OTS missile and rear radar of a fighter can not get any information about its rear target.

1 Introduction

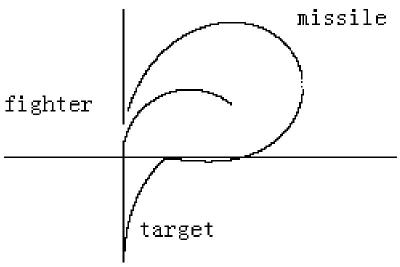

Fig.1. Trajectory of fighter, missile and target

OTS is a new combat attack mode, where a fighter uses its airborne fire control system to launch and control an air-to-air missile to attack a rear target. The OTS' missile is designed for a typical compound guidance, which usually consists of three phases, namely, programmed guidance phase, inertial and data link guidance phase, and homing guidance phase. Fig.1 shows trajectory of fighter, missile and target in an OTS process.

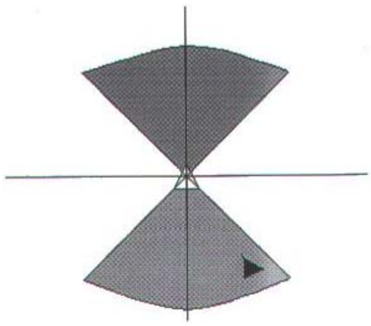

Fig.2. Fighter's rear radio detects target.

For an OTS control process, Fig. 2 shows a fighter's rear radar detects a target that appears in the fighter's capture zone and then, the fighter's fire control system helps to make decision on how to maneuver.

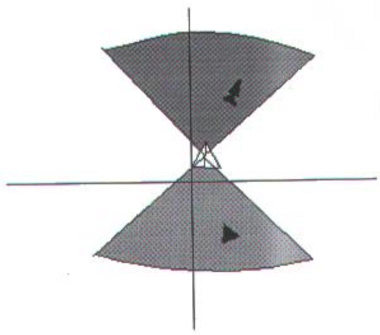

Fig.3. Fighter launches OTS' missile.

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Fig.3 displays the fighter launches OTS missile, and the fighter's rear radar continues to track the target while the fighter's forward radar tracks the missile in order to send guidance data to it. Finally, Fig.4 shows the homing guidance phase of OTS missile begins as soon as the missile captures the target. At the same time, the fighter can be free to flight, because missile does not need the information about the target any more, and also the fighter does not need to send guidance information to the missile.

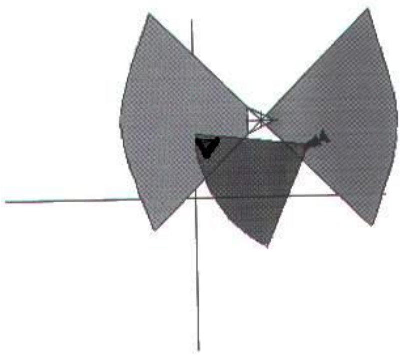

Fig.4. Missile captures target.

After the OTS fire control principle had been validated and simulated, a method based on DM is introduced in this paper to discovery knowledge from a vast of data obtained from OTS simulation experiments. The aim of our present research is to identify what is the vital factor that determines an OTS capture zone.

2 DM and Simulation Experiments

Different from the traditional ballistic analysis method, OTS is considered as a dynamical and logical physics process. Usually, the three phases in an OTS process proceed in turn. For example, if it fails to complete programmed guidance phase, OTS missile could not start inertial and data link guidance phase, and If hitting at rear target at last, OTS missile must primarily start homing phase. In principle, relative to completion of OTS process, the importance of each phase is different from another. Although the missile will miss the target if any one of these phases is not completed, the guidance process without passing homing guidance phase is better than without passing inertial and data-link guidance phase. On the other hand, there are many cases where the missile can not hit the target, but they may happen in different phases, and reasons for these cases may be different from case to case. In the past, however, it was only thought of if hitting the target or not, and cases for missing target were not identified clearly, although the reasons may be different. In order to explore the underlying mechanism behind the OTS process, according to the DM theory, all simulation results would be classified, and then processed by visualization method in scientific computing, instead of only considering if the missile hits the rear target or not.

2.1 Preprocessing

Generally, capture zone is an area where a target in front of a fighter can be detected by the fighter's radar, and the radar always is forward radar. For a simulation of launching missile in the capture zone, there are usually two results, i.e., hitting the target or not. The OTS capture zone, however, is such an area where a target behind a fighter can be detected by the fighter's rear radar. Similarly, in a simulation of launching OTS missile, there are two results, i.e. hitting the rear target in the OTS capture zone (that is launch area) or not. However, we do drill-down to the result missing target, and find there are five different cases. Accordingly, an OTS capture zone can be further divided into six areas resulting from a simulation of an OTS process as follows:

- R1: Hitting the target,
- R2: Missing because forward radar can not track the OTS missile,
- R3: Missing because rear radar can not track the rear target,
- R4: Missing because missile can not meet miss distance demands,
- R5: Missing because missile's velocity is smaller than collision velocity, and
- R6: Missing because missile's fighting goes beyond the limit of biggest flight time.

2.2 Visualization Processing

There is a vast amount of data after simulating OTS' capture zone. In order to effectively process the results obtained from the simulation of OTS capture zone under certain conditions and clearly display the distribution of different areas in an OTS capture zone, each ease will be indicated respectively as follows:

- R1 area: filled with ,
- R2 area: filled with ,
- R3 area: filled with ,
- R4 area: filled with ,
- R5 area: filled with , and
- R6 area: filled with .

2.3 Simulation Experiments

In this subsection, several representative simulation results are processed, and some figures are given that show capture zone. Simulation conditions are H=9000m and a target behind a fighter is pursuing the fighter.

Simulation experiment 1: The overload of the fighter and the target is 0g and ≤ 4g, respectively. The simulation result is given in Fig. 5.

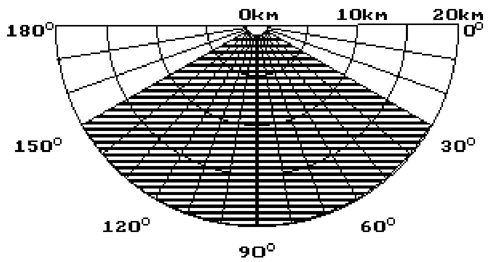

Fig.5. Simulation experiment 1.

Simulation experiment 2: The overload of the fighter and the target is 1g and ≤ 4g, respectively. The simulation result is given in Fig. 6.

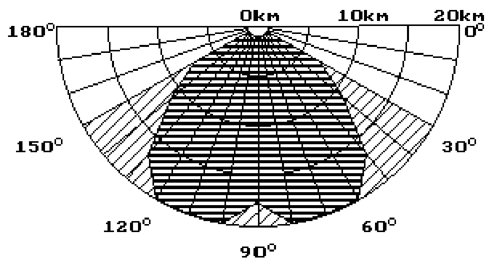

Fig.5. Simulation experiment 2.

Simulation experiment 3: The overload of the fighter and the target is 2g and ≤ 4g, respectively. The simulation result is given in Fig. 7.

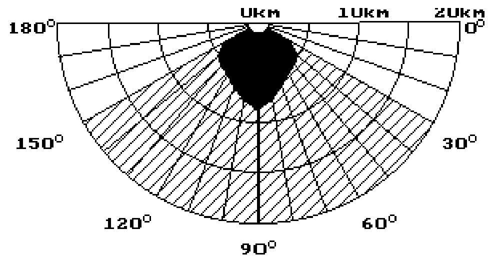

Fig.7. Simulation experiment 3.

Simulation experiment 4: The overload of the fighter and the target is 3g and ≤ 4g, respectively. The simulation result is given in Fig. 8.

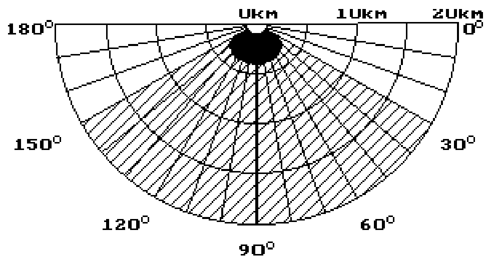

Fig.8. Simulation experiment 4.

Simulation experiment 5: The overload of the fighter and the target is 4g and ≤ 4g, respectively. The simulation result is given in Fig. 9.

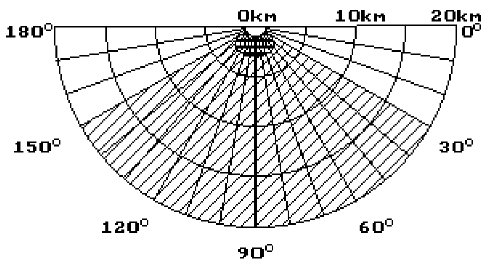

Fig.9. Simulation experiment 5.

Simulation experiment 6: the overload of fighter and target is 2g and ≤6g, respectively. The result of simulation is the same as Fig.7.

Simulation experiment 7: the overload of fighter and target is 2g and ≤8g, respectively. The result of simulation is the same as Fig.7.

From Fig.5 to Fig.9, we can see that there are R1, R2 and R3 in the OTS capture zone, and R4, R5 and R6 don't appear.

2.4 Process tree and analysis

Using the decision tree method, a set of data can be classified into different subsets according to different features (or characters) of the data. In this subsection, simulation results of OTS in capture zone have been considered as a kind of data being classified, too. But here, it is according to OTS' process, rather than data's features that these data are classified. Therefore, we call it process tree. In an OTS process, R2 might happen in programmed guidance phase, R2 and R3 might happen in inertial and data link guidance phase, and R1, R4, R5 and R6 might happen in homing phase, although R1 is "hitting the target", and others are "missing the target". Fig.10 shows process tree of the OTS simulation results.

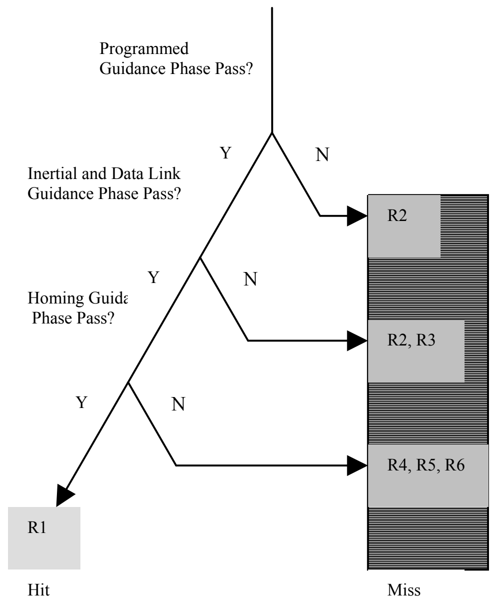

Fig.10. Process tree of OTS.

From Fig.5 to Fig.9, we can find that the simulation result is either R2 or R3 if missing. Using process tree of OTS' simulation results, it is found that if missing, missile must pass neither programmed guidance phase nor inertial and data link guidance phase. In fact, the two phases are very important for completing an OTS process, too. In the two phases, it must be met synchronously that both OTS' missile must be tracked by fighter's forward radar and rear target must be tracked by fighter's rear radar. Appearance of only R2 and R3 in OTS capture zone if missing means that the most important factors that affect the OTS capture zone are that missile don't pass programmed guidance phase or inertial and data link guidance phase. In other words, forward radar of fighter can not track its own OTS missile and rear radar of fighter can not track the rear target. We call it compatibility of tracking of both forward and rear radar.

3 Conclusions

In this paper, a method is introduced for processing data of OTS simulation result, based on the theory of DM. From our experiment and analysis, the following conclusion can be drawn:

1. DM is an effect method for processing data of OTS simulation.
2. The most important factor that affects the OTS capture zone is compatibility of tracking of both forward and rear radar in OTS process.

References

[1] Jiawei Han and Micheline Kamber. *Data Mining: Concepts and Techniques.* 1st edition, San Francisco: Morgan Kaufmann, 2001.

[2] Jingsong Gao, Y. Lu and H. Lan. A sort of New Control Principle: "Over the Shoulder". *International Aviation*, Vol.5, pp57, 1994.

[3] Jingsong Gao, S. Chen and P. Wang. Two Launch Mode of Over the Shoulder. *Journal of Command and Control*, Vol.4, pp23-25, 1998.

[4] Jingsong Gao, L. Shun and M. Tong. Over the Shoulder and Rear—Firing. *International Aviation*, Vol.11, pp60, 2000.

[5] Fudong Cai, Xiaoguang Gao, Jinsong Gao. Bearing-Corrected Guidance with Incomplete Target Information for Over the Shoulder. *ICAS 2000 CD-ROM Proceedings*, Horrogate,UK,2000

[6] Jingsong Gao, L. Shun. Simulation of OTS' principal. *Journal of Command and Control,* Vol.3, 2002.(will be published).