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Simulations of field MACHINE INFORMATION WITH vision systems IN FIELD irregularities

OO Brovarets, Ph.D.

In the article the method of modeling information field oscillations of the machine vision systems when driving on the surface roughness of the field. Established the degree of influence of structural parameters, elastic suspension and damper elements of field information to stabilize the machine vision systems in compliance.

Precision Agriculture, fluctuations machines, vision systems, suspension stiffness.

Problem. Spatial fluctuations in the field of information machines (PIM) with vision systems arising from the movement on the surface roughness of the field, adversely affecting the quality monitoring using computer vision. However, the amplitude and frequency of these oscillations depend not only on the terrain, but also on the forward speed of the machine, placing working equipment relative to the supporting wheels, machine design parameters and more. Established the feasibility of using elastic suspension and damper elements PIM to stabilize vision systems, which is placed on the machine.

Analysis of recent research. To investigate the nature of the fluctuations and the choice of optimal design parameters and machine elements pidisky, is a mathematical model. Obtained during modeling differential equations should include a whole needed to assess and calculate the ratio

between design parameters and stiffness and damping suspension and tire machines.

The purpose of research. To investigate the nature of the processes occurring and selection of optimal parameters, design parameters necessary to mathematical modeling the field of information transport in surface roughness field. draw up a mathematical model.

Results. In constructing a mathematical model of chassis for robotic systems used field technique [1, 2]. The frame chassis is a complex dynamic system.

Due to the placement of the rear suspension chassis at an angle γ the working platform we have the following scheme chassis (Fig. 1). Angle γ is a function of movement under the left and right rear wheels f_{21}, f_{22}. Previous studies have shown that changing the angle γ occurs within 40° to 44°When you move the corresponding rear wheel from 0 to 0,10m. In drawing up the differential equations will have a system of nonlinear equations, since the change in the angle γ depends on the movement of the rear wheel (f_{21} and f_{22}). In the first approximation believe that γ = 42°(Average angle γ), On the basis of studies have found that it will give 2% measurement error, which is within 5% elastic and damping force corresponding wheel design on the vertical axis. Thus, in a first approximation, we have a linear system, and PIM design model for the study of fluctuations is shown as follows (Fig. 1).

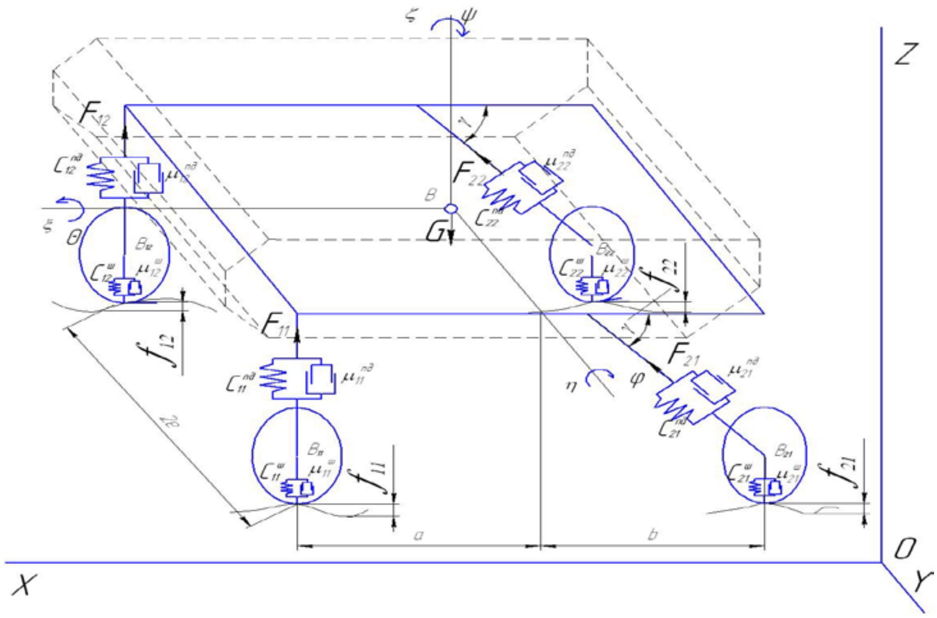

Fig. 1. The dynamic model of the field of information machine.

We construct a mathematical model of the chassis. Take it to a fixed space system fixed Cartesian coordinates *OXYZ*. Let while plane *OXZ* is perpendicular to the surface of the field. The body chassis (center of mass *In the*) Assign to the moving system of Cartesian coordinates *B*$\xi\eta\zeta$ invariably linked with it. This axis *In the*ξ coincides with the longitudinal axis of the machine axis *In the*η - Slip parallel to the axis (left in the direction of motion) and the axis *In the*ζ - Upward [2]. We denote the coordinates of the center of mass of the chassis *In the* a fixed coordinate system *OXYZ*. We introduce the following notation: *AD* - Mid-center distance between the front accordance Powered and rear-wheel drive; $L=(a+b)$ - Longitudinal base machine; a - Transverse distance from the front wheels to the center of mass *In the*; b - Transverse distance between the rear wheels to the center of mass *In the*; $2e$ - Longitudinal distance between the axles of wheels turning control [2].

In the vertical plane, the following forces: $F_{11}, F_{12}, F_{21}, F_{22}$ - Force transmitted to the appropriate wheels and suspension chassis. In the center of mass (*In the*) Applied force of gravity machines - *G*[2].

When driving on the open field chassis carries angular movements that can be described, around the axis *In the* ζ - Angle ψ (Yaw) *In the* η - Angle φ (Vasitis) *In the* ξ - Angle Θ (Roll). Angle ψ (Yaw) is neglected because we believe that the system performs rectilinear motion. Linear motion carried along the center of mass of the respective axes fixed coordinate system O*XYZ*. Thus, fluctuations in the coordinate system *XYZ* will be determined by the movement of the center of mass *In the* in a vertical plane along the axis *OZ* and angular displacement Θ *(T)* (Bias) in the transverse and φ *(T)* (Vasitis) in the longitudinal plane. Counting roll (angle Θ) And vasitis (corner φ) Made from a situation in which previously selected stationary and moving system of coordinates were parallel. That is the initial time, the $t=0, \varphi(t)=0, \theta(t)=0$ [2]. We believe that the chassis performs rectilinear motion, that is moving along the axis *Y* negligible, therefore the velocity $\dot{Y}=0$. Chassis provides moving along the axis *X* and *Z*, Perform research movement as an example the center of mass *In the*While the forward speed of the chassis will look like $V_B=\sqrt{\dot{X}^2+\dot{Z}^2}$ [2]. To describe the kinetic energy of the system previously submitted has been determined the approximate weight of the car ($M=100\hat{e}\tilde{a}$) And calculated the coordinates of the center of mass of the chassis where the fastening vision systems. In the transverse plane of the center of mass is located (Fig.1) $e=0{,}45м$ As efforts on each drive and steering wheels evenly distributed between the respective wheels, ie $F_{11}=F_{12}, F_{21}=F_{22}$. In the longitudinal plane (Fig. 1) the center of mass is located $\grave{a}=0{,}40\grave{\imath}$, $b=0{,}60\grave{\imath}$. If we assume that in the process of moving the chassis moves on irregularities field, without going into the ground and not zmynayuchy it, then there are points of contact with the surface of the soil $f_{11}, f_{12}, f_{21}, f_{22}$. These points of contact are the current values of roughness heights under appropriate wheels. We assume that the tires chassis submitted in the form of elastic-distorting elements and have a constant stiffness $C_{ii}^{ш}$ and damping $\mu_{ii}^{ш}$ Each element has a suspension stiffness $C_{ii}^{пд}$ and damping $\mu_{ii}^{пд}$. In the second approach the effect of elastic and damping elements corresponding suspension and tires replace one wheel chassis value and weight of the wheel will be considered in the total mass. The effect of elastic damper and suspension parts and tires chassis will present their pruzhnodeformuyuchymy equivalents of stiffness *FIC* and damping μ*and*and [3, 4]

$$C_{ii} = \frac{C_{ii}^{n\partial} \cdot C^{ш}{}_{ii}}{C_{ii}^{n\partial} + C^{ш}{}_{ii}}; \mu_{ii} = \frac{\mu_{ii}^{n\partial} \cdot \mu^{ш}{}_{ii}}{\mu_{ii}^{n\partial} + \mu^{ш}{}_{ii}}. \quad (1)$$

where C_{ii} - Reduced stiffness of this entry wheel suspension chassis; μ_{ii} - Reduced damping factor of the element wheel suspension chassis; $C_{ii}{}^{ш}$ - Tire stiffness; $\mu_{ii}{}^{ш}$ - Coefficient of viscous friction tire; $C_{ii}^{n\partial}$ - Stiffness suspension springs; $\mu_{ii}^{n\partial}$ - Coefficient of damping suspension.

Based on the previous static calculation according to known methods [4], taking into account the weight ($G = 1000H$) And height irregularities ($f = 0{,}10м$) An optimal stiffness $C = \frac{G}{f} = \frac{1000}{0{,}10} = 10000H$. Preliminary calculations according to known methods [4] showed that the system weight *100kg* when driving on inequalities in a range of speeds *2.0* to *4.0 m /*s and maximum whist inequalities *0.10 m*, Is optimal stiffness in the range of *5000N / m* to *15000N / m*. Because $F_{11} = F_{12} = F_{21} = F_{22} = 300H$, It is accepted that $C_{11} = C_{12} = C_{21} = C_{22}$ and $\mu_{11} = \mu_{12} = \mu_{21} = \mu_{22}$.

According to the method proposed in [2, 3], the expression vertical components of the forces acting in the relevant elastic suspension and damper elements chassis:

$$F_{ii} = F_{iic} + F_{ii\mu}, \quad (2)$$

where $F_{iic} = C_{ii} \cdot \delta_{ii}$ - Vertical component of the force that is proportional to the radial deformation suspension δ_{ii}, N; $F_{зз\mu} = C_{зз} \cdot \dot{z}_{зз}$ - Vertical component of the force is proportional to the velocity of radial deformation strain suspension $\dot{\delta}_{ii}$, N; $\delta_{ii}, \dot{\delta}_{ii}$ - Under radial deformation (m) and radial strain rate suspension and tires (m / s).

To calculate these components determine the strength and vertical coordinates corresponding movement of suspension components. According to Fig. 1 and previously accepted designations coordinates equal [4]:

$$\begin{cases} Z_{11} = Z - l_z - \Theta \cdot e - \varphi \cdot a - r_{11}; \\ Z_{12} = Z - l_z + \Theta \cdot e - \varphi \cdot a - r_{12}; \\ Z_{21} = Z - l_z - \Theta \cdot e + \varphi \cdot b - r_{21}; \\ Z_{22} = Z - l_z + \Theta \cdot e + \varphi \cdot b - r_{22}. \end{cases} \quad (3)$$

where l_z - Distance from the wheel center to the point of attachment vision systems on the axis z, M.

The radial deformation of the tire and chassis suspension is determined by the relationship:

$$\delta_{ii} = f_{ii} - Z_{ii},\ [\text{M}] \tag{4}$$

where f_{ii} - Ordinate heights uneven ground under the relevant elements of the wheel suspension systems, m; Z_{ii} - Coordinate points of contact frame elastic elements, m.

Substituting the values of expressions (3) and (4) in the expression (5), we obtain the value of vertical forces acting on the tires chassis and suspension:

$$\begin{cases} F_{11} = C_{11} \cdot (f_{11} - Z + l_z + \Theta \cdot e - \varphi \cdot a) + \mu_{11} \cdot (\dot{f}_{11} - \dot{Z} + e \cdot \dot{\Theta} - a \cdot \dot{\varphi}); \\ F_{12} = C_{12} \cdot (f_{12} - Z + l_z - \Theta \cdot e + \varphi \cdot a) + \mu_{12} \cdot (\dot{f}_{12} - \dot{Z} - e \cdot \dot{\Theta} + a \cdot \dot{\varphi}); \\ F_{21} = C_{21} \cdot (f_{21} - Z + l_z + \Theta \cdot e - \varphi \cdot b) + \mu_{21} \cdot (\dot{f}_{21} - \dot{Z} + e \cdot \dot{\Theta} - b \cdot \dot{\varphi}) \cdot \sin\gamma; \\ F_{22} = C_{22} \cdot (f_{22} - Z + l_z - \Theta \cdot e - \varphi \cdot b) + \mu_{22} \cdot (\dot{f}_{22} - \dot{Z} - e \cdot \dot{\Theta} - b \cdot \dot{\varphi}) \cdot \sin\gamma. \end{cases} \tag{5}$$

The kinetic energy of the chassis, moving, calculated using the formula

$$T = \frac{M \cdot V^2}{2} + \frac{I_{M\xi} \cdot \dot{\Theta}^2}{2} + \frac{I_{M\eta} \cdot \dot{\varphi}^2}{2}. \tag{6}$$

As defined by the kinetic energy of the masses moving, it is possible to make an expression of the kinetic energy of the whole system studied. It has the form:

$$T = \frac{M \cdot (\dot{X}^2 + \dot{Z}^2)}{2} + \frac{I_{M\xi} \cdot \dot{\Theta}^2}{2} + \frac{I_{M\eta} \cdot \dot{\varphi}^2}{2}, \tag{7}$$

where $I_{M\xi}$ - Moment of inertia about the axis of the whole machine ξ; $I_{M\eta}$ - Moment of inertia about the axis of the whole machine η; M - Mass of the chassis with wheels.

Using recommendations for dynamic modeling proposed in [1-4], to describe fluctuations in PIM, there is every reason to use Lagrange dynamics equation of the 2nd kind:

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_i}\right) - \frac{\partial T}{\partial q_i} = Q_i, \tag{8}$$

where T - Kinetic energy; Q_i - Generalized force; q_i - Generalized coordinate.

Considered oscillating system can be represented as a mechanical system with three degrees of freedom and is given to the generalized coordinates [2]:

$$\left.\begin{aligned} q_1 &= Z \\ q_2 &= \varphi \\ q_3 &= \Theta \end{aligned}\right\}. \tag{9}$$

Then we have

$$\left.\begin{aligned} \frac{d}{dt} \cdot \left(\frac{\partial T}{\partial \dot{Z}}\right) - \frac{\partial T}{\partial Z} &= Q_Z \\ \frac{d}{dt} \cdot \left(\frac{\partial T}{\partial \dot{\varphi}}\right) - \frac{\partial T}{\partial \varphi} &= Q_\varphi \\ \frac{d}{dt} \cdot \left(\frac{\partial T}{\partial \dot{\Theta}}\right) - \frac{\partial T}{\partial \Theta} &= Q_\Theta \end{aligned}\right\}. \tag{10}$$

To calculate the generalized forces will make the system work the elementary expression of active forces towards possible movements [2, 3]. As a result of the substitution of certain variables in the equation (10) dynamics and perform the necessary operations differentiation obtained system of differential equations chassis movement in the vertical plane, vasitis and roll:

$$
\begin{aligned}
&\ddot{Z}\cdot M = C_{11}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{11}\right))-Z+l_z+\Theta\cdot e-\varphi\cdot a+r_{11}\right)+\mu_{11}\cdot\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{11}\right)-\dot{Z}+e\cdot\dot{\Theta}-a\cdot\dot{\varphi}\right)+\\
&+C_{12}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{12}\right))-Z+l_z-\Theta\cdot e+\varphi\cdot a+r_{12}\right)+\mu_{12}\cdot\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{12}\right)-\dot{Z}-e\cdot\dot{\Theta}+a\cdot\dot{\varphi}\right)+\\
&+(C_{21}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{21}\right))-Z+l_z+\Theta\cdot e-\varphi\cdot b+r_{21}\right)+\mu_{21}\cdot\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{21}\right)-\dot{Z}+e\cdot\dot{\Theta}-b\cdot\dot{\varphi}\right))\cdot\sin\gamma+\\
&+(C_{22}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{22}\right))-Z+l_z-\Theta\cdot e-\varphi\cdot b+r_{22}\right)+\mu_{22}\cdot\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{22}\right)-\dot{Z}-e\cdot\dot{\Theta}-b\cdot\dot{\varphi}\right))\cdot\sin\gamma-G;\\
&I_{M\eta}\ddot{\varphi}=\left[C_{22}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{22}\right))-Z+l_z-\Theta\cdot e-\varphi\cdot b+r_{22}\right)+\mu_{22}\cdot\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{22}\right)-\dot{Z}-e\cdot\dot{\Theta}-b\cdot\dot{\varphi}\right)\right]\cdot b\cdot\sin\gamma+\\
&+\left[C_{21}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{21}\right))-Z+l_z+\Theta\cdot e-\varphi\cdot b+r_{21}\right)+\mu_{21}\cdot\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{21}\right)-\dot{Z}+e\cdot\dot{\Theta}-b\cdot\dot{\varphi}\right)\right]\cdot b\cdot\sin\gamma-\\
&-\left[C_{11}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{11}\right))-Z+l_z+\Theta\cdot e-\varphi\cdot a+r_{11}\right)+\mu_{11}\cdot\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{11}\right)-\dot{Z}+e\cdot\dot{\Theta}-a\cdot\dot{\varphi}\right)\right]\cdot a-\\
&-\left[C_{12}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{12}\right))-Z+l_z-\Theta\cdot e+\varphi\cdot a+r_{12}\right)+\mu_{12}\cdot\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{12}\right)-\dot{Z}-e\cdot\dot{\Theta}+a\cdot\dot{\varphi}\right)\right]\cdot a;\\
&I_{M\xi}\cdot\ddot{\Theta}=\left[C_{12}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{12}\right))-Z+l_z-\Theta\cdot e+\varphi\cdot a+r_{12}\right)+\mu_{12}\cdot\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{12}\right)-\dot{Z}-e\cdot\dot{\Theta}+a\cdot\dot{\varphi}\right)\right]\cdot e+\\
&+\left[C_{22}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{22}\right))-Z+l_z-\Theta\cdot e-\varphi\cdot b+r_{22}\right)+\mu_{22}\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{22}\right)-\dot{Z}-e\cdot\dot{\Theta}-b\cdot\dot{\varphi}\right)\right]\cdot e\cdot\sin\gamma-\\
&-\left[C_{11}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{11}\right))-Z+l_z+\Theta\cdot e-\varphi\cdot a+r_{11}\right)+\mu_{11}\cdot\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{11}\right)-\dot{Z}+e\cdot\dot{\Theta}-a\cdot\dot{\varphi}\right)\right]\cdot e-\\
&-\left[C_{21}\cdot\left(\lambda\cdot(1-\cos\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{21}\right))-Z+l_z+\Theta\cdot e-\varphi\cdot b+r_{21}\right)+\mu_{21}\cdot\left(\frac{2\cdot\pi\cdot\lambda}{\alpha}\cdot(V+3\cdot\beta\cdot V^3\cdot t^2)\cdot\sin\left(\frac{2\cdot\pi}{\alpha}\cdot\left(V\cdot t+\beta\cdot V^3\cdot t^3\right)+\varphi_{21}\right)-\dot{Z}+e\cdot\dot{\Theta}-b\cdot\dot{\varphi}\right)\right]\cdot e\cdot\sin\gamma.
\end{aligned}
\tag{11}
$$

The system of differential equations (11) is calculated by the mathematical model of motion information field of machine vision systems for surface roughness field and gives the opportunity to observe the change of vertical, longitudinal and transverse vibrations PIM when changing speed and suspension settings of the machine.

Next, we determined the numerical values of design parameters and power chassis. Some of them were calculated by working drawings, the second - experimental and calculated on the basis of some theoretical assumptions.

For the solution of equations (11) were given initial conditions for the output functions $Z(t)$, $\Theta(t)$ and $\varphi(t)$. They will be:

$$Z(0)=0,\dot{Z}(0)=0,\Theta(0)=0,\dot{\Theta}(0),\varphi(0)=0;\dot{\varphi}(0)=0 \tag{12}$$

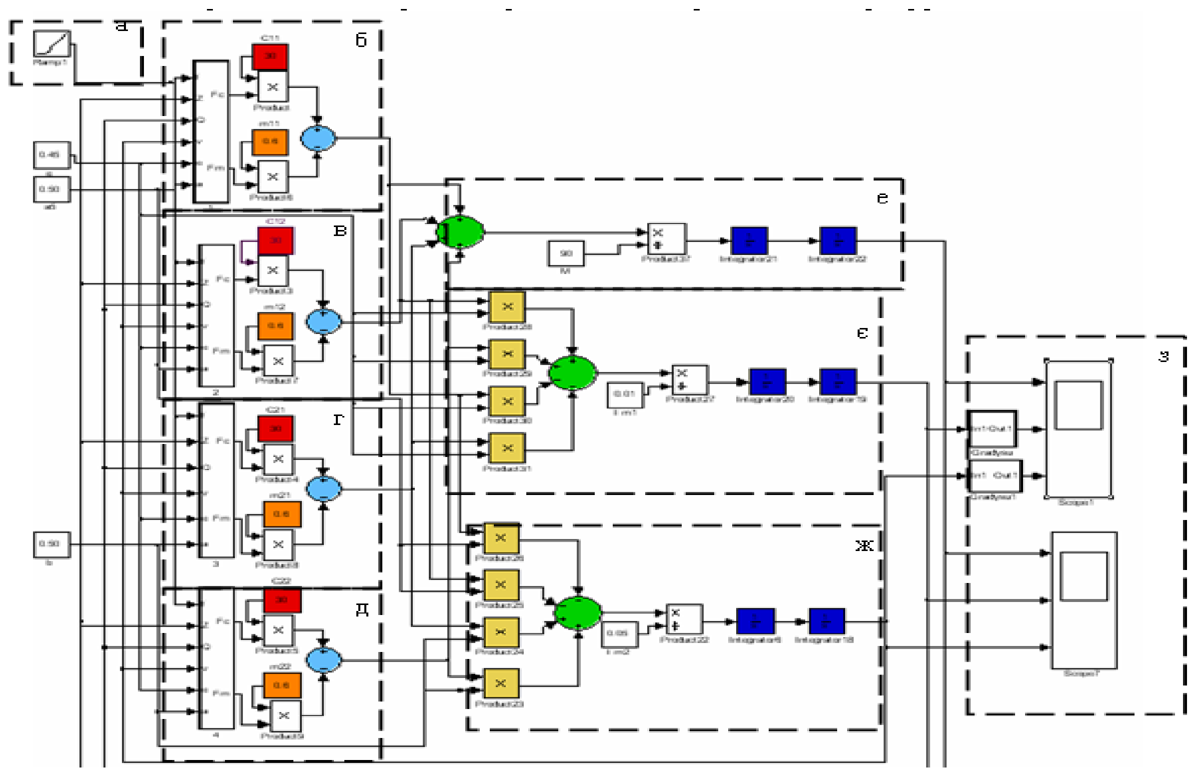

Fig. 2. The algorithm is simulated process environment "Simulink" software "Matlab V6.5": *and* - Parameter block movement; b - parameter block vertical components of the forces acting in the relevant elastic suspension elements 11 chassis; *to* - Parameter block vertical components of the forces acting in the relevant elastic suspension elements 12 chassis; *g* - Parameter block vertical components of the forces acting in the relevant elastic suspension elements 21 chassis; *d* - Parameter block vertical components of the forces acting in the relevant elastic suspension elements 22 chassis; *e* - A block from the first equation of mathematical models; *there is* - Parameter block second equation of mathematical models; *same* - Parameter block third equations of mathematical models; *from* - Oscilloscopes unit (moving *S*; vertical displacement *Z*, Angles *θ* and *φ*).

Numerical solution dependencies performed using the software "Matlab V6.5", directly using simulation pidpaketu "Simulink". The feature of this product is that it makes it possible to simulate pidpaket, identify and fix processes that occur when moving the chassis, depending on the stiffness, suspension and wheels dempferuvannya and speed of the direct control of the transient regimes using oscilloscopes are included in the mathematical model in any location compound algorithm. Algorithm for solving equations (11) are shown in Fig. 2.

The solution of equations (11) for a machine with parameters $M = 100кг$, $\gamma = 42^0$, $I_\xi = 28{,}0кг \cdot м^2$, $I_\eta = 30{,}0кг \cdot м^2$, $L = 1{,}00м$, $a = 0{,}40м$, $b = 0{,}60м$, $e = 0{,}45м$ was performed using the software "Matlab

V6.5" and modeling pidpaketu «Simulink». Numerical solution dependencies by means of symbolic units that perform mathematical transformation of the signal supplied to them. To set the time using moving block and that pid`yednuyetsya to block b, c, d, e, which mimic the strength and stiffness dempferuvannya. Using the unit e, is also allows using oscilloscopes with track and describe the processes that occur when moving the chassis. The research results are presented in Table. 1.

1. The results of the impact stiffness C and damping μ suspension on the amplitude and velocity of vertical displacement $Z(t)$, Longitudinal $\theta(t)$ and transverse $\varphi(t)$ fluctuations in PIM theoretical calculation with different speed on different ahrofonam.

The velocity, m / s	Suspension type								
	Suspension 1 $C = 5000\frac{H}{\text{м}}, \mu = 75\frac{H \cdot c}{\text{м}}$			Suspension 2 $C = 10000\frac{H}{\text{м}}, \mu = 150\frac{H \cdot c}{\text{м}}$			Suspension 3 $C = 15000\frac{H}{\text{м}}, \mu = 270\frac{H \cdot c}{\text{м}}$		
	Ahrofony								
	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	2	3	4	5	6	7	8	9	10
2.0	$Z = 0{,}035\text{м}$ $\varphi = 0{,}02$ $\Theta = 0{,}03$ $\dot{Z} = 0{,}060\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}022\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}038\frac{\text{рад}}{c}$	$Z = 0{,}036\text{м}$ $\varphi = 0{,}04$ $\Theta = 0{,}04$ $\dot{Z} = 0{,}070\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}023\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}040\frac{\text{рад}}{c}$	$Z = 0{,}049\text{м}$ $\varphi = 0{,}05$ $\Theta = 0{,}07$ $\dot{Z} = 0{,}080\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}025\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}045\frac{\text{рад}}{c}$	$Z = 0{,}010\text{м}$ $\varphi = 0{,}02$ $\Theta = 0{,}02$ $\dot{Z} = 0{,}040\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}010\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}020\frac{\text{рад}}{c}$	$Z = 0{,}018\text{м}$ $\varphi = 0{,}02$ $\Theta = 0{,}03$ $\dot{Z} = 0{,}060\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}020\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}030\frac{\text{рад}}{c}$	$Z = 0{,}030\text{м}$ $\varphi = 0{,}03$ $\Theta = 0{,}05$ $\dot{Z} = 0{,}070\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}024\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}040\frac{\text{рад}}{c}$	$Z = 0{,}037\text{м}$ $\varphi = 0{,}03$ $\Theta = 0{,}05$ $\dot{Z} = 0{,}080\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}026\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}045\frac{\text{рад}}{c}$	$Z = 0{,}056\text{м}$ $\varphi = 0{,}07$ $\Theta = 0{,}09$ $\dot{Z} = 0{,}090\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}028\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}050\frac{\text{рад}}{c}$	$Z = 0{,}072\text{м}$ $\varphi = 0{,}10$ $\Theta = 0{,}11$ $\dot{Z} = 0{,}090\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}030\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}050\frac{\text{рад}}{c}$

Extension Table. 1

1	2	3	4	5	6	7	8	9	10
3.0	$Z = 0{,}035\text{м}$ $\varphi = 0{,}06$ $\Theta = 0{,}07$ $\dot{Z} = 0{,}090\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}020\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}040\frac{\text{рад}}{c}$	$Z = 0{,}037\text{м}$ $\varphi = 0{,}07$ $\Theta = 0{,}07$ $\dot{Z} = 0{,}140\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}025\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}045\frac{\text{рад}}{c}$	$Z = 0{,}060\text{м}$ $\varphi = 0{,}07$ $\Theta = 0{,}08$ $\dot{Z} = 0{,}200\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}030\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}054\frac{\text{рад}}{c}$	$Z = 0{,}012\text{м}$ $\varphi = 0{,}02$ $\Theta = 0{,}03$ $\dot{Z} = 0{,}050\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}018\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}034\frac{\text{рад}}{c}$	$Z = 0{,}024\text{м}$ $\varphi = 0{,}03$ $\Theta = 0{,}04$ $\dot{Z} = 0{,}060\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}022\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}037\frac{\text{рад}}{c}$	$Z = 0{,}035\text{м}$ $\varphi = 0{,}04$ $\Theta = 0{,}04$ $\dot{Z} = 0{,}080\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}024\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}040\frac{\text{рад}}{c}$	$Z = 0{,}035\text{м}$ $\varphi = 0{,}06$ $\Theta = 0{,}08$ $\dot{Z} = 0{,}100\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}030\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}050\frac{\text{рад}}{c}$	$Z = 0{,}071\text{м}$ $\varphi = 0{,}09$ $\Theta = 0{,}10$ $\dot{Z} = 0{,}120\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}035\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}055\frac{\text{рад}}{c}$	$Z = 0{,}082\text{м}$ $\varphi = 0{,}11$ $\Theta = 0{,}12$ $\dot{Z} = 0{,}150\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}045\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}060\frac{\text{рад}}{c}$
4.0	$Z = 0{,}036\text{м}$ $\varphi = 0{,}06$ $\Theta = 0{,}07$ $\dot{Z} = 0{,}030\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}056\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}064\frac{\text{рад}}{c}$	$Z = 0{,}045\text{м}$ $\varphi = 0{,}07$ $\Theta = 0{,}08$ $\dot{Z} = 0{,}047\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}078\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}080\frac{\text{рад}}{c}$	$Z = 0{,}070\text{м}$ $\varphi = 0{,}09$ $\Theta = 0{,}10$ $\dot{Z} = 0{,}075\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}115\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}110\frac{\text{рад}}{c}$	$Z = 0{,}020\text{м}$ $\varphi = 0{,}03$ $\Theta = 0{,}04$ $\dot{Z} = 0{,}060\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}026\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}044\frac{\text{рад}}{c}$	$Z = 0{,}036\text{м}$ $\varphi = 0{,}05$ $\Theta = 0{,}05$ $\dot{Z} = 0{,}080\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}028\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}045\frac{\text{рад}}{c}$	$Z = 0{,}040\text{м}$ $\varphi = 0{,}05$ $\Theta = 0{,}05$ $\dot{Z} = 0{,}090\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}028\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}048\frac{\text{рад}}{c}$	$Z = 0{,}038\text{ì}$ $\varphi = 0{,}07$ $\Theta = 0{,}08$ $\dot{Z} = 0{,}490\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}090\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}110\frac{\text{рад}}{c}$	$Z = 0{,}080\text{ì}$ $\varphi = 0{,}08$ $\Theta = 0{,}09$ $\dot{Z} = 0{,}840\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}110\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}140\frac{\text{рад}}{c}$	$Z = 0{,}100\text{ì}$ $\varphi = 0{,}12$ $\Theta = 0{,}13$ $\dot{Z} = 0{,}900\frac{\text{м}}{c}$ $\dot{\varphi} = 0{,}130\frac{\text{рад}}{c}$ $\dot{\Theta} = 0{,}160\frac{\text{рад}}{c}$

Thus, the quality of the MS SGU vision systems defined vibrational PIM process, which placed work equipment and estimated change in generalized coordinates vertical displacement - Z (t), longitudinal oscillations - φ(T) and transverse vibrations - θ(T).

In accordance with the requirements imposed on vision systems, mounted on PIM demands are to:

– amplitude - $z \le 0{,}040м$ and speed - $\dot{z} \le 0{,}100м/с$ vertical displacement;

– amplitude - $\varphi \le 0{,}05$ and speed - $\dot{\varphi} \le 0{,}03рад/с$ longitudinal oscillations;

– amplitude - $\Theta \le 0{,}06$ and speed - $\dot{\Theta} \le 0{,}05рад/с$ transverse vibrations.

Theoretical studies almost found that deviations from these requirements affects the quality monitoring, the reliability of the data and complicates interpretation of images.

The main parameter that determines the fluctuations of the center of mass of the chassis is the magnitude of stiffness and damping of tires wheels and suspension suspension systems. Research conducted at steady-state oscillation motion PIM different speeds.

During the research it was found that a suspension spring stiffness $C \ge 15000\frac{H}{м}$ and damping $\alpha \ge 274\frac{H \cdot c}{м}$ - Not ameliorate inequalities sufficiently and spring stiffness less $C \le 5000\frac{H}{м}$ and damping $\alpha \le 75\frac{H \cdot c}{м}$ - Lead to excessive oscillatory processes (soft suspension).

Meet the eligibility criteria to fluctuations in the field of information machine when driving on ahrofonam (Class 1, Class 2, Class 3) in a range of speeds $V = 2{,}0м/м$ to $V = 4{,}0м/с$ responsible suspension type 2 of the following values of design parameters: $C = 10000\frac{H}{м}$, $\mu = 154\frac{H \cdot c}{м}$.

Conclusion. Based on the studies found that fluctuations in vision systems placed on PIM can be reduced by the structural parameters (under agro-technical requirements $a = 0{,}60м$, $b = 0{,}40м$), Elastic suspension and damper elements Machine ($C = 10000\frac{H}{м}$, $\mu = 154\frac{H \cdot c}{м}$). Using mathematical modeling can reduce the number of experimental studies to find optimal parameters suspension PIM to stabilize vision systems into compliance.

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In Article Present methods of modeling fluctuations polevoy Informational mashiny with systemoy tehnycheskoho of view in motion by nerovnostyam surface field. Installed the degree of influence konstruktyvnыh parameters, elastic and dempfernыh elements podvesky polevoy Informational mashiny on Stabilization system tehnycheskoho In accordance of view requirements.

Tochnoe zemledelye, fluctuations Machines, system tehnycheskoho of view, zhestkost podvesky.

In paper resulted method of design of vibrations of field informative machine with system of technical sight at motion to inequalities of surface of field. The degree of influencing of structural parameters is set, resilient and damper elements of pendant of field informative machine on stabilization of system of technical sight in accordance to requirements.

Exact agriculture, oscillation of machine, system of technical sight, inflexibility of pendant.

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Experimental determination of specific power STIRRING IN BIOMASS rotating REACTOR

GA Holub, PhD
OV Dubrovin, V. Chub, MY Pavlenko, engineers

Powered experimental curves to determine the specific energy of mixing biomass in a rotating reactor.

The reactor, biomass, biogas, mixing power.

Problem. Improving the energy efficiency of biogas plants is one of the main areas of improvement process biogas as well as study methods for determining the specific power and energy parameters of operation of