Situational Control of RADAR

Ivan Evtimov Korobko

Abstract: **The possibilities of adaptive control of RADAR in complex electromagnetic environment are considered. The adaptation and the control are executed by names of matrix antagonistic games continuously evaluating the control effectiveness.**

Key words: **RADAR, control, adaptation, theory of games**

I. Introduction

The control task's general scheme is shown on fig. 1 [1]. It includes current situation description, its analysis, classification, correlation and impact on the object.

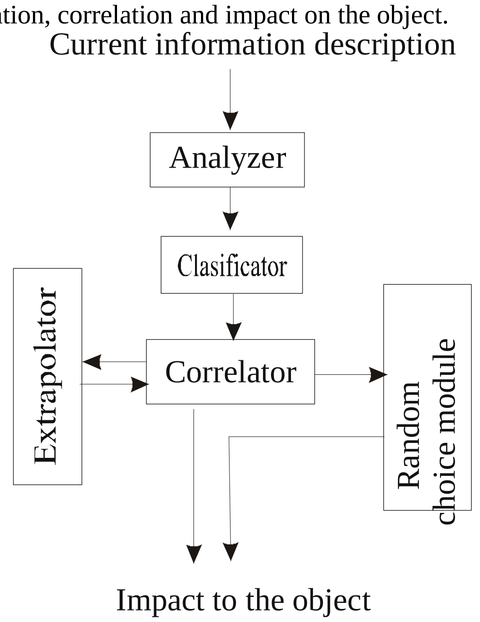

Fig 1

The current situation is understood as a data collection with information about its functionality at certain moment of time. The analyzer evaluates the message and it decides it is necessary to interfere in control system or not. The analyzer do not transmit the message further of there is no necessity of it. In the opposite case the message is to be passed to the classificator which classify the situation depending on single step solutions. This information is transmitted to the correlator. The correlator defines the rule which will be used for control. If several rules exist all of them have to transmitted to the extrapolator. If the extrapolator also is not able to make a decision, an information supporting random choice of control impact is to be generated.

The above scheme is not working well enough for the radio location station due to the reason of presence of a man-operator who is performing the most part of operations. There is no good enough model created by the moment which could give adequate description of human behavior when working with radio location information. The main reason for that is the variety of the information, its perception and decision making. Another reason is that the operator works in a priori undetermined situation and with a priori undefined information.

II. Task definition

In the most cases the radar's work can be considered as an interaction with the nature or with the opponent (enemy). We have a game with incomplete information taking in mind that the information at the moment of radio location signal detection in a priori undefined.

When we have a game with incomplete information the opponent's strategy and the profit's function are not known. Also it is not known are there any other players in the game. In this case the player (radar operation) makes subjective decision about random distribution of situations. The player has random evaluation about the game, about profit's function, opponent's strategy, about himself etc. He has information about different aspects of the game.

A game with incomplete information appears due to the technical imperfection of the equipment and systems or due to special actions of other participants in the conflict. At such type of games a series of mathematical difficulties appears in task definition and in its resolution.

One of the possibilities to eliminate the incomplete information is to create a system based on the ability to define appointments strategies and their parameters. Such a system must have an additional investigating receiver in its structure. Depending on the receiver's features the limitation of the decision making information absence will be eliminated. The target is to create a radar structure witch will allow adaptation to the electromagnetic situation with maximal effectiveness.

III. System description

The RADAR diagram of discussed type is shown on fig.2., where RLT is Receiver's Line Tract, IPU – Interference Protection Unit, TU – Threshold Unit, Tr – Transmitter with ability of frequency funning, AU – Adaptation Unit, QFM – Quality Factor Measuring unit, NA – Noise Analyzer, DF – Directed Deflector.

Ivan Evtimov Korobko is a professor at the TU Sofia , Bulgaria, e-mail: ikor @abv.bg

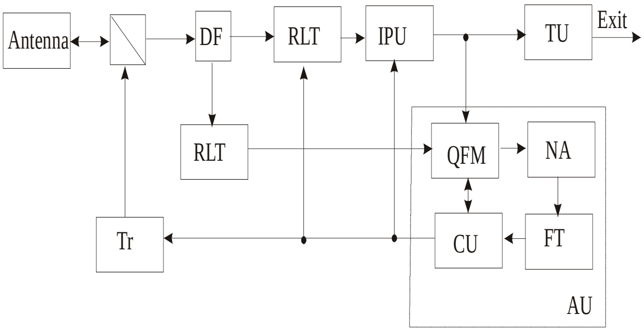

Fig.2

The shown RADAR differs from the standard known RADAR be presence of an additional receiver and of an Adaptation Unit, which improve quality factors of RADAR and they secure operation in situations where that factors are the best. As quality factors the ratio “sgnal/noise” or the difference between their powers could be used.

The purpose of the additional receiver is to analyze the electromagnetic situation and to define the appointment’s strategy. This information must be transmitted in real time to the information processing system and to the interference protection system. The real time is defined by the location rate.

The adaptation unit is the main unit in the described RADAR. This unit measures the quality factor and analyses the noise using QFM and it defines the opponent’s strategy and it select/ define the RADAR’ strategy using the functional transmitter(FT) and the control unit(CU). The choice of strategy is possible only if the RADAR structure is flexible. i.e. it allows parameters changing and possibilities of changes in hardware and software of the receiver, of the transmitter and of the antenna [2].

The purpose of the functional transformer Unit is to define RADAR strategies. This is possible using evaluation matrix (2). A sample evaluation matrix is shown on fig. 3, where FNN is filter of non synchronous noise, WLA – wideband amplifier – limiter – narrow band amplifier,WLF– wideband amplifier – limiter-matched filter, LFM – line frequency modulated signal, PCM – phase-code manipulation, CFAR-constant- false- alarm rate, MTI – moving targets indication, SL of AP – site lobe of antenna pattern. The evaluation is understood as quality factor of as a profit of use of some noise protection device. The noise protection device could be designed as hardware unit or software program. Some authors refer about 150 variants [3,4]. These devices define RADAR structure depending on its purpose. In the same time they define the level of RADAR noise protection. The changes in the electromagnetic situation case changes of the number of connected devices. The simplest way to do this is to select pure strategies. The opponent’s strategy recognition causes activation of one or another device, which gives the biggest effect. Using of pure strategies gives appointments to perform all actions in the real time by steps, adapting RADAR to the electromagnetic situation. If it is impossible to use pure strategy a mixed strategy has to be selected.

The matrix on fig.3. gives visual imagination about the size and the complexity of the solutions an about the difficulties in finding of optimal RADAR strategies. The optimal RADAR strategies do fine its structure. For this purpose it is necessary to to find max min a_{ij} and all points which are members of the optimal strategies’ set. This set has to be convex, closed, limited and not empty. The line programming is used to overcome the complexity of finding of optimal mixed strategies.

Fig.3	*Aimed noise interference*	*Barrage noise interference*	*Passive interference*	*Chaotic interference*	*Wide band interference*	*Answering pulse interference*	*Max min a_{ij}*
Tuning from view to view	100	0	0	100	100	100	0
Tuning with pause	100	1	1	100	100	100	1
Tuning from pulse to pulse	100	2	2	100	100	100	2
Adaptive tuning	200	4	4	200	200	200	4
PCM signal	13	13	3	13	10	1	1
LFM signal	30	30	0	30	20	1	0
Compressed noise signal	100	100	3	100	100	100	3
WLF	80	20	1	30	80	1	1
WLF + CFAR	160	40	2	60	160	2	2
FNN	10	10	10	80	10	0	0
FNN + CFAR	20	20	20	100	20	10	10
MTI	0	0	100	50	0	0	0
MTI + CFAR	2	2	200	100	2	0	0
Polarization selection	2	2	2	2	2	2	2
Compensation of SL of AP	80	80	0	80	80	80	0
Low SL of AP	1000	1000	0	1000	1000	1000	0
min max a_{ij}	1000	1000	200	1000	1000	1000	

The matrix solution (fig.3.) using line programming is as follows:

RADAR' optimal strategy:

1) MDS + CFAR with probability of 0.833;
2) Low side lobe of AP with probability of 0.167

Opponent's optimal strategy:

1) Passive interference with probability of 0.833;
2) Answering pulse interference with probability of 0.167.

The received game solutions show guaranteed profit for RADAR and as opponent loss. As it is shown here this solution demonstrate only weak points of RADAR which could be opposed by the opponent by certain strategies to minimize this loss. It has noted that RADAR trends towards to receive max min $a_{ij.}$ That means that in the proper column on fig.3. only minimal profit values are shown (on certain strategies), all other profits are bigger. i.e. all other game values are always bigger than received minimal values.

In this case maximums of minimums in order to their value and the optimal strategies define RADAR' structure.

The shown matrix gives complete imagination about the RADAR' structure, but it shows also that a précised apprised of different units' effectiveness is necessary. The decision about RADAR structure creation and RADAR control in dynamics will be more effective if the values of matrix members will be calculated with more accuracy. The dynamics in this case is defined by the abilities of the opponent and by the time for analysis of the opponent and by the time for analysis and decision making by the adaptation unit.

IV. Conclusion

The proposed radar's structure with additional receiver for electromagnetic environmental evaluation and with unit for adaptation to the electromagnetic environment works at the best quality factor. A specific feature of the radar is that it works with pure strategies which can give the biggest profit at antagonistic games. The analysis performed and the solutions received complete the synthesis of RADAR structure which is oriented to processing in complex dynamically changing electromagnetic environment.

The usage of matrix antagonistic games prompts that optimal strategies finding helps not only to determine RADAR' structure but to select the strategy of maximal profit in dynamically changing electromagnetic environment. The changes of the electromagnetic environment is followed by continuous changes of RADAR' structure and parameters, by steps. Basically, only pure strategies are used as they can be executed easily in real time and always, at recognized situation, a strategy of maximal effect can be found. At least, of all possibilities are exchanged, a mixed strategy can be used. Unfortunately when mixed strategy is used the solution might be not optimal.

When using pure strategies an exact evaluation of the effect of different strategies usage is needed which means that they have to be played preliminary.

The performed calculations of detection parameters and their comparison with others shown certain advantages of the described RADAR. The presence of an adaptation shows significant improvement of the detection characteristics.

References

[1] Pospelov D.A. Situational Control. Theory and practice. M. Nauka, 1986.

[2] Korobko I. E. Radio Technical Systems (System Design). S. Korvet press publ. Ltd, 144 p., 2003.

[3] Johnson S. L. Radar Electronic Counter – countermeasures. IEEE Transactions on Aerospace and Electronic Systems. Vol. AES-14, Ni, 1978.

[4] Radiointerferences Protection. Under ed. of M. V. Maximova., Sov. Radio,1976