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TASKS FOR COMBAT VEHICLE ARTIFICIAL INTELLIGENCE IN CONFRONTATION WITH FPV-DRONE

Abstract. Authors show – implementation of artificial intelligence in combat vehicle shell reduce the time for detection and recognition of air attack object. As result, combat vehicle winning probability against that object is arising thanks to that implementation. Besides that, artificial intelligence helps to assess a rate of threat, determines the time, which has combat vehicle personnel for execution the actions in case of significant threat from side of air attack object and recommend the most effective weapon against target for combat vehicle personnel. The next step stays for native industry for these tasks implementation into specific samples of the combat vehicles.

Keywords: combat vehicle, air attack object, detection and recognition, rate of threat, artificial intelligence.

Introduction

Issues of artificial intelligence (AI) implementation in combat vehicle (CV) are considering often in the production plan on pages of special publication as prospect for that technique development [1, 2, 3]. Primarily, in confrontation with air attack objects (first of all with FPV-drones) the CV personnel decide a task on target detection and recognition for making decision deal with effective using of available CV armament [4]. That task demands the relevant time for its decision at the limited volume of target alphabet in human head.

Problem statement

From other side, as it is shown in work [5], the bigger probability to destroy a target at confrontation has opposite side *X* or *Y* which earlier detected and recognized a target and began the effective fire:

$$P_{X>Y}(t, \Delta t) = [e^{-x\Delta t} e^{-x(t-\Delta t)} (1- e^{-y(t-\Delta t)})]/[1-(1- e^{-x(t-\Delta t)})(1- e^{-x(t-\Delta t)} e^{-y(t-\Delta t)})],$$

where $P_{X>Y}$ – probability of win a side *X* against side *Y*, *t* – fire duration, Δt – advantage if time of fire beginning of some side, *x* and *y* – the effective flows of gunshots of both confrontation sides *X* and *Y* correspondently.

Research purpose

Hence, there is a feasibility (even necessity) to use the AI and to include the turret machine gun with optical-electronic sight (instead angle sight or collimator sight which are using up to now) and laser rangefinder into structure of CV sighting-search system. That paper purpose – to consider the basic tasks of AI should be provided for win of CV in its confrontation with air attack object.

Basic material description

On our way of thinking, CV on-board computer should content the images of the possible air targets (FPV-drones, missiles, aircrafts) to be able to scale its, to change view angle and to present complete information about recognized image for operator on the results of compare with image formed by optical-electronic sight.

On-board computer should determine also the rate of air target danger for CV on base of analysis target movement trajectory. For example, if target course direction is 0^0 and its altitude is constant, then AI makes a reasoned decision that target is dangerous for CV. When there is descent and constant course direction then target presents a significant threat for CV. There is importance of time which has CV personnel for destroy of the target or for other actions for defense of

CV in case of significant threat. On-board computer calculates that time by means of presented below algorithm, when the parameters of target movement are known for AI, and indicates that time on display of optical-electronic sight.

CV operator rotates manually a turret around both axles be means of control panel or automatically (at presence of the drivers for turret rotation) and visually controls whole process of optical-electronic sight reticle superposition with target after its detection and recognition by artificial intelligence. In moment of superposition the operator provides the command from control panel. In accordance with that command:

– laser rangefinder is switch on and electrical signal, which is proportional to current distance to target D_1, is given to on-board computer. Timer is switching on by that signal and time countdown t begins. Value of distance D_1 is indicating on optical-electronic sight display;

– the electrical signals from feedback potentiometers on turret axles, which are proportional to target current position: azimuth α_1 and elevation angle β_1 are given to on-board computer. Angle α_1 is accepted as the start point for azimuth angles.

After a certain time t (in dependence of relationship of distance D_1 and machine guns effective firing D_{ef}:: if $D_1 > D_{ef}$ then time more, if $D_1 < D_{ef}$ then time less) operator again rotates a turret around both axles and visually controls whole process of optical-electronic sight reticle superposition with target. In moment of superposition the operator provides the command from control panel. In accordance with that command:

– laser rangefinder is switch on again and electrical signal, which is proportional to current distance to target D_2, is given to on-board computer. Timer is turns off by that signal and electrical signal, which is proportional to time t, is given to on-board computer. Value of distance D_2 is indicating on optical-electronic sight display;

– the electrical signals from feedback potentiometers on turret axles, which are proportional to target current position: azimuth α_2 and elevation angle β_2 are given to on-board computer.

On-board computer processes all input parameters α_i, β_i, D_i and t and sequentially calculates:

– horizontal distance to target in point of the first measurement as

$$L_1 = D_1 cos\beta_1;$$

– horizontal distance to target in point of the second measurement as

$$L_2 = D_2 cos\beta_2;$$

– value of target course direction q:

$$q = arctg\{sin\alpha_2/[(L_1/L_2) - cos\alpha_2]\} \quad (1)$$

– target altitudes H_i by formula

$$H_i = D_i \, sin\beta_i; \quad (2)$$

– target velocity V_t by formula

$$V_t = [(D_1 cos\alpha_1)^2 + (D_2 cos\alpha_2)^2 - 2D_1D_2 cos\alpha_1 cos\alpha_2 cos(\beta_2 - \beta_1)]^{1/2} / t. \quad (3)$$

The values of target course direction and altitude are indicating on optical-electronic sight display. Now let us consider the importance of parameter t for task of rate of threat determination.

Particularly, if $\alpha_2 = 0^0$ in equation (1) and H_i = const in accordance with equation (2) then $q = 0^0$ and AI makes a reasoned decision that target is dangerous for CV. If $q = 0^0$, $H_2 < H_1$ and β_i = const – target is significantly dangerous for CV. In case of significant threat the importance has information about time T, which has CV personnel for destroy of attacker or for other actions for CV protection. If based from assumption that target has constant velocity V_t, then in accordance with (3) at $\alpha_1 = \alpha_2 = 0^0$ and $\beta_1 = \beta_2$ would be valid formula for calculation V_t: $V_t = (D_1 - D_2)/t$. From here we have expression for calculation T parameter by on-board computer:

$$T = D_2 / V_t = D_2 t / (D_1 - D_2).$$

Value *T* is indicating on display of optical-electronic sight.

Because of the precise devices (laser rangefinder and feedback potentiometers) are using in turret machine gun then target course direction and altitudes are determining without errors practically. It gives possibility for AI to assess a rate of threat. Possible diagram for calculation of rate of threat by on-board computer depends on analysis of the parameters of target movement and for representation on display of optical-electronic sight as a dot is presented in fig. 1. That dot indicated by symbol A in fig. 1.

The authors proceeded from the next considerations at its development. When target altitude is constant (H_2=H_1) and flank movement (q= 90^0), then target is not a threat for CV and rate of threat is accepted by zero.

When there is front movement of target ($q \rightarrow 0^0$) and constant altitude then a target may pose a threat for CV (especially, if target is recognized on big distance and it has time for descent and attack of CV) then rate of threat is accepted by 0,5.

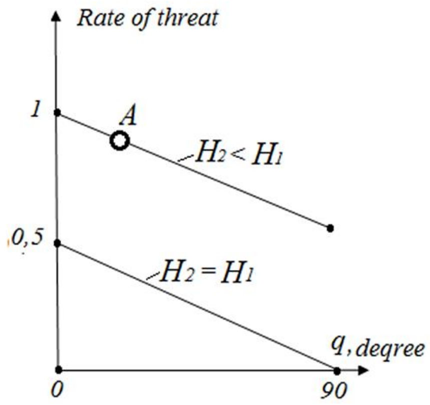

Fig. 1. Diagram for calculation of rate of threat by AI

When there is change of altitude of target (H_2<H_1) and front movement ($q \rightarrow 0^0$) then target poses a sufficient threat for CV and then rate of threat is accepted by 1,0.

On the results of self-learning the CV artificial intelligence may be able to identify the target images quickly and to form the signal independently for CV armament controls for aiming the most effective weapon to target.

The final decision on weapon activation is remaining with CV battle personnel.

Conclusion

The basic tasks of artificial intelligence of combat vehicle in its confrontation with air attack objects are determined. They are target detection and recognition, help to CV personnel to assess a rate of threat and recommend the most effective weapon against target.

The next step stays for native industry for these tasks implementation into specific samples of the combat vehicles.

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