Chatbot for functionating application programing interface in the human operation training aviation complex

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Abstract. The polyergatic method of self-learning in relation to targets by the operator of the training complex a signal/filter pair is proposed for suppressing unwanted side lobes with the aim of improving the processes of target detection and identification during influence of different heterogeneous disturbances. The qualitative characteristics and stages of the space-time code signal processing in the adaptive radar are justified under the conditions of a consistent cross-correlation function between the received and expected signal values. The usage under hindrances noisy conditions of probing radar signals, were proposed in order to reduce the power of reflections from the underlying surface and increase the contrast of the radar image. Proposed method and accompanied mathematical models proved their efficiency during practical implementation on board of aircrafts and mobile water transport objects, which were conducted high accuracy navigation under influence of non linear disturbances in locally confined area. Proposed generalized information model formation of an air situation could be used during training of personnel, which forms navigation watch.

1. Introduction

It is known that not less than a half of the aviation incidents which took place in recent years around the world, caused by human factors. For this reason, improvement of quality of performance of flight tasks on training machines leads to sharp decrease in probability of aviation incidents in flight operation of aircrafts (AC). It is obvious that reduction of aviation incidents number because of pilots is one of the main ways increase in the integrated efficiency of training of the individual agent system (IAS) ergatic flight control of AC. Training of pilots of IAS on the aviation training machine is one of the most important elements of ensuring safe operation of the aircraft. It allows to minimize negative impact, a so-called pilot errors, that is allows to minimize a possibility of wrong actions of crew. At the same time on the training machine the special software allows to change dynamics of flight hindrances conditions almost instantly: weather, a geographical location to stop performance of a task for analysis and repetition, etc. Also, on the training machine it is possible to carry out without restrictions working off of actions in non-staff situations some of which or dangerous to working off in real flight, or their working off in real flight it is forbidden. Besides, training of pilots of IAS on an air training complex is favorable from the economic point of view.

Lack of many training machines, as a result and insufficient efficiency in the system of training of flight personnel the similarity of modeling to real service conditions is incomplete. As a result, we have inadequate nearness of the operator of IAS together with the radar equipment to the aircraft equipment. For this reason, close attention in the first section it is devoted to means of a radar-location, the principles of action and obstacles, methods of obtaining radar information, types of space time code signals. During performance of this work the patent for useful model was taken out that belongs to the aircraft equipment (helicopters, planes, etc.). The training complex as aviation educational is appointed for preparation of IAS of operators (pilots). By means of this complex there is an improvement of skills, abilities and professional actions of IAS. Target experience of IAS connected with use of the radar equipment in a complex with the aircraft equipment. Only under these conditions occur achievements of target results when performing each flight task.

2. Ggeneralized information model formation of an air situation in a zone of radar system functioning

Generally it is accepted to understand some as onboard radiolocation (RL) systems hierarchical spatially distributed set of means of a radar-location (MRL), complex of the automation equipment (CAE), means of reception, processing and information transfer. The end result is achieved also at the expense of appropriate means and technologies of management. Then IAS owns synergetic property of system integrity (some more total information effect) due to existence financially - power, information and functional communications (structure). In stage-by-stage processes of training of IAS occurs careful implementation of radar control and to studying land, air and space of future flight tasks (Figure 1). Owing to the developed information space and also the information nature of solvable tasks for IAS modern RL systems provide in real time creations of dynamic information model of an air situation. Given similarity it is capable to provide the most effective solution of the tasks set within over the system of self-training [1].

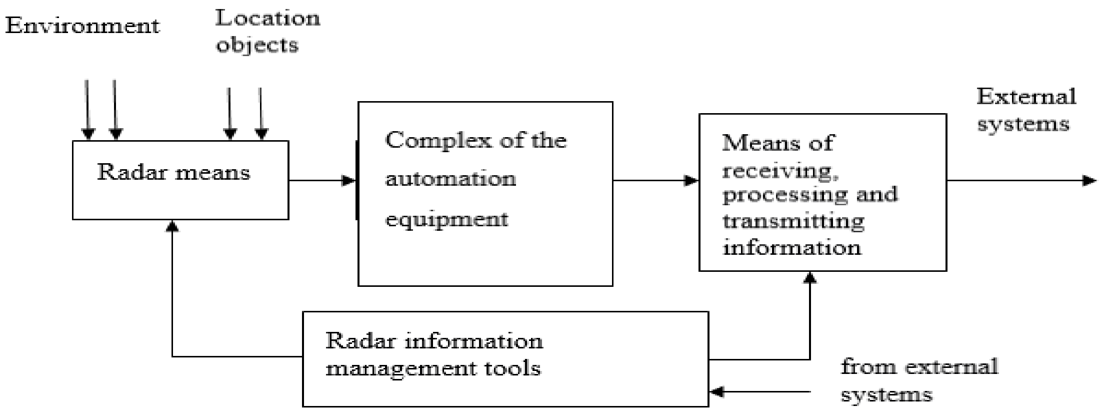

Figure 1 The generalized structure of the training machine`s radiolocation under-system

Means of a radar-location, namely radar stations (RS) and complexes (RSC) are primary sources of radar information (RI). They carry out the radar review of space, collecting and preprocessing of information on objects location. Radar stations represent the radio engineering devices intended for identification, determination of spatial coordinates and parameters of the movement and also recognition (classification) and definition by means of the radiation by radio waves radar target objects (RTO), registration and the analysis of parameters of their reflections from the corresponding objects. Depending on tactical (functional) appointment to concrete radar station, the training instructor of concrete IAS, can assign either everything, or some from the listed problems of RL observation. Data on radar-location objects which it is necessary to be received by IAS call RTO (further - target objects). In radar practice it is accepted to distinguish the following target objects: space (space crafts, orbital planes, artificial Earth satellites, ballistic missiles, space objects of natural origin, etc.), aerodynamic (planes, helicopters, airships, unmanned aerial vehicles, etc.), land and surface (cars, vessels, groups of people or certain people, etc.), natural origin (clouds, natural reference points on areas, hydrometeors, the migrating flocks of birds), etc.

Therefore, in an ergatic radar-location term «a target object» information contents are provided. Radar information is called the set of data on existence target objects, their coordinates and other parameters of the movement in certain areas of space, flight information, quantity target objects and their characteristics. The complex of the automation equipment provides secondary processing of RI (determination of coordinates and identification of a trajectory target objects) and also formation of the generalized information air model (space, land, surface) situations in a zone of RL system functioning.

Means of reception and information transfer provide exchange of RI and information of management in RL system with an external system control elements (over-system) for the benefit of performance over-system of the functional tasks facing it. Control facilities provide programmer planning, the organization and control of functioning of RL system for the benefit of information function performance by it within global function over-system of IAS preparation training center.

Multiple increase and signals amplitude coding at the video-path release of the intake of radar station precedes all listed operations (3-7), the signals using digital processing in modern CAE. In this case the device of discrete transformation and signals coding is an allowing link. Processes of coordination of temporary situations are carried out between the analog structure of RL receiver and the digital system of processing of RI CAE. The performance sequence of the listed RI processing operations it is shown on Figure 2. At the heart of the receiving primary RI procedure about target objects is the phenomenon diffusion reflection of electromagnetic waves from limit of the two environments section with various dielectric and magnetic permeability. In radar location electromagnetic radiations of meter, decimeter, centimetric and millimetric waves are applied.

From all set of the listed above information problems of RL system, radars provide target objects identifications. Group of processes from coordinates measurement, permission estimations and other parameters during their movement, inclusive before classification registered objects, it is accepted to call RL observation. At the same time requirements to RL observation quality continuously raise. Conditions of MRL work, in turn, become complicated. The rapidity of change and complexity of RL situation demand the high rate of adequate data issue for IAS.

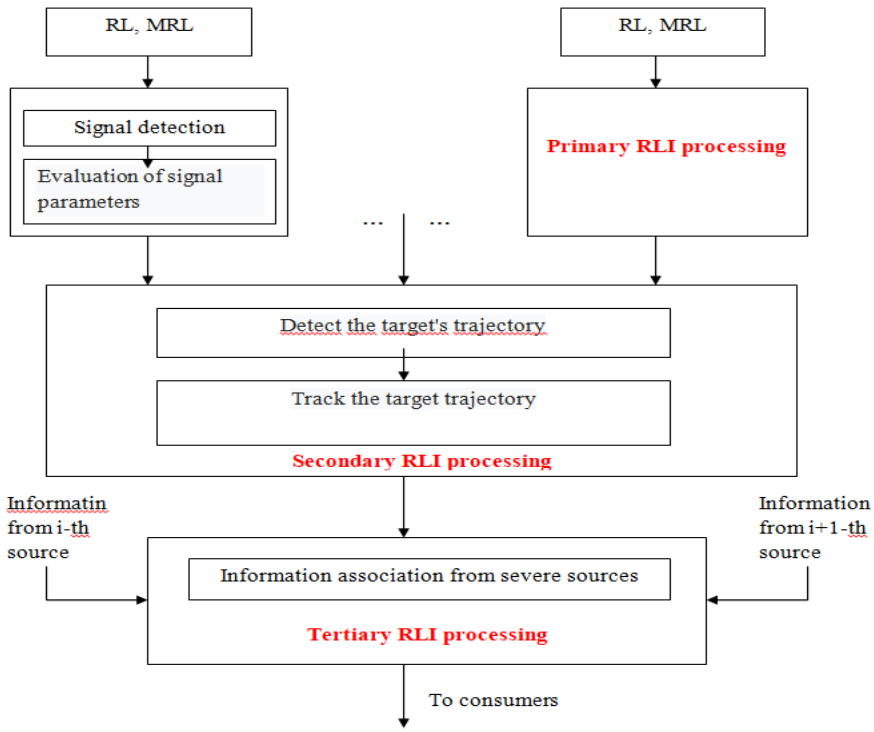

Figure 2 The sequences of RI processing performance in RL under-system

The radar stations are influenced by obstacles in actual practice of work. Obstacles of natural origin, from other radio-electronic means (REM) are naturally mutual. Socially technical obstacles in some cases are organized (deliberate). Therefore, one of the most important tasks of the modern theory and the radar equipment is increase in noise immunity of radar station. Therefore, to maintenance of RI quality in obstacle situations on acceptable level is a current problem of functional safety. For the solution of this task use various actions. It is known protection against obstacles as devices (adaptation) of radar station to obstacle situations. Thus, complications of working conditions need quality improvement of radar observation demand complex solution of this problem.

Ergatic distribution of functions provides rational use of modern innovative opportunities: RI receiving; interface the equipment which does not limit ability of the aircraft operator to work. While IAS is performing the flight task, he has to perceive, analyze quickly obtained information and beforehand make decisions; the micro program equipment that receives in a directive way command realizes the IAS decision by all means of technical and technological management for a target flight task performance.

3. Maximizing of signal-noise ratio at the output of the filter with use of self-organization procedure

Let's consider more detailed an improvement of adaptive couple "signal-filter" methods of work. Improvements of detection and identification onboard radar station target object consist in the solution of a variation space time code task. The description gives it to the system of the integrated equations. Then perhaps determination of a signal and filter parameters with the purpose to have SNR maximum. The self-improvement technique of work "signal-filter" pair consist in serial process. Continually we do the integrated equations solutions for obtaining values of filter and signal parameters at the fixed norm of signal and filter [2-7]. At the first stage for the set initial signal vector the equation is solved that defines respond of the filter. At the second stage for the received thus way filter the equation is solved that defines a signal, etc. Thus, the method of self-organization consists of preparatory and executive stages. But each value of the found filter or a signal corresponds to process of rationing on each cycle. At the same time, it is necessary to consider restrictions for losses in SNR and on a time constant permission. SNR has the following appearance:

$$S_{NR} = \frac{\left| \int_{-\infty}^{\infty} W^*(t)\,\mathrm{S(t)\,dt} \right|^2}{\nu \int_{-\infty}^{\infty} |W(t)|^2 dt + \sigma_0 \int_{-\infty}^{\infty} \sigma_\xi(\tau,0) |\chi_{sw}(\tau,0)|^2 \, d\tau},$$

where $\chi_{sw}(\tau,\mathrm{f}) = \chi_\rho(\tau,f) \sum_{n=0}^{N-1} W_n^* S_{n+k} e^{i2\pi nfT_0}$ – ambiguity function; T_0 – elementary pulse duration in the signal; f – Doppler frequency; N – pulses quantity in signal *(n=N-1)*; NT_0 – signal period (in periodic work mode); $S_{n+k} = \left[S_{n+k} \right] e^{i\varphi_{n+k}}$ – signal amplitude, delayed on k positions; φ_{n+k} – signal phase; $\overset{*}{W_n}$ – filter complex amplitude; σ_0 – coefficient that characterize obstacle reflected features; $\sigma_\xi(\tau,0)$ - range-speed distribution of the disturbing reflections; ξ – parameter that determines restrictions for a permission constant by time.

The permission constant by time T_R has the best value when all MAF side lobes are equal to zero:

$$\frac{\int_{-\infty}^{\infty}\left|\chi_{sw}(\tau,0)\right|^{2}d\tau}{\left|\chi_{sw}(0,0)\right|^{2}}=\frac{\int_{-\infty}^{\infty}\left|\int_{-\infty}^{\infty}W^{*}(t)\mathrm{S}(\mathrm{t}+\tau)dt\right|^{2}d\tau}{\left|\int_{-\infty}^{\infty}\mathrm{W}^{*}(t)\mathrm{S}(\mathrm{t})\,\mathrm{dt}\right|^{2}}=T_{R}.$$

Task solutions should be looked for at values of parameters $\nu = N_{0,}\xi = 1.$ Actually, we consider a problem of maximizing SNR (noise with a spectral density N_0) at restrictions for a permission constant on time. The offered method provides improvements of signal identification which contains useful radar information about target object [7]. At the first stage we look for such filter which provides at the chosen parameters almost full side lobes suppression. It is connected with the fact that the task for discrete signals correspond a case of side lobes suppression. Task solutions correspond to a condition of zero zones that is zones with full side lobes suppression.

Expression of losses in the ratio signal / noise has the following appearance: $\rho = \frac{\left|W^{*}S\right|^{2}}{W^{*}\,\mathrm{W}\cdot\mathrm{S}^{*}\,S}.$

Big losses in the signal / noise ratio can take place already at the beginning of practical calculations. Therefore, it is offered to use the procedures described above for formation of adaptive filters which allow receiving the minimum losses in SNR.

4. Imitating check of the developed technique and model in the Matlab

An imitating inspection of the developed application programming interface (API) technique for the purpose of reliability confirmation of the offered algebraic expressions is carried out. Testing it is executed by means of mathematical model which is realized in the Matlab programming environment. This program realizes algebraic recurrent process of adaptive pair joint optimization "signal-filter". The result of calculations presents evident API information in the form of the developed graphics of MAF sections at $f = \frac{l}{4NT_0}$ (Figure 3, 4).

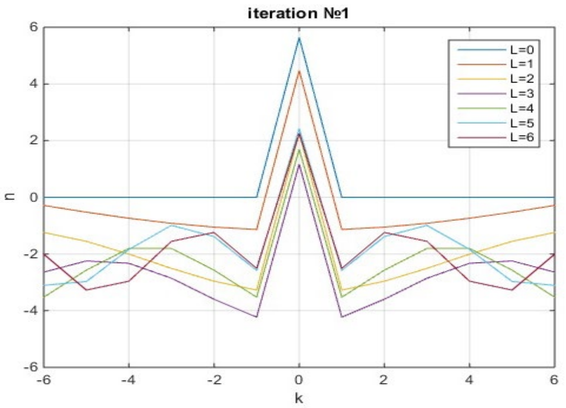

Figure 3 MAF spectral components l = 0 ... 6 for signal s = [1; -1; -1; -1; -1; -1; -1] at the iteration № 1.
Optimal filter value [2.2563; -0.5641; -0.5641; -0.5641; -0.5641; -0.5641; -0.5641]
Optimal signal value [1.0003; -1.0000; -1.0000; -1.0000; -1.0000; -1.0000; -1.0000]
Losses in SNR 0.6495

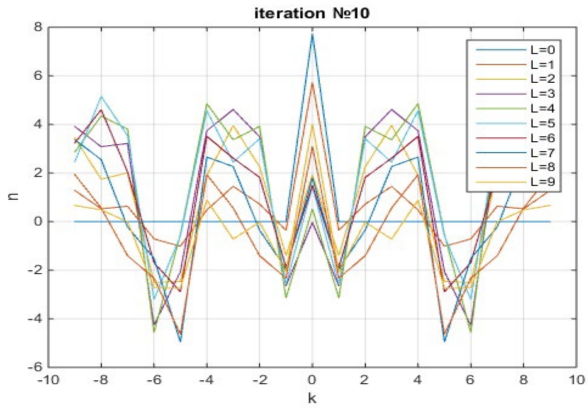

Figure 4 MAF spectral components l = 0 ... 9 for signal s = [1; 1; 1; 1; -1; -1; 1; 1; 1; -1] at iteration № 10
Optimal filter value [2.1938; 0.4395; 0.0883; 0.7907; -0.6150; -1.6669; 0.4395; 0.0883; 0.7907; -0.6150]
Optimal signal value [1.0018; 0.9996; 0.9991; 1.0000; -0.9998; -1.0012; 0.9996; 0.9991; 1.0000; -0.9998]

Losses in SNR 0.5980

At each iteration at first, we find value of the optimum filter for this signal at $l = 0 \dots 6$, and then values of an optimum signal for accepted pulse respond of the filter. Every time calculate value of controlled losses in the relation signal / noise. In figures 3-4 graphics of MAF sections for a signal which was set in the discrete sequence form are represented in the following look: *s = [1; -1; -1; -1; -1; -1; -1]* for components l = 0 ... 6; components l = 0 ... 9 for signal s = [1; 1; 1; 1; -1; -1; 1; 1; 1; -1]. Similarly, calculations of the optimal filter for signal *N=12, s= [1; -1; -1; 1; -1; 1; 1; 1; 1; 1; 1; 1]* are given. Values of the filter and signal for accepted pulse respond and also value of losses in the ratio signal / noise specified in the API table for each iteration. Above the reported results of the held testing during imitating check it is carried out in the Matlab programming environmentof work.

5. Conclusions

The second section is devoted to optimum signals processing against the background of obstacles. The conclusion was drawn that optimum signals processing against the background of passive obstacles (not - white noise) includes as the accumulation procedure of signal estimates (the coordinated processing), and the procedure of obstacles suppression. Adaptation depends on distribution of obstacle spectral density. The system engineering allocation of signals ranges of mobile objects uses change of the bearing frequency. In calculation also we consider pulse repetition frequencies and pulses duration which are observed at reflection of the probing signal from such objects. However, the last two effects are very small and it is heavy to find them. It is almost impossible to record situational change of the bearing frequency. Thus, Doppler's frequency is the basic API informative parameter by means of which STM against the background of passive obstacle is carried out.

In some cases, together with the maximum obstacle suppression it is necessary to provide the set restrictions for permission sizes and loss in the ratio signal / noise in relation to coordinated processing. In this regard, it is considered methods of signal-filter joint optimization taking into account additional restrictions for a permission constant on time and the size SNR. The method is in the solution of a variation task that brings to the system of the integrated equations, for the purpose of signal and filter definition that provide SNR maximum for improvement of detection and identification target object of onboard radar station. The technique of improvement of adaptive pair "signal-filter" work consists in serial solution of the integrated equations for the filter and a signal at the fixed norm of a signal and the filter. The integrated effect is in application of the procedure of self-organization. At the first stage for the set initial vector of a signal the equation is solved that defines respond of the filter. At the second stage for the filter received thus the equation is solved that defines a signal, etc. Thus, the offered technique consists of preparatory and executive stages. Each value of the found filter or a signal undergoes process of rationing on each cycle. It is offered to use described procedure for formation of filters which allow receiving the minimum losses in the ratio signal / noise.

An imitating inspection of the developed technique for the purpose of reliability confirmation of the offered algebraic expressions was carried out. Testing it is executed by means of mathematical model which is realized in the Matlab programming environment. Received pair "signal-filter" provides value of a constant of permission in time $T_R = 1$ (that is full side lobes suppression $l = 0$) and $\rho = 1$. It means lack of losses in the ratio signal / noise that completely corresponds a case of the matched processing. Practical use of self-organization method allows solving flight problems for radar station. Preliminary procedural problems of optimum identification target objects against the background of the spreading surface in the obstacles conditions allow to improve its operational characteristics in helicopter complexes. For the purpose of the accelerated preliminary information submission about the environment it is necessary corresponding increases in work productivity of the training complex operator. Without matched distribution of intellectual functions in a uniform ergatic control system cannot carry out difficult flight tasks when objects actively counteract and disturb in order definitely not to identify them.

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