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MODELING AND STUDY THE DISTRIBUTION OF OPERATOR ATTENTION IN CONTROLLING THE LATERAL MOVEMENT OF AN UNMANNED AERIAL VEHICLE

Peter Getsov

Space Research and Technology Institute – Bulgarian Academy of Sciences
e-mail: getsovp@mail.space.bas.bg

Keywords: *"Operator-UAV" system, Distribution of visual attention, Transverse movement of the UAV, Stabilization of the course, heel and distans*

Abstract

The report examines the transients in the system "Operator-Unmanned Aerial vehicle" in case of external disturbing influences. A model of the system in the system "MATLAB Simulink" has been developed, taking into account the distribution of the visual attention of the Operator. The parameter area of the transmission functions of the Operator is defined depending on the switching of attention.

Introduction

In recent years, Unmanned Aerial Vehicles (UAVs) have been increasingly used both in warfare and for civilian tasks in various areas of economic activities, which requires systematic analysis and synthesis in their construction and operation.

The study of the "Operator-UAV" system can be carried out by modeling and analytical study of the control loop of the UAV Operator, consisting of three units (blocks) [1] and using the transmission functions of the UAV derived from the linearized system equations describing the aerodynamics of the UAV (Fig. 1).

According to a Diamantidis transmission function [2,3]

(1) $$W_{on}(p) = W_1(p).W_2(p).W_3(p) = k_{on}e^{-n\tau p}\frac{T_1 p+1}{(T_2+1)(T_3+1)},$$

where:

$W_1(\mathrm{p}) = e^{-n\tau p}$; $W_2(\mathrm{p}) = k_{op}\frac{T_1 p+1}{(T_2+1)}$; $W_3(\mathrm{p}) = \frac{1}{(T_3+1)}$,

n – parameters, controlled by the operator;

τ – delay in receiving information on one parameter only;

k_{op} – amplification factor (transmission factor) of operator.

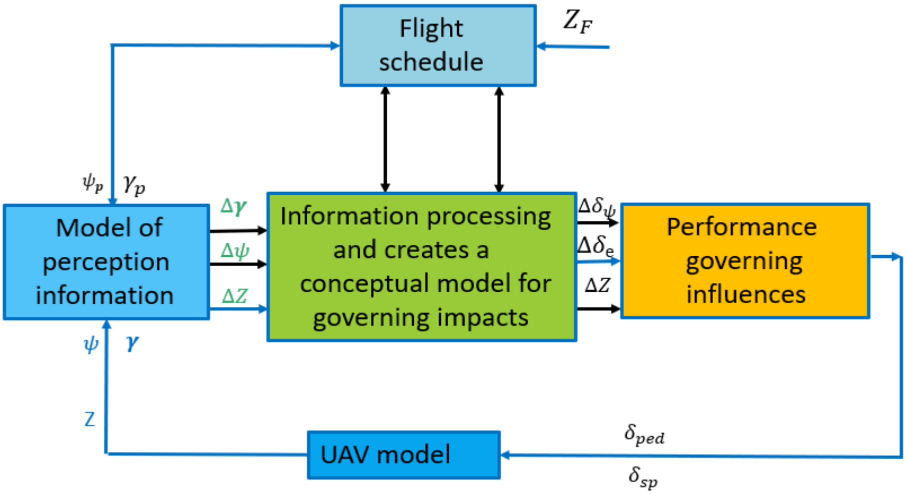


Fig. 1. Conceptual model for the study of the Operator

The delay block $W_1(\mathrm{p}) = e^{-n\tau p}$ is characterized by time $\tau\ (s)$ for excitation of receptors, passage of the excitation signal to the nervous system, interpretation of the received information.

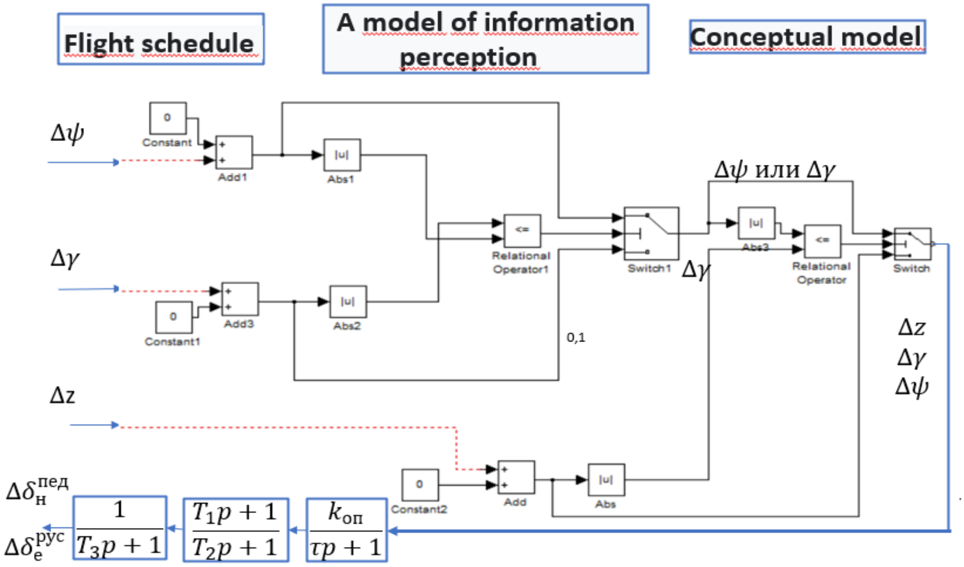


Fig. 2. Model of the distribution of the visual attention of the Operator

The second block $W_2(\mathrm{p}) = k_{op}\frac{T_1 p+1}{(T_2+1)}$ is corrective end it reflects the ability of a person to self-tune and adjust to the dynamic characteristics of the other units of the loop and to the spectral characteristics of the input signal. The adjustment is done by the variation of k_{op}, $T_1$and T_2.

The third block (neuro-muscular) $W_3(\mathrm{p}) = \frac{1}{(T_3+1)}$ reflects the delay between the entry of the command into the neuromuscular system and the muscular impact on the control lever.

The modelling of switching the attention of the Operator can be accomplished by comparing the relative values of the course, heel and lateral bias by the choice of the dominant value of the specified parameters with the help of the UAV model in a "MATLAB Simulink" system (Fig. 2) [5, 6].

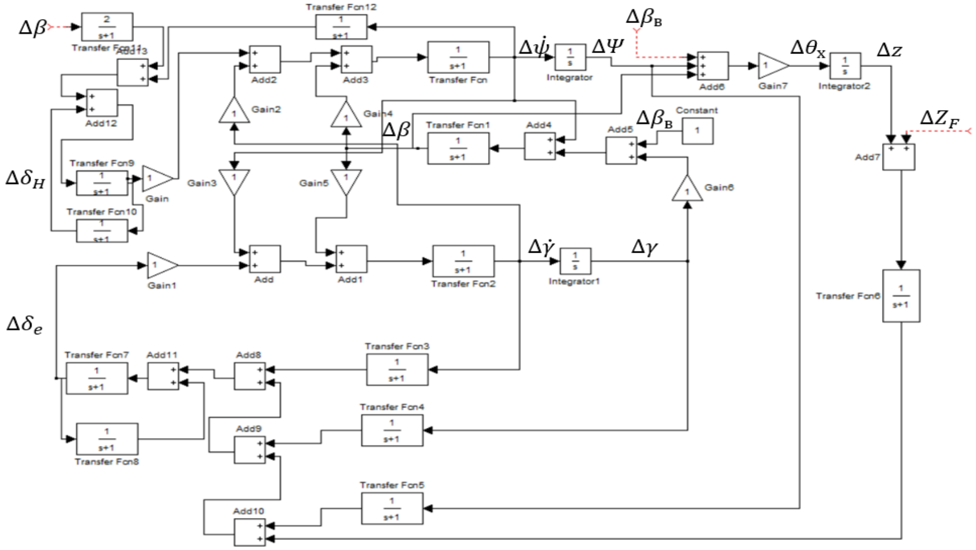


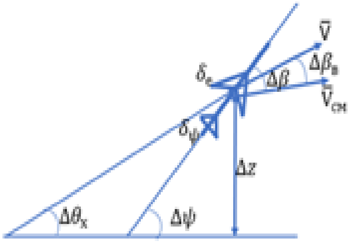
Fig. 3. BLA continuous motion model in MATLAB Simulink environment

The equations for the transverse motion of the UAV are obtained by a Laplace transform of the Eulerian equations [4]:

$$
(2) \quad \begin{cases}
\left(p + a_z^{\beta}\right)\Delta\beta(p) - p\Delta\psi(p) + a_z^{\gamma}\Delta\gamma(p) = 0; \\
a_{my}^{\beta}\Delta\beta(p) + \left(p^2 + a_{my}^{\omega y} p\right)\Delta\psi(p) + a_{my}^{\omega x} p\Delta\gamma(p) = a_{my}^{\delta_H}\Delta\delta_{н}(p); \\
a_{mx}^{\beta}\Delta\beta(p) + (p^2 + a_{mx}^{\omega x} p)\Delta\gamma(p) + a_{mx}^{\omega y} p\Delta\Psi(p) = a_{mx}^{\delta e}\Delta\delta_e(p),
\end{cases}
$$

where:

Θ_x – inclination of the flight trajectory in the horizontal plane;
γ – angle of heel;
ψ – angle of the course;
β – angle between longitudinal axis and velocity;
$\delta_н$ – rudder for direction;
δ_e - ailerons;
α – aerodynamic coefficients.



The corresponding parameters are also shown in the above diagram, and the structure of the lateral movement model in Fig. 3.

On the basis of (1) and (2) and consideration of the attention distribution, the structural scheme of the transverse channel in horizontal flight mode control under external perturbation effects was obtained (Fig. 4).

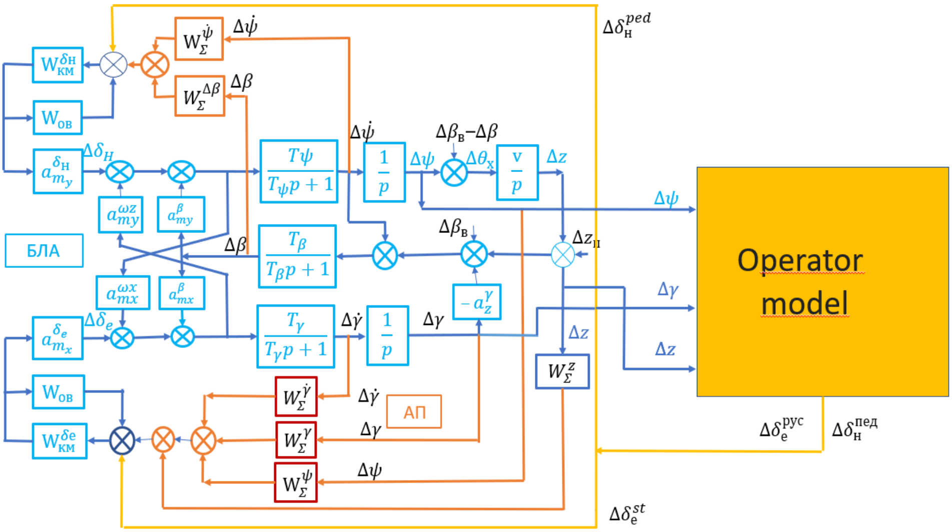


Fig. 4. Structural diagram of the “UAV-Operator” system

As a parameter and for control in the channel and the reconciling of the set and current parameters of the course and the transverse deviation depending on the dominant parameter determined by the conceptual model of the Operator is used.

For the study of the "Operator-UAV" system with consideration of the attention distribution, a model was developed in an of the MATLAB Simulink system (Fig. 5).

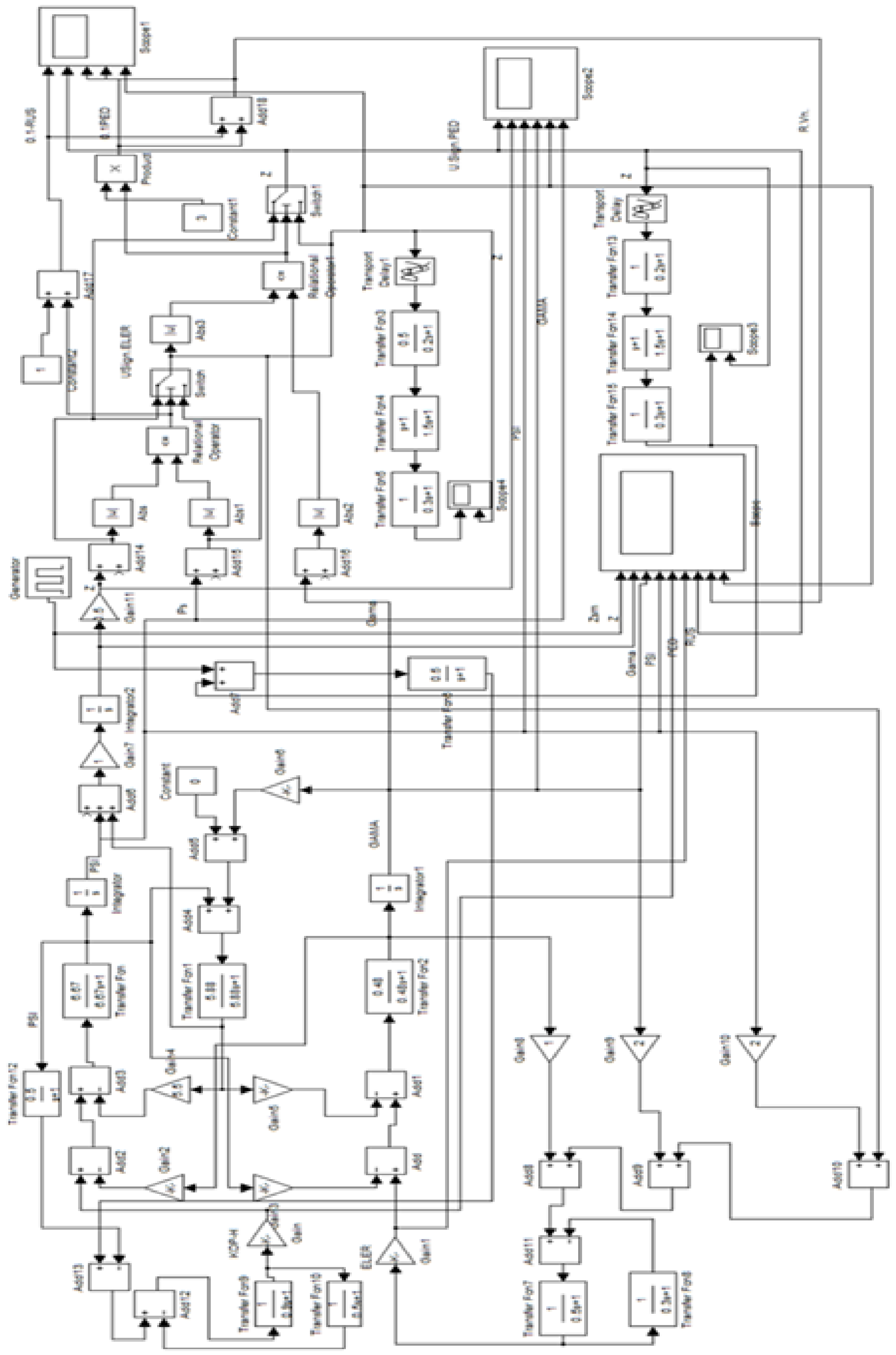


Fig. 5. ,,UAV-Operator" model in MATLAB Simulink environment

The proposed model allows the study of transients in external interference effects (single stepping signal; random stepping signal with white noise distribution and periodic stage) (Fig. 6).

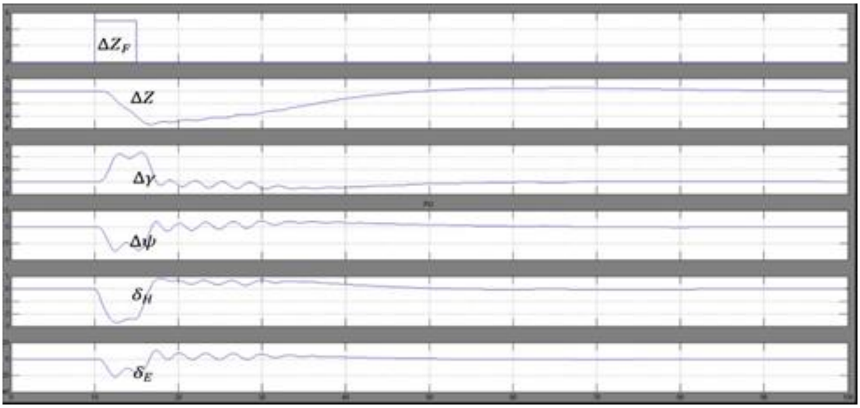


Fig. 6. Transient processes of UAV under external disturbance

From experiments they found that there is a possibility to determine the zones of the distribution of attention between the aviohorizont (γ), the compass (P_{si}), distans (z) (Fig. 7).

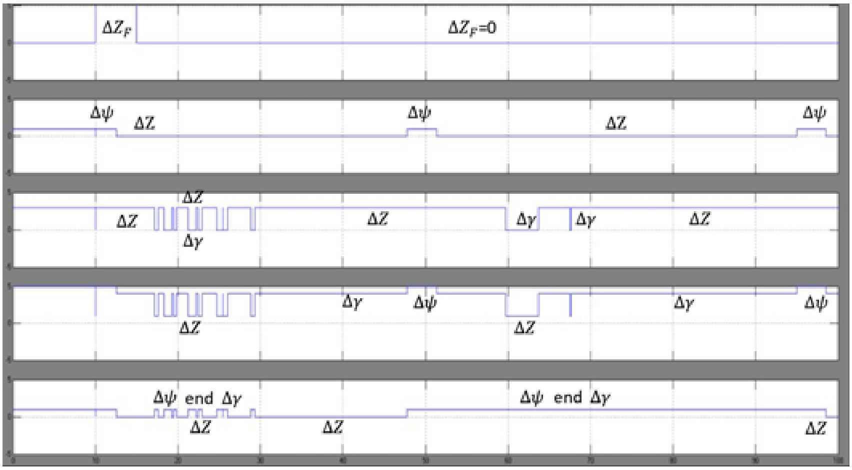


Fig. 7. Areas of distribution of visual attention

In Table 1, Table 2 and Fig. 8 the dependence of the number of switches on the parameters of the transmission function of the Operator shown distribution of $N_{(1,2)_{so}} = f_{(1,2)}\left(k_{op}, \tau, T_1, T_2, T_3\right)$ attention, where 1, 2 are Rudder Channel and Aileron Channel respectively.

Table 1. Switching visual attention in the direction rudder channel $n_1 = f_1(X_{1so})$

f(X) / N	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
$N_{\delta_н} = (K_{оп})$	33	32	31	24	22	19	17	12	10	9
$N_{\delta_н}$=f(τ)	22	19	18	16	14	13	13	13	13	13
$N_{\delta_н}$=f(T_1)	14	13	13	13	14	14	16	18	18	19
$N_{\delta_н}$=f(T_2)	65	58	58	53	40	39	33	27	25	23
$N_{\delta_н}$=f(T_3)	25	19	19	25	16	16	14	14	13	13

Table 2. Switching visual attention in the aileron channel $n_2 = f_2(X_{2so})$

f(X) / N	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
$N_{\delta_e} = (K_{оп})$	20	20	22	19	19	17	18	16	14	11
N_{δ_e}=f(τ)	19	18	19	21	19	19	18	18	19	21
N_{δ_e}=f(T_1)	21	21	21	21	21	21	21	21	21	19
N_{δ_e}=f(T_2)	19	19	19	19	19	19	21	18	20	18
N_{δ_e}=f(T_3)	21	18	19	21	19	19	18	18	17	21

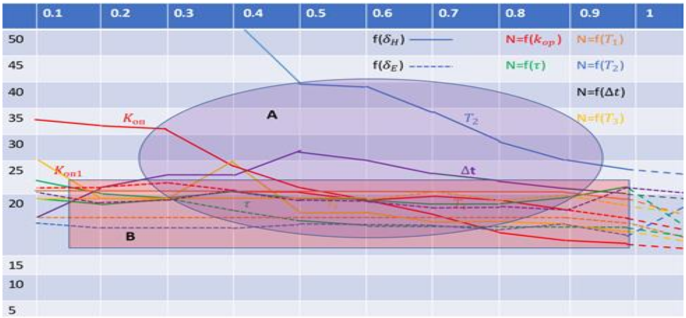


Fig. 8. Distribution of visual attention depending on the condition of the Operator

Areas (A) and (B) show plots of the distribution of visual attention as a function of variation in the parameters of the Operator's transfer functions for the rudder channel and ailerons, respectively.

Conclusions

1. The developed linear model of the longitudinal channel of the "Operator-UAV" system in a MATLAB-Simulink environment makes it possible to study the transients under external disturbing and controlling influences.

2. On the basis of the developed model, the optimal parameters of the distribution of visual attention between the aircraft horizon and the altimeter in horizontal flight are determined, depending on the preparedness and individual qualities of the Operator.

3. The proposed conceptual model to determine the disagreement of managed parameters, information processing and the implementation of managing impacts can be used as an element of artificial intelligence in the automatic management of UAVs.

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МОДЕЛИРАНЕ И ИЗСЛЕДВАНЕ НА РАЗПРЕДЕЛЕНИЕТО НА ВНИМАНИЕТО НА ОПЕРАТОРА ПРИ УПРАВЛЕНИЕ НА СТРАНИЧНОТО ДВИЖЕНИЕ НА БЕЗПИЛОТЕН ЛЕТАТЕЛЕН АПАРАТ

П. Гецов

Резюме

В доклада са изследвани преходните процеси в системата „Оператор-Безпилотни летателни апарати“ при външни смущаващи въздействия. Разработен е модел на системата в среда „MATLAB Simulink“ с отчитане на разпределението на зрителното внимание на Оператора. Определена е зоната на параметрите на предавателните функции на Оператора в зависимост от превключването на вниманието.