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(54) **Target pointing system**

Zielanvisierungssystem

Système de visée d'une cible

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Description

[0001] The present invention concerns a target pointing system.

[0002] In particular, the present invention concerns a pointing system installed onboard a terrestrial vehicle, corresponding, for example, to a tank or similar vehicle, and is configured for conveniently aiding an operator in the operation of aiming at a target, making the tracking operation easier when the vehicle and the target are both in movement.

[0003] More in detail, the present invention concerns a pointing system of the type comprising an optical pointing device, which in turn is equipped with an optical reflection unit movably mounted on the terrestrial vehicle so that it can move on two orthogonal axes (typically indicated as the "azimuth axis" and the "elevation axis"), an optical sensor (for example, a telecamera) mounted on the vehicle so as to cooperate with the optical unit in order to acquire the images reflected by the latter, a moving device for the optical unit and an automatic optics control system able to pilot the moving device so as to adjust the positions of the optical unit on the azimuth and/or elevation axes during the course of acquiring images.

[0004] The pointing system also comprises a display able to show the operator/gunner the images acquired by the optical sensor and a graphical pointer, typically represented by crosshairs superimposed on the images, which defines both an "optical pointing reference" regarding the position assumed by the optical unit on the azimuth and elevation axes, and a "firing reference" indicating a quantity correlated to the assumed position of the target and therefore utilizable by an weapon system possibly installed on the terrestrial vehicle for determining the line of fire with which to operate the weapon in order to hit the aimed-at target.

[0005] The pointing system also comprises a joystick that can be manually controlled by the operator on two mutually orthogonal control axes, and is configured to provide the automatic control system with control quantities correlated to the displacement of the joystick lever on the two control axes.

[0006] In particular, the automatic control system processes the control quantities in order to control the displacement of the optical unit on the azimuth axis and on the elevation axis in response to the displacement of the joystick lever on the first and second control axes respectively.

[0007] In known pointing systems of the above-described type, the optical unit comprises a mirror that has an optical pointing axis arranged perpendicular to the flat surface of the mirror itself and is movably mounted on the vehicle such that it is possible to move the optical pointing axis on the azimuth axis, and/or on the elevation axis. Regarding the moving unit, this comprises electric motors connected to the optical mirror via motion transmission members to enable moving of the mirror on the azimuth and elevation axes.

[0008] With regards to the automatic control system, this comprises an adjustment module, which is configured to stabilize the orientation of the mirror's optical axis, making it independent of the vehicle's angles of orientation measured with respect to the azimuth and elevation axes assumed by the vehicle itself during its movement.

[0009] In the case in point, the adjustment module comprises a gyroscopic device firmly fixed to the tank that receives a precession control angle in input indicating the position to make the precession axis of the gyroscope assume and is able to provide an output signal proportional to the relative angular speed between the gyroscope's precession axis and the mirror's optical pointing axis. In other words, the adjustment module is configured to cancel the relative angular speed between the precession axis of the gyroscopic device's rotor and the mirror's optical pointing axis by means of a feedback system. The optical pointing axis of the mirror therefore tends to assume an angular position that will differ from the precession axis by a constant angle over time, i.e. they will tend to coincide, except for an offset.

[0010] The automatic control system also comprises an electronic controller, which is configured to receive the control quantities generated by the joystick in input, these corresponding to the angular speeds of displacement of the joystick along the two control axes, and to carry out an integration calculation on them in order to generate a command containing the angle that the precession axis of the gyroscopic device's rotor must be made to assume.

[0011] The above-mentioned pointing system is very efficient because the response of the commands issued by the automatic control system to the optical unit based on the speed command generated by joystick, apart from being extremely rapid, exhibits high sensitivity to the manual action exerted by the operator on the joystick lever.

[0012] However, if on one hand the sensitivity and rapidity of response of the control is extremely useful to the operator in the initial phase of approach and positioning the pointer on the target, a condition hereafter indicated as the re-phasing operative condition, on the other it has been shown to be not entirely efficient when the operator, after positioning the pointer on the target, must keep the pointer locked on the target in movement, this latter condition indicated as the tracking operative condition.

[0013] In fact, in the tracking operative condition, the joystick lever is subjected to accidental movements caused by the shaking produced by the tank while on the move. In this condition, the operator is consequently obliged to manually compensate movements induced on the joystick lever in order to maintain target tracking, this last condition being extremely difficult when the target to follow has a steady angular motion.

[0014] This difficulty manifests itself as a state of tension for the operator that, as times passes, causes an involuntary increase in imprecision in target pointing.

[0015] The object of the present invention is therefore that of embodying a pointing system that is capable of facilitating the operator in maintaining correct aiming on a mobile target.

[0016] According to the present invention, a system is made to facilitate aiming at a target, as provided for in claim 1 and preferably, but not necessarily, in any of the claims directly or indirectly dependent on claim 1.

[0017] According to the present invention, a tank is made, as provided for in claim 11.

[0018] The present invention shall now be described with reference to the enclosed drawings, which show a non-limitative example of embodiment, where:

- Figure 1 schematically shows a terrestrial vehicle equipped with a target pointing system made according to the principles of the present invention,
- Figure 2 shows a block diagram of the pointing system installed on the terrestrial vehicle shown in Figure 1,
- Figure 3 is the block diagram of a pointing aid module of the pointing system shown in Figure 2,
- Figure 4 is a flow chart of the operation of the pointing aid module shown in Figure 3, while
- Figure 5 shows the flow chart of the calculation algorithm implemented by the pointing aid module shown in Figure 3.

[0019] With reference to Figure 1, reference numeral 1 indicates, in its entirety, a terrestrial vehicle comprising a pointing system 2 configured to facilitate an operator in aiming at a target when the vehicle 1 and/or the target are in movement.

[0020] In the example shown in Figure 1, the terrestrial vehicle 1 is a tank, which comprises a hull 3, extending along a longitudinal axis A and structured to allow the accommodation of operators/gunners, and a weapon system 4, which is mounted on top of the hull 3 and in turn comprises a rotating turret 5, which extends upwards from the hull 2 along an axis B orthogonal to the longitudinal axis A for turning around the same axis B, and a weapon 6, in particular, a cannon positioned on the rotating turret 5.

[0021] The weapon system 4 is of known type and will not be further described, other than specifying that it comprises a moving unit 7 able, upon command, to turn the rotating turret 5 around axis B and/or move the weapon 6 around one or more axes of rotation (not shown), and a weapon control system (not shown) configured to calculate the line of fire to give the weapon 6 and the moment of firing based on a first reference quantity associated with the pointing position established by the pointing system 2, and to pilot the moving unit 7 based on the calculated line of fire.

[0022] With regards to the pointing system 2, this comprises an optical pointing device 8, which in turn is provided with an optical reflection unit 9 movably mounted on the vehicle 1, and an optoelectronic sensor 10, preferably, but not necessarily, comprising a telecamera mounted on the vehicle 1 near to the optical reflection unit 9 so that it acquire the images reflected by the optical reflection unit 9.

[0023] In particular, with reference to Figures 1 and 2, the optical reflection unit 9 comprises a mirror, which has an optical pointing axis C that extends orthogonally from the reflective surface of the mirror and is movably mounted on the turret 5 of the vehicle 1 so as to move the optical pointing axis C along an azimuth axis Ox. In particular, in the example shown in Figure 1, the azimuth axis Ox lies on a plane that is substantially horizontal and is parallel to the longitudinal axis A and orthogonal to axis B, while the mirror of the optical reflection unit 9 is movably mounted on the vehicle 1 so as to keep the optical pointing axis C on the same horizontal plane.

[0024] The mirror of the optical reflection unit 9 is also movably mounted such that the optical pointing axis C can be moved along an elevation axis Oy, which is substantially orthogonal to the azimuth axis Ox. In particular, the elevation axis Oy lies on a substantially vertical plane, while the mirror of the optical reflection unit 9 is movably mounted on the vehicle 1 to keep the optical pointing axis C on the same vertical plane.

[0025] The optical pointing device 8 also comprises a moving device 11 for the optical reflection unit 9 and an automatic optics control system 12, which is configured to pilot the moving device 11 in order to adjust the positions of the optical reflection unit 9 along axis Ox and/or axis Oy during pointing.

[0026] In this case, in the example shown in Figure 2, the moving device 11 comprises electric motors and/or electromechanical actuators 13 that are connected to the mirror of the optical reflection unit 9 via known systems of motion transmission (not shown) for moving the mirror so as to cause the traverse of the optical pointing axis C along axes Ox and Oy.

[0027] With reference to Figures 1 and 2, the pointing system 2 also comprises a display 14 located inside the crew compartment built in the hull 2 and able to display the images acquired by the optoelectronic sensor 10 to the operator/gunner.

[0028] The display 14 is also able to display a graphical pointer 30 (shown in Figure 2) for the operator, preferably, but not necessarily, represented by crosshairs superimposed on the images, which defines both an "optical pointing reference" (i.e. associated with the angular position assumed by the optical pointing axis C with respect to axes Ox and Oy) and the first reference quantity to supply to the weapon system 4 for calculating the line of fire.

[0029] The pointing system 2 also comprises a manual user control, preferably a joystick 15, which can be manually controlled by the operator in two mutually orthogonal control axes, and is configured to provide the automatic control

system 12 with control quantities correlated to the displacement of the joystick lever on the same two control axes.

[0030] In particular, with reference to Figures 2 and 3, the joystick 15 is equipped with a control lever that can be operated by a user on a first axis X associated with a displacement command of the optical pointing axis C along axis Ox, and a second axis Y orthogonal to axis X and associated with a displacement command of the optical pointing axis C along axis Oy.

[0031] In this case, the joystick 15 is configured to generate quantities $X(t_n)$, $Y(t_n)$ indicating the angular position assumed by the control lever of the joystick 15 at nth time t_n along the first axis X and/or the second axis Y respectively.

[0032] With reference to Figure 2, the automatic control system 12 comprises an adjustment module 16, which is configured to stabilize the orientation of the mirror's optical pointing axis C, rendering it independent of the vehicle's angles of orientation 1 measured with respect to the azimuth and elevation axes assumed by the vehicle 1 itself when in movement.

[0033] In this case, in the example shown, the adjustment module 16 comprises a gyroscopic device 18 firmly fixed to the vehicle 1, which receives a precession command ω_p in input indicating the angular speed that must be given to the precession axis (not shown) of the gyroscopic device 18 and is able to provide an output signal containing the angular speed ω_E existing between the precession axis of the gyroscopic device 18 and the optical pointing axis C of the mirror.

[0034] The adjustment module 16 is of known type and will not be further described, other than specifying that it is configured to cancel the angular speed ω_E existing between the precession axis of the rotor (not shown) of the gyroscopic device 18 and the optical pointing axis C of the mirror by means of a feedback control chain 19.

[0035] The automatic control system 12 also comprises an electronic controller 21, which is configured to receive a command in input containing saturated angular speeds $V_s(t_n) = (V_{sx}(t_n); V_{sy}(t_n))$ and carry out a known (and therefore not described in detail) integration calculation on them, in order to generate the precession command ω_p to apply to the precession axis of the rotor of the gyroscopic device 18 so as to cause movement of the mirror of the optical reflection unit 9.

[0036] In this case, the saturated angular speeds $V_s(t_n) = (V_{sx}(t_n); V_{sy}(t_n))$ are associated with the angular displacement of the joystick 15 along axes X and Y and are processed by the electronic controller 21 to define a precession command ω_{Px} , based on which the adjustment module 16 provides for activating, in a known manner, the moving of the mirror along the azimuth axis Ox, and/or a precession command ω_{Py} , based on which the adjustment module 16 provides for activating, in a known manner, the moving of the mirror along the elevation axis Oy.

[0037] Unlike known pointing systems, the automatic control system 12 of the pointing system 2 comprises a pointing aid module 22, which is configured to receive as input the quantities $X(t_n)$, $Y(t_n)$ indicating the angular position assumed by the joystick lever 15 and to filter them, according to a calculation algorithm described in detail further on, so as to provide the control quantities containing the angular speeds $V_s(t_n) = (V_{sx}(t_n); V_{sy}(t_n))$ in input to the electronic controller 21.

[0038] In particular, the pointing aid module 22 is configured to implement a first adaptive filtering of the quantities $X(t_n)$, $Y(t_n)$ regarding the angular position assumed by the control lever of the joystick 15, so as to assign a value to the angular speeds $V_s(t_n) = (V_{sx}(t_n); V_{sy}(t_n))$ proportional to the manual displacement speed applied to the control lever of the joystick 15 when the system 2 is in a re-phasing operative condition.

[0039] The pointing aid module 22 is also configured to implement a second adaptive filtering of the quantities $X(t_n)$, $Y(t_n)$ regarding the angular position assumed by the joystick lever 15, so as to assign a value to the angular speeds $V_s(t_n) = (V_{sx}(t_n); V_{sy}(t_n))$ proportional to the acceleration of the manual displacement applied to the joystick lever 15 when the pointing system 2 is in a tracking operative condition.

[0040] With reference to the example shown in Figure 3, the pointing aid module 22 comprises an adaptive filter 23 and is configured to modify the transfer function of the adaptive filter 23 on the basis of the re-phasing or tracking operative condition in course on the pointing system 2.

[0041] The adaptive filter 23 receives the time t_n and the position $X(t_n)$ and $Y(t_n)$ of joystick 15 in input and provides a filtered angular speed command $V(t_n) = (V_x(t_n), V_y(t_n))$ in output.

[0042] The pointing aid module 22 also comprises a compensator module 24 that receives the filtered angular speed command $V(t_n) = (V_x(t_n), V_y(t_n))$ in input and provides the saturated angular speed command $V_s(t_n)$ in output, for supply to the electronic controller 21.

[0043] The adaptive filter 23 is a digital filter configured to modify the coefficients that characterize the transfer function according to a first or, alternatively, a second filter configuration.

In this case, when the pointing aid module 22 detects the re-phasing operative condition, the adaptive filter 23 assumes a first filter configuration in which the filter's transfer function is a one-pole first order function. Instead, when the pointing aid module 22 detects the tracking operative condition, the adaptive filter 23 assumes a second filter configuration, in which the filter's transfer function is a two-pole second order function.

[0044] In particular, with reference to the example shown in Figure 3, the adaptive filter 23 assumes the first filter configuration schematized by block 25 or, alternatively, the second filter configuration schematized by block 26.

[0045] From that described above, it should be specified that the pointing system 2 provides for controlling the two quantities $Ox(t_n)$ and $Oy(t_n)$ associated with the angular position of the optical pointing axis C along axes Ox and Oy on the basis of the two control quantities $X(t_n)$ and $Y(t_n)$ indicating the position of the joystick lever 15 along axes X and Y

at time t_n .

[0046] In particular, in the first filter configuration, the digital adaptive filter 23 assumes the function (block 25):

$$a1) \quad Vx(t_n) = (1 - \alpha_x) \cdot Vsx(t_{n-1}) + \alpha_x \cdot X(t_n)$$

$$a2) \quad Vy(t_n) = (1 - \alpha_y) \cdot Vsy(t_{n-1}) + \alpha_y \cdot Y(t_n)$$

where $X(t_n)$ and $Y(t_n)$ correspond to the positions of the control lever of the joystick 15 along axis X and axis Y respectively at sampling time t_n ; $Vx(t_n)$ and $Vy(t_n)$ correspond to the filtered angular speeds, namely those provided in output from the adaptive filter 23 at sampling time t_n , and α_x is the coefficient of the first-order filter's transfer function associated with quantity $X(t_n)$ in the first configuration, while α_y is a coefficient of the first-order filter associated with quantity $Y(t_n)$ in the first configuration.

[0047] In the second filter configuration, the adaptive filter 23 calculates the angular speeds $Vx(t_n)$ and $Vy(t_n)$ filtered by means of the following functions (block 26):

$$b1) \quad Ox(t_n) = \alpha_x \cdot X(t_n)$$

$$b2) \quad Oy(t_n) = \alpha_y \cdot Y(t_n)$$

where $Ox(t_n)$ and $Oy(t_n)$ correspond to the angular displacements of the optical pointing axis C at time t_n ,

$$c1) \quad Vfx(t_n) = Vfx(t_{n-1}) + (\beta_x/T) \cdot X(t_n)$$

$$c2) \quad Vfy(t_n) = Vfy(t_{n-1}) + (\beta_y/T) \cdot Y(t_n)$$

where α_y , β_x , α_x and β_y are coefficients of the filter in the second configuration, T is the quantity sampling interval, and $Vfx(t_n)$ and $Vfy(t_n)$ correspond to the non-saturated filtered angular speeds at time (t_n) ,

$$d1) \quad Oxp_{n+1/n} = Ox(t_n) + Vfx(t_n) \cdot T$$

$$d2) \quad Oyp_{n+1/n} = Oy(t_n) + Vfy(t_n) \cdot T$$

where $Oxp_{n+1/n}$ and $Oyp_{n+1/n}$ correspond to the angular displacements of the optical pointing axis C, transversally and in elevation, at time (t_{n+1}) , but estimated at previous time t_n , and

$$e1) \quad Vx(t_n) = Oxp_{n+1/n} / T$$

$$e2) \quad Vy(t_n) = Oyp_{n+1/n} / T$$

[0048] Regarding the compensator module 24, this is configured to compare the filtered speeds $Vx(t_n)$ and $Vy(t_n)$ with a predetermined maximum angular speed threshold V_{MAX} .

[0049] In the case where the absolute value of one of the two filtered angular speeds $Vx(t_n)$ and $Vy(t_n)$ is greater than the predetermined maximum angular speed threshold V_{MAX} , the compensator module 24 determines a speed saturation condition and assigns the same absolute value of the predetermined maximum angular speed V_{MAX} to the module, at the same time maintaining the sign of the non-saturated quantity.

[0050] Instead, if the absolute value of the filtered angular speeds $Vx(t_n)$ and $Vy(t_n)$ is less than or equal to the predetermined maximum angular speed threshold V_{MAX} , the compensator module 24 determines a "non saturation" condition for the speed and assigns the corresponding angular speeds $Vx(t_n)$ and $Vy(t_n)$, obtained in output from the adaptive filter 23, to the speed command $Vsx(t_n)$, $Vsy(t_n)$.

[0051] With reference to Figure 4, the operations implemented by the pointing aid module 22 while the operator is aiming at a target will now be described in detail.

[0052] It is assumed that in the re-phasing condition, the pointing aid module 22 assigns a first logical value, equal to 0 for example, to a filter status variable indicated as "Filter Status", whilst in the tracking condition, the pointing aid module 22 assigns a second logical value, equal to 1 for example, to FilterStatus.

[0053] It is also assumed that at sampling time $t = t_n$, the adaptive filter 23 receives as input the position of the joystick $X(t_n) = JoyX$, $Y(t_n) = JoyY$ imposed by the operator and a saturated speed command $V_s(t_{n-1}) = (V_{sx}(t_{n-1}), V_{sy}(t_{n-1}))$ calculated by the compensator module 24 following filtering carried out at time t_{n-1} , prior to the current time t_n .

[0054] It should be specified that the pointing aid module 22 can preferably, but not necessarily, carry out auxiliary processing on the joystick position commands $X(t_n) = JoyX$, $Y(t_n) = JoyY$ to modify the response sensitivity of the pointing system 2 to the moving of the control lever of the joystick 15, on the basis of the current operative condition.

[0055] To this end, the pointing system can preferably, but not necessarily, envisage that in one of the operative conditions, in the tracking operative condition for example, the position quantities generated by the joystick 15 are processed in the following manner (block 99):

$$X(t_n) = JoyX_{ris} = JoyX * K_{joyX}$$

$$Y(t_n) = JoyY_{ris} = JoyY * K_{joyY}$$

where K_{joyX} and K_{joyY} are predetermined constants and can conveniently take a constant value equal, for example, to approximately 0.05.

[0056] The pointing aid module 22 receives as input the saturated speed $V_{sx}(t_{n-1})$, hereafter indicated as Ω_{p1X} , the saturated speed $v_{sy}(t_{n-1})$, hereafter indicated as Ω_{p1Y} , and the FilterStatus variable and determines whether or not a change in the operative condition is in course on the basis of these parameters.

[0057] In particular, if variable FilterStatus = 1 (exit 100a from block 100), the pointing aid module 22 checks if the system was operating in the tracking operative phase at the previous sampling time t_{n-1} . In this case, the pointing aid module 22 compares the Ω_{p1X} and Ω_{p1Y} speeds related to the saturated speeds in the previous tracking operative phase, with a first predetermined speed threshold $SogliaAccVel$ (block 110).

[0058] If the absolute values of both speeds Ω_{p1X} and Ω_{p1Y} are less than the first predetermined speed threshold $SogliaAccVel$ (NO exit from block 110), the pointing aid module 22 confirms the state of preserving the tracking operative phase. In this case, the pointing aid module 22 keeps the second filter configuration of the two-pole filter (block 120) existing at previous time t_{n-1} unchanged.

[0059] Instead, if the absolute value of at least one of the speeds Ω_{p1X} or Ω_{p1Y} regarding tracking is greater than the first predetermined speed threshold $SogliaAccVel$ (YES exit from block 110), the pointing aid module 22 orders the changeover from the tracking operative condition to the re-phasing operative condition.

[0060] In this last case, the pointing aid module 22 changes the FilterStatus variable, setting it to 0, sets the first configuration for implementation on the adaptive filter (block 120) and carries out smoothing on the coefficients of the same adaptive filter (block 130). Coefficient smoothing provides for gradually modifying the filter's coefficients during the passage from the second to the first configuration of the filter, so that achieving the operating value to assign to each

alpha and beta coefficient in the first configuration takes place through a predetermined asymptotic trend with a rise time dependent on the band assigned to the filter itself.

[0061] In particular, the change of configuration (block 120) envisages that the pointing aid module 22 calculates the final values of the coefficients α_x , α_y and β_x , β_y , henceforth respectively indicated as AlfaX, AlfaY, BetaX and BetaY, so as to assign the first configuration to the filter in the following manner: AlfaX=AlfaVeloX, AlfaY=AlfaVeloY and BetaX = 0, BetaY = 0, where AlfaVeloX and AlfaVeloY are predetermined values that will be described in detail further on.

[0062] Instead, the smoothing phase carried out by the pointing aid module 22 (block 130) envisages that the change of configuration of the two-pole filter associated with the tracking condition and having the coefficients AlfaX=AlfaAcceX, AlfaY=AlfaAcceY and BetaX=BetaAcceX, BetaY = BetaAcceY, to the one-pole filter associated with the re-phasing condition and having the coefficients AlfaX=AlfaVeloX, AlfaY=AlfaVeloY and BetaX=0, BetaY=0, takes place so as to gradually modify the filter's band.

[0063] In particular, in the smoothing phase, the pointing aid module 22 envisages modifying the coefficients AlfaX=AlfaAcceX, AlfaY=AlfaAcceY such that they asymptotically reach the coefficients AlfaX=AlfaVeloX, AlfaY=AlfaVeloY and, at the same time, modifies the coefficients BetaX=BetaAcceX, BetaY=BetaAcceY such that they asymptotically reach the null value.

[0064] At the end of the smoothing phase, completion of the first configuration of the adaptive filter 23 has taken place and the pointing aid module 22 carries out filtering on the position of the joystick $X(t_n) = JoyX$, $Y(t_n) = JoyY$ controlled by the operator and the speed command Omega_p1X, Omega_p1Y, and generates the speed commands $V_x(t_n)$, $V_y(t_n)$ in output, henceforth respectively indicated as OmegaX and OmegaY.

[0065] If variable FilterStatus = 0 in the initial phase (exit 100b from block 100), then the compensator module 24 determines that the pointing system was in the re-phasing operative condition at previous time t_{n-1} .

[0066] At this point, the pointing aid module 22 compares the absolute value of the speeds Omega_p1X, Omega_p1Y associated with the re-phasing operative phase with a second predetermined speed threshold SogliaVelAcc (block 160).

[0067] From that described above, it should be specified that the first SogliaAccVel and the second SogliaVelAcc predetermined speed thresholds have different values from each other to guarantee hysteresis in the comparison of the parameters so as to conveniently cancel possible instability conditions in the pointing aid module.

[0068] If the absolute value of at least one of the speeds Omega_p1X, Omega_p1Y is greater than the second predetermined speed threshold SogliaVelAcc (NO exit from block 160), the pointing aid module 22 decides to keep the previous re-phasing operative phase and keeps the first configuration of the one-pole filter present at previous time t_{n-1} (block 120) substantially unchanged.

[0069] Instead, if the absolute values of both speeds Omega_p1X and Omega_p1Y regarding the tracking are less than the second predetermined speed threshold SogliaVelAcc (YES exit from block 160), the pointing aid module 22 operates the changeover from the re-phasing operative phase to the tracking operative phase.

[0070] In this last case, the pointing aid module 22 modifies the variable FilterStatus = 1, sets the second configuration for implementation on the adaptive filter 23 (block 170) and carries out smoothing on the coefficients of the same adaptive filter (block 180), which provides for gradually modifying the coefficients of the filter during the passage from the first to the second configuration of the filter, so that achieving the operating value of each coefficient of the second configuration takes place in an asymptotic manner with a rise time dependent on the band assigned to the filter itself.

[0071] In particular, the configuration change (block 170) envisages that the pointing aid module 22 calculates the final values of the coefficients AlfaX, AlfaY and BetaX, BetaY to assign to the filter in the first configuration in the following manner: AlfaX = AlfaAcceX, AlfaY = AlfaAcceY and BetaX = BetaAcceX, BetaY = BetaAcceY, where AlfaAcceX, AlfaAcceY, BetaAcceX and BetaAcceY are predetermined values.

[0072] Instead, the smoothing phase carried out by the pointing aid module 22 (block 180) envisages that the change of configuration of the one-pole filter associated with the re-phasing condition and having the coefficients AlfaX = AlfaVeloX, AlfaY = AlfaVeloY and BetaX = 0, BetaY = 0, to the two-pole filter associated with the tracking condition and having the coefficients AlfaX = AlfaAcceX, AlfaY = AlfaAcceY and BetaX = BetaAcceX, BetaY = BetaAcceY, takes place so as to gradually modify the filter's band.

[0073] In particular, in the smoothing phase, the pointing aid module 22 modifies the coefficients AlfaX = AlfaVeloX, AlfaY = AlfaVeloY such that they asymptotically reach the coefficients AlfaX = AlfaAcceX, AlfaY = AlfaAcceY and, at the same time, modifies the coefficients BetaX = 0, BetaY = 0 such that they asymptotically reach the predetermined values BetaX = BetaAcceX, BetaY = BetaAcceY.

[0074] At the end of the smoothing phase, completion of the second configuration of the adaptive filter 23 has taken place: in this phase, the pointing aid module 22 carries out filtering on the position of the joystick $X(t_n) = JoyX$, $Y(t_n) = JoyY$ chosen by the operator and the speeds Omega_p1X and Omega_p1Y, and generates the speed commands OmegaX and OmegaY in output (block 190).

[0075] From that described above, it is therefore evident that if the current operative condition corresponds to the re-phasing operative condition, the pointing aid module 22 provides the compensator module 24 with the speeds OmegaX

and OmegaY generated by the adaptive filter 2e using the first configuration (block 140), whilst failing this, namely if the current operative condition corresponds to the tracking operative condition, the pointing aid module 22 provides the compensator module 24 with the speed command OmegaX and OmegaY generated by the adaptive filter 23 using the second configuration.

[0076] The speeds OmegaX and OmegaY are then supplied in input to the compensator module 23, which compares these same speeds OmegaX and OmegaY with the predetermined maximum angular speed threshold V_{MAX} .

[0077] The compensator module 23 then generates the saturated speed $V_{sx}(t_n)$ $V_{sy}(t-n)$ on the basis of the above-indicated comparison and supplies it to the electronic controller 16.

[0078] At this point, the electronic controller 16 outputs precession command ω_p , while the adjustment module 16 pilots the moving device 11 to cause displacement of the mirror of the optical reflection unit 9 as a function of the angle δ_{Px} and angle δ_{Py} .

[0079] With reference to Figure 5, the operations and/or calculation relations implemented by the pointing aid module 22 in the course of controlling the above-described filtering shall now be described in greater detail. It should be specified that the adaptive filter 23 could be defined by a calculation algorithm implemented by a DSP microprocessor and comprising a series of operations described in detail in the following.

[0080] To this end, it is first of all necessary to define the variables involved in the calculation algorithm.

[0081] In particular, the calculation algorithm provides for the processing of a series of first variables, which are associated with the transition of the pointing system from the re-phasing operative condition to the tracking operative condition and vice versa.

[0082] Second variables are instead associated with quantities regarding the transversal displacement of the optical pointing axis C along axis O_x in response to a manual displacement of the control lever of the joystick 15 along axis X.

[0083] Third variables are instead associated with quantities regarding the elevation displacement of the optical pointing axis C along axis O_y in response to a manual displacement of the control lever of the joystick along axis Y.

[0084] More in detail, the first variables include a variable AlfaVelAcc associated with the temporary alpha coefficient of the filter that can be used in the above-described smoothing phase in the case of transition from the re-phasing condition to the tracking condition. In the example shown, the algorithm assigns a constant value of approximately 0.12 to the variable AlfaVelAcc. It should be specified that configuring the adaptive filter 23 with the variable AlfaVelAcc conveniently gives a correlation time T_c for the adaptive filter 23 of approximately 1 second.

[0085] The first variables also include a coefficient AlfaAccVel associated with the temporary alpha coefficient of the adaptive filter 23 that can be used in the above-described smoothing phase in the case of transition from the tracking condition to the re-phasing condition.

[0086] In the example shown, the algorithm assigns a constant value of approximately 0.2 to the variable AlfaAccVel. It should be specified that configuring the adaptive filter 23 with the variable AlfaAccVel=0.2 conveniently gives a correlation time T_c for the adaptive digital filter 24 of approximately 0.55 seconds.

[0087] The first variables also include the predetermined speed threshold SogliaVelAcc that, as previously stated, is associated with the transition from the re-phasing condition to the tracking condition. In the example shown, the calculation algorithm assigns a value of approximately 10 mrad/sec (0.573 deg/sec) to the variable SogliaVelAcc.

[0088] The first variables also include the predetermined speed threshold SogliaAccVel that, as previously stated, is associated with the transition from the tracking condition to the re-phasing condition. In the example shown, the calculation algorithm assigns a value of approximately 14 mrad/sec (0.8 deg/sec) to the variable SogliaAccVel.

[0089] From that described above, it should be specified that the values assigned to the variables AlfaVelAcc and AlfaAccVel are calculated to manage the smoothing gradually during the configuration changeover of the adaptive filter 23.

[0090] Regarding the second variables, these include the variable AlfaVeloX, containing the value to assign to the alpha parameter of the adaptive filter 23 in conditions of completion of the first configuration associated with the re-phasing operative phase.

[0091] In the example shown in Figure 5, the calculation algorithm assigns variable AlfaVeloX with the unitary value AlfaVeloX=1 that, when operating regularly, corresponds to an unfiltered condition for the signal arriving from the joystick. It should be specified that in this particular configuration, filtering is delegated to the interlocking that controls the moving of the optical mirror. Therefore, the correlation time when operating regularly in the re-phasing phase is equal to zero, i.e. the condition $T_c = 0$ seconds is applicable.

[0092] Regarding the adaptive filter in the tracking phase 23, this corresponds to an alpha-beta type filter, in which the coefficients are identified by the second variables AlfaAccX and BetaAccX. In the example shown, the calculation algorithm assigns the value 0.1 to variable AlfaAccX and BetaAccX = 0.0005, which results in a correlation time $T_c=0.8$ seconds in the alpha-beta filter.

[0093] Regarding the third variables, these include AlfaVeloY, indicating the value to assign to the alpha parameter of the adaptive filter 23 in conditions of completion of the first configuration associated with the re-phasing operative phase. In the example shown, the calculation algorithm assigns a value of 1 to variable AlfaVeloY.

[0094] Regarding the adaptive filter in the tracking phase 23, this corresponds to an alpha-beta type filter, in which

the coefficients are identified by the third variables AlfaAccY and BetaAccY. In the example shown, the calculation algorithm assigns the value 0.1 to variable AlfaAccY and BetaAccY = 0.0005, which results in a correlation time $T_c=0.8$ seconds in the alpha-beta filter.

[0095] During filtering, the pointing aid module 22 also provides for processing the following variables: JoyX and JoyY that (as described above) are associated with the position of the control lever of the joystick 15 along axes X and Y respectively, OmegaX and OmegaY that (as described above) correspond to the filtered transversal speeds along axis X and in elevation along axis Y, and the variable FilterStatus to which the value 0 is assigned in the re-phasing condition and 1 in the tracking condition.

[0096] Upon reaching a condition of regular re-phasing operation, the calculation algorithm configures the coefficients AlfaX, AlfaY, BetaX and BetaY of the adaptive filter 23 in the following manner: AlfaX=AlfaVeloX, BetaX= 0, AlfaY=AlfaVeloY, BetaY=0.

[0097] The calculation algorithm also configures the following variables associated with the coefficients of the adaptive filter 23 at time t_{n-1} : AlfaFil_p1X=AlfaVeloX, BetaFil_p1X=0, AlfaFil_p1Y=AlfaVeloY, BetaFil_p1Y=0.

[0098] The calculation algorithm also configures the following variables associated with the speeds: OmegaX_p1=0 corresponding to the saturated angular speed set for the electronic controller 12 during displacement of the optical pointing axis C along axis O_x at time t_{n-1} preceding the current time t_n and OmegaXfil_p1=0 corresponding to the angular speed estimated by the adaptive filter 23 at time t_{n-1} preceding current time t_n , OmegaY_p1=0 corresponding to the saturated angular speed set for the electronic controller 21 during displacement of the optical pointing axis C along axis O_y at time t_{n-1} preceding current time t_n and OmegaYfil_p1=0 corresponding to the angular speed estimated by the adaptive filter 23 in the second configuration, calculated at time t_{n-1} preceding current time t_n .

[0099] With reference to Figure 5, the pointing aid module 22 implements a first calculation operation (block 300) on the scaled position commands of the joystick's control lever used in the tracking condition:

$$\text{JoyXris} = \text{JoyX} * K_{\text{joyX}}$$

$$\text{JoyYris} = \text{JoyY} * K_{\text{joyY}}$$

[0100] At this point, the pointing aid module 22 selects the operative phase in course.

[0101] If it is found that (block 310):

Status FilterStatus=1 (YES exit from block 310) (corresponding to the tracking condition), then if one of the following conditions is applicable (YES exit from block 320):

$|\text{Omega_p1X}| > \text{SogliaAccVel}$ or

$|\text{Omega_p1Y}| > \text{SogliaAccVel}$, then (YES exit from block 320) assign FilterStatus = 0 and request changeover to the re-phasing condition; in this case, the following assignments are made: AlfaX=AlfaVeloX, BetaX=0, AlfaY=AlfaVeloY, BetaY=0 (block 360).

Instead, if the following condition is found: $|\text{Omega_p1X}| < \text{SogliaVelAcc}$ and $|\text{Omega_p1Y}| < \text{SogliaVelAcc}$ (YES exit from block 360):

then assign FilterStatus=1 (i.e. the new phase is tracking) and the following assignments are made:

AlfaX=AlfaAcceX, BetaX=BetaAcceX,

AlfaY=AlfaAcceY, BetaY=BetaAcceY (block 330).

[0102] At this point, the operating configuration of the adaptive filter 23 is completed and the smoothing operation is started, which gradually modifies the configuration of the adaptive filter 23 so as to achieve the operating configuration provided for in the previous phase.

[0103] In particular, the operations implemented by the pointing aid module 22 during smoothing are as follows:

If FilterStatus=1, i.e. if passage of the tracking condition to the re-phasing condition takes place (block 370), then it is preferable to implement the following relations (block 380) :

$$\text{AlfaFilX} = (1 - \text{AlfaAccVel}) * \text{AlfaFilX_p1} + \text{AlfaAccVel} * \text{AlfaX}$$

$$\text{BetaFilX} = (1 - \text{AlfaAccVel}) * \text{BetaFilX_p1} + \text{AlfaAccVel} * \text{BetaX}$$

$AlfaFilY = (1 - AlfaAccVel) * AlfaFilY_p1 + AlfaAccVel * AlfaY$

5 $BetaFilY = (1 - AlfaAccVel) * BetaFilY_p1 + AlfaAccVel * BetaY$

Otherwise, if the condition $FilterStatus=0$ arises (block 360), the following relations are implemented:

10 $AlfaFilX = (1 - AlfaVelAcc) * AlfaFilX_p1 + AlfaVelAcc * AlfaX$

$BetaFilX = (1 - AlfaVelAcc) * BetaFilX_p1 + AlfaVelAcc * BetaX$

15 $AlfaFilY = (1 - AlfaVelAcc) * AlfaFilY_p1 + AlfaVelAcc * AlfaY$

20 $BetaFilY = (1 - AlfaVelAcc) * BetaFilY_p1 + AlfaVelAcc * BetaY$ (block 340) .

[0104] Once smoothing terminates, the pointing aid module 22 carries out filtering on the positions.

25 **[0105]** In detail, if $FilterStatus=1$, the tracking condition is identified, and then (block 350):

$OmegaX = (1 - AlfaFilX) * Omega_p1X + AlfaFilX * JoyX$

30 $OmegaY = (1 - AlfaFilY) * Omega_p1Y + AlfaFilY * JoyY$

$OmegaFil_p1X = 0$

35 $OmegaFil_p1Y = 0$

Instead, if $FilterStatus=0$, then:

40 $OtticaFilX = AlfaFilX * JoyXris$

$OtticaFilY = AlfaFilY * JoyYris$

45 $OmegaFilX = Omega_Fil_p1X + (BetaFilX / TCAMP) * JoyXris$

50 $OmegaFilY = Omega_Fil_p1Y + (BetaFilY / TCAMP) * JoyYris$

55 $OtticaPreX = OtticaFilX + OmegaFilX * TCAMP$

OtticaPreY=OtticaFilY+OmegaFilY*TCAMP

5

OmegaX=OmegaPreX/TCAMP

10

OmegaY=OmegaPreY/TCAMP

Omega Fil_p1X=OMegaFilX

15

Omega Fil_p1Y=OmegaFilY (block 390) .

20

[0106] At this point, the compensator module 24 saturates the speed command OmegaX and OmegaY while the pointing aid module 22 controls the saving of the following parameters, which will be used in the next step t_{n+1} :

AlfaFilX_p1=AlfafilX

25

BetaFilX_p1=BetafilX

AlfaFilY_p1=AlfafilY

30

BetaFilY_p1=BetafilY

35

Omega_p1Y=OmegaX (saturated values)

Omega_p1Y=OmegaY (block 390) .

40

[0107] The above-described pointing system is extremely advantageous as it is capable of modifying the filtering band over time as a function of the movement of the joystick produced by the operator.

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[0108] In particular, when the corrections requested by the pointer operator are substantial, the filter is modified to render pointer movements more rapid. Subsequently, when the operator has positioned the pointer on the target and tends to make small corrections, the calculation algorithm gradually modifies the coefficients that determine the band in order to estimate the speed of the target with good precision. In this condition, the adaptive filter interprets the commands of the joystick lever as acceleration commands and in the case of the target moving at a constant speed, the operator's command will tend to be null.

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[0109] In other terms, in conditions of constant angular speed, the speed command tends to be null, as the pointing system has identified the speed of the target. In this case, an ideal tracking condition is created in which the sensitivity to disturbances transferred to the joystick lever by the shaking of the vehicle is substantially null.

[0110] Finally, it is evident that modifications to and variants of the above-described pointing system can be made without however leaving the scope of the present invention defined by the enclosed claims.

55

Claims

1. A target pointing system (2) installable on a terrestrial vehicle (1), said system comprising:

- optical pointing means (8) configured so as to acquire images outside said terrestrial vehicle (1) and having a mobile target optical pointing axis (C);

- moving means (11) able to move said optical pointing means (8) so as to modify the spatial position of said target optical pointing axis (C);

5 - display means (14), which are able to display both images acquired by said optical pointing means (8) and a pointer (30) associated with the position taken by said target optical pointing axis (C);

- manual operating command means (15), which are able to generate a displacement command ($X(t_n)$, $Y(t_n)$), associated with the displacement to be given to said target optical pointing axis (C), in response to a manual displacement action exerted by a user by means of said manual operating command means (15);

10 - an automatic control system (12) of the position of said optical pointing means (8), which is configured so as to receive as an input a control quantity related to said displacement command ($X(t_n)$, $Y(t_n)$) and is able to determine as a function of the control quantity the position said optical pointing means (8) are to be commanded to take through said moving means (11);

said target pointing system (2) being **characterised in that** said automatic control system (12) comprises pointing aiding electronic means (22), which are able to receive said displacement command ($X(t_n)$, $Y(t_n)$), and are configured so as to perform:

15 - a first adaptive filtering of said displacement command ($X(t_n)$, $Y(t_n)$) so as to assign said control quantity a value proportional to the speed of the manual displacement given to the manual operating command means (15), when said pointing system (2) is in a re-phasing condition;

20 - a second adaptive filtering of said displacement command ($X(t_n)$, $Y(t_n)$) so as to assign said control quantity a value proportional to the acceleration of the user manual displacement when said target pointing system (2) is in a tracking condition.

- 25 2. The pointing system according to claim 1, wherein said pointing aiding electronic means (22) are provided with an adaptive filter (23) and are configured so as to modify the transfer function of said adaptive filter (22) as a function of the operative condition of re-phasing/tracking of said target pointing system (2).
- 30 3. The pointing system according to claim 2, wherein said pointing aiding electronic means (22) are configured so as to perform said first adaptive filtering, when said pointing system (2) is in a re-phasing operative condition, leading said adaptive filter (23) to have a first one-pole first order transfer function, or alternatively said second adaptive filtering when the system is in a tracking operative condition leading said adaptive filter (23) to have a second two-pole second order transfer function.
- 35 4. The pointing system according to claim 3, wherein said pointing aiding electronic means (22) comprise a pointing aid module (22), which is configured so as to determine a transition of the pointing system (2) from the re-phasing operative condition to the tracking operative condition and vice versa; in the course of each transition of the pointing system (2), said pointing aid module (22) modifies the coefficients of said adaptive filter (23) so that the same reach the values provided by said first or second transfer function, according to a predetermined continuous temporal function.
- 40 5. The system according to claim 4, wherein said control quantity corresponds to a control speed; said displacement command comprises manual positions associated with the manual displacement given through said manual command means (15).
- 45 6. The system according to claim 5, comprising a compensator module (24), which is able to receive said displacement control speed from said pointing aid module (22) and provides as an output a saturated control speed; said pointing aid module (22) being able to determine said transition from the re-phasing operative condition to the tracking operative condition and vice versa, as a function of said saturated control speed.
- 50 7. The system according to claim 6, wherein said pointing aid module (22) detects a transition of said pointing system (2) from the re-phasing operative condition to the tracking operative condition when the following condition occurs: the operative condition performed by the pointing system (2) corresponds to the re-phasing operative condition and the saturated control speed, obtained in the course of the last filtering performed by said adaptive filter (23) results being lower than a first speed threshold.
- 55 8. The system according to claim 6, wherein said pointing aid module (22) detects a transition from the tracking operative condition to the re-phasing operative condition when the following condition occurs: the performed operative condition of said pointing system (2) corresponds to the tracking operative condition and the saturated control speed during

the last filtering performed by said adaptive filter (23) is greater than a second speed threshold.

9. The system according to claims 7 or 8, wherein when said pointing aid module (22) detects a transition of the pointing system (2) from the tracking operative condition to the re-phasing operative condition, it provides that said adaptive filter (23) is configured implementing the following equations:

$$a1) \quad Vx(t_n) = (1 - \alpha_x) \cdot Vsx(t_{n-1}) + \alpha_x \cdot X(t_n)$$

$$a2) \quad Vy(t_n) = (1 - \alpha_y) \cdot Vsy(t_{n-1}) + \alpha_y \cdot Y(t_n)$$

wherein $X(t_n)$ and $Y(t_n)$ correspond to the displacement commands associated with corresponding positions given to said manual operating command means (15) along an axis X and respectively an axis Y at a sampling time t_n ; $V_x(t_n)$ $V_y(t_n)$ correspond to the angular speeds provided as an output by said adaptive filter (23) at the sampling time t_n ; and α_x is the coefficient of the transfer function of the adaptive filter (23) associated with the quantity $X(t_n)$ in the first configuration; whereas α_y is a coefficient of said first order adaptive filter (23) associated with the quantity $Y(t_n)$ in the first configuration.

10. The system according to claims 7, 8 or 9, wherein when the pointing aid module (22) detects a transition of the pointing system (2) from the tracking operative condition to the re-phasing operative condition, the pointing aid module (22) provides that said adaptive filter (23) is configured implementing the following equations:

$$b1) \quad Ox(t_n) = \alpha_x \cdot X(t_n) ;$$

$$b2) \quad Oy(t_n) = \alpha_y \cdot Y(t_n)$$

wherein $Ox(t_n)$ and $Oy(t_n)$ correspond to the displacements given to said optical pointing means (8) at time t_n ;

$$c1) \quad Vfx(t_n) = Vfx(t_{n-1}) + (\beta_x/T) \cdot X(t_n) ;$$

$$c2) \quad Vfy(t_n) = Vfy(t_{n-1}) + (\beta_y/T) \cdot Y(t_n)$$

wherein α_y, β_x and α_x, β_y are the coefficients of said adaptive filter (23) in said second transfer function; T is the sampling interval of the displacement command; $Vfx(t_n)$ $Vfy(t_n)$ correspond to non saturated angular speeds filtered by said adaptive filter (23) at time (t_n) .

$$d1) \quad Oxp_{n+1/n} = Ox(t_n) + Vfx(t_n) \cdot T ;$$

$$d2) \quad Oyp_{n+1/n} = Oy(t_n) + Vfy(t_n) \cdot T$$

wherein $Oxp_{n+1/n}$ $Oyp_{n+1/n}$ correspond to the transversal and elevational displacements of said optical pointing means (8) at time (t_{n+1}) although assessed at the previous time t_n ;

$$e1) \quad Vx(t_n) = Oxp_{n+1/n} / T$$

$$e2) \quad Vy(t_n) = Oyp_{n+1/n} / T$$

- 5 11. A tank (1) comprising a target pointing system (2) made according to any of the preceding claims.

Patentansprüche

- 10 1. Zielanvisiersystem (2), das an einem terrestrischen Fahrzeug (1) installiert werden kann, wobei das System umfasst:
- optische Mittel (8), die konfiguriert sind, um Bilder außerhalb des terrestrischen Fahrzeugs (1) zu erfassen, und eine optische Anvisierachse (C) zum Zielen auf ein mobiles Ziel besitzen;
 - Bewegungsmittel (11), die die optischen Anvisiermittel (8) bewegen können, um die räumliche Position der optischen Anvisierachse (C) zu modifizieren;
 - Anzeigemittel (14), die sowohl Bilder, die durch die optischen Anvisiermittel (8) erfasst werden, als auch einen Zeiger (30), der der von der optischen Anvisierachse (C) eingenommenen Position zugeordnet ist, anzeigen können;
 - Befehlsmittel (15) für manuelle Betätigung, die in Reaktion auf eine manuelle Verlagerungsaktion, die von einem Anwender mittels der Befehlsmittel (15) für manuelle Betätigung ausgeübt wird, einen Verlagerungsbefehl ($X(t_n)$, $Y(t_n)$) erzeugen können, der der Verlagerung zugeordnet ist, die der optischen Anvisierachse (C) verliehen werden soll;
 - ein automatisches Steuersystem (12) für die Position der optischen Anvisiermittel (8), das konfiguriert ist, um als einen Eingang eine Steuergröße zu empfangen, die mit dem Verlagerungsbefehl ($X(t_n)$, $Y(t_n)$) in Beziehung steht, und als Funktion der Steuergröße die Position zu bestimmen, deren Einnahme mittels der Bewegungsmittel (11) den optischen Anvisiermitteln (8) befohlen wird;
- wobei das Zielanvisiersystem (2) **dadurch gekennzeichnet ist, dass** das automatische Steuersystem (12) elektronische Anvisierunterstützungsmittel (22) umfasst, die den Verlagerungsbefehl ($X(t_n)$, $Y(t_n)$) empfangen können und konfiguriert sind, um Folgendes auszuführen:
- eine erste adaptive Filterung des Verlagerungsbefehls ($X(t_n)$, $Y(t_n)$), um der Steuergröße einen Wert zuzuweisen, der zu der Geschwindigkeit der manuellen Verlagerung, die in die Befehlsmittel (15) für manuelle Betätigung eingegeben wird, proportional ist, wenn das Anvisiersystem (2) in einem Neusynchronisationszustand ist;
 - eine zweite adaptive Filterung für den Verlagerungsbefehl ($X(t_n)$, $Y(t_n)$), um der Steuergröße einen Wert zuzuweisen, der zu der Beschleunigung der manuellen Verlagerung des Anwenders proportional ist, wenn das Zielanvisiersystem (2) in einem Verfolgungszustand ist.
2. Anvisiersystem nach Anspruch 1, wobei die elektronischen Anvisierunterstützungsmittel (22) mit einem adaptiven Filter (23) versehen sind und konfiguriert sind, um die Übertragungsfunktion des adaptiven Filters (23) als Funktion des Betriebszustands der Neusynchronisation/Verfolgung des Zielanvisiersystems (2) zu modifizieren.
3. Anvisiersystem nach Anspruch 2, wobei die elektronischen Anvisierunterstützungsmittel (22) konfiguriert sind, um die erste adaptive Filterung auszuführen, wenn das Anvisiersystems (2) in einem Neusynchronisationsbetriebszustand ist, was dazu führt, dass das adaptive Filter (23) eine erste Einpol-Übertragungsfunktion erster Ordnung hat, oder um alternativ die zweite adaptive Filterung auszuführen, wenn das System in einem Verfolgungsbetriebszustand ist, was dazu führt, dass das adaptive Filter (23) eine zweite Zweipol-Übertragungsfunktion zweiter Ordnung besitzt.
4. Anvisiersystem nach Anspruch 3, wobei die elektronischen Anvisierunterstützungsmittel (22) ein Anvisierunterstützungsmodul (22) umfassen, das konfiguriert ist, um einen Übergang des Anvisiersystems (2) von einem Neusynchronisations-Betriebszustand in den Verfolgungsbetriebszustand und umgekehrt zu bestimmen; wobei im Verlauf jedes Übergangs des Anvisiersystems (2) das Anvisierunterstützungsmodul (2) die Koeffizienten des adaptiven Filters (23) modifiziert, so dass diese die Werte, die von der ersten oder der zweiten Übertragungsfunktion bereitgestellt werden, in Übereinstimmung mit einer vorgegebenen stetigen zeitlichen Funktion erreichen.
5. System nach Anspruch 4, wobei die Steuergröße einer Steuergeschwindigkeit entspricht; der Verlagerungsbefehl manuelle Positionen enthält, die der manuellen Verlagerung zugeordnet sind, die mittels der manuellen Befehlsmittel (15) gegeben wird.

6. System nach Anspruch 5, das ein Kompensationsmodul (24) umfasst, das die Verlagerungssteuergeschwindigkeit von dem Anvisierunterstützungsmodul (22) empfangen kann und als einen Ausgang eine gesättigte Steuergeschwindigkeit bereitstellt; wobei das Anvisierunterstützungsmodul (22) den Übergang von dem Neusynchronisations-Betriebszustand in den Verfolgungsbetriebszustand und umgekehrt als Funktion der gesättigten Steuergeschwindigkeit bestimmen kann.
7. System nach Anspruch 6, wobei das Anvisierunterstützungsmodul (22) einen Übergang des Anvisiersystems (2) von dem Neusynchronisations-Betriebszustand in den Verfolgungsbetriebszustand detektiert, wenn die folgende Bedingung auftritt: der Betriebszustand, der von dem Anvisiersystem (2) ausgeführt wird, entspricht dem Neusynchronisations-Betriebszustand und die gesättigte Steuergeschwindigkeit, die im Verlauf der von dem adaptiven Filter (23) ausgeführten letzten Filterung erhalten wird, erweist sich als niedriger als ein erster Geschwindigkeitsschwellenwert.
8. System nach Anspruch 6, wobei das Anvisierunterstützungsmodul (22) einen Übergang von dem Verfolgungsbetriebszustand in den Neusynchronisations-Betriebszustand detektiert, wenn die folgende Bedingung auftritt: der ausgeführte Betriebszustand des Anvisiersystems (2) entspricht dem Verfolgungsbetriebszustand und die gesättigte Steuergeschwindigkeit während der durch das adaptive Filter (23) ausgeführte letzten Filterung ist größer als ein zweiter Geschwindigkeitsschwellenwert.
9. System nach Anspruch 7 oder 8, wobei dann, wenn das Anvisierunterstützungsmodul (22) einen Übergang des Anvisiersystems (2) von dem Verfolgungsbetriebszustand in den Neusynchronisationsbetriebszustand detektiert, vorgesehen ist, dass das adaptive Filter (23) konfiguriert ist, um die folgenden Gleichungen zu implementieren:

$$a1) \quad Vx(t_n) = (1 - \alpha_x) \cdot Vsx(t_{n-1}) + \alpha_x \cdot X(t_n);$$

$$a2) \quad Vy(t_n) = (1 - \alpha_y) \cdot Vsy(t_{n-1}) + \alpha_y \cdot Y(t_n)$$

wobei $X(t_n)$ und $Y(t_n)$ den Verlagerungsbefehlen entsprechen, die den entsprechenden Positionen längs einer X-Achse bzw. einer Y-Achse zugeordnet sind, die in die Befehlsmittel (15) für manuelle Betätigung zu einer Abtastzeit t_n eingegeben werden; wobei $Vx(t_n)$ und $Vy(t_n)$ den Winkelgeschwindigkeiten entsprechen, die durch das adaptive Filter (23) als ein Ausgang zu der Abtastzeit t_n bereitgestellt werden; und wobei α_x der Koeffizient der Übertragungsfunktion des adaptiven Filters (23) ist, das der Größe $X(t_n)$ in der ersten Konfiguration zugeordnet ist; während α_y ein Koeffizient des adaptiven Filters (23) erster Ordnung ist, das der Größe $Y(t_n)$ in der ersten Konfiguration zugeordnet ist.

10. System nach den Ansprüchen 7, 8 oder 9, wobei dann, wenn das Anvisierunterstützungsmodul (22) einen Übergang des Anvisiersystems (22) von dem Verfolgungsbetriebszustand in den Neusynchronisations-Betriebszustand detektiert, das Anvisierunterstützungsmodul (22) vorsieht, dass das adaptive Filter (23) konfiguriert ist, um die folgenden Gleichungen zu implementieren:

$$b1) \quad Ox(t_n) = \alpha_x \cdot X(t_n);$$

$$b2) \quad Oy(t_n) = \alpha_y \cdot Y(t_n)$$

wobei $Ox(t_n)$ und $Oy(t_n)$ den Verlagerungen entsprechen, die den optischen Anvisiermitteln (8) zur Zeit t_n verliehen

werden;

$$c1) \quad Vfx(t_n) = Vfx(t_{n-1}) + (\beta_x/T) \cdot X(t_n);$$

$$c2) \quad Vfy(t_n) = Vfy(t_{n-1}) + (\beta_y/T) \cdot Y(t_n)$$

wobei α_x , β_x und α_y , β_y die Koeffizienten des adaptiven Filters (23) in der zweiten Übertragungsfunktion sind; T das Abtastintervall des Verlagerungsbefehls ist; $Vfx(t_n)$ und $Vfy(t_n)$ nicht gesättigten Winkelgeschwindigkeiten entsprechen, die durch das adaptive Filter (23) zur Zeit t_n gefiltert werden;

$$d1) \quad Oxp_{n+1/n} = Ox(t_n) + Vfx(t_n) \cdot T;$$

$$d2) \quad Oyp_{n+1/n} = Oy(t_n) + Vfy(t_n) \cdot T$$

wobei $Oxp_{n+1/n}$ und $Oyp_{n+1/n}$ der transversalen Verlagerung bzw. der Höhenverlagerung der optischen Anvisiermittel (8) zur Zeit (t_{n+1}) entsprechen, obwohl zur früheren Zeit t_n festgelegt;

$$e1) \quad Vx(t_n) = Oxp_{n+1/n} / T;$$

$$e2) \quad Vy(t_n) = Oyp_{n+1/n} / T$$

11. Panzer (1), der ein Zielanvisiersystem (2) nach einem der vorhergehenden Ansprüche enthält.

Revendications

1. Système de pointage de cible (2) pouvant être installé sur un véhicule terrestre (1), ledit système comprenant :

- un moyen de pointage optique (8) configuré afin d'acquérir des images à l'extérieur dudit véhicule terrestre (1) et possédant un axe de pointage optique de cible mobile (C) ;
- un moyen mobile (11) capable de déplacer ledit moyen de pointage optique (8) afin de modifier la position spatiale dudit axe de pointage optique de cible (C) ;
- un moyen d'affichage (14), qui est capable d'afficher les deux images acquises par ledit moyen de pointage optique (8) et un pointeur (30) associé à la position prise par ledit axe de pointage optique de cible (C) ;
- un moyen de commande de fonctionnement manuel (15), qui est capable de générer une commande de déplacement ($X(t_n)$, $Y(t_n)$), associée au déplacement destiné à être fourni audit axe de pointage optique de cible (C), en réponse à une action de déplacement manuel exercée par un utilisateur grâce audit moyen de commande de fonctionnement manuel (15) ;
- un système de contrôle automatique (12) de la position dudit moyen de pointage optique (8), qui est configuré afin de recevoir, en tant qu'entrée, une quantité de contrôle liée à ladite commande de déplacement ($X(t_n)$, Y

(t_n) et est capable de déterminer, en fonction de la quantité de contrôle, la position que ledit moyen de pointage optique (8) doit prendre selon la commande dudit moyen mobile (11) ;

ledit système de pointage de cible (2) étant **caractérisé en ce que** ledit système de contrôle automatique (12) comprend un moyen électronique d'aide au pointage (22), qui est capable de recevoir ladite commande de déplacement ($X(t_n)$, $Y(t_n)$), et est configuré afin de réaliser :

- un premier filtrage adaptatif de ladite commande de déplacement ($X(t_n)$, $Y(t_n)$) afin d'attribuer à ladite quantité de contrôle une valeur proportionnelle à la vitesse du déplacement manuel fourni au moyen de commande de fonctionnement manuel (15), lorsque ledit système de pointage (2) est dans une condition de remise en phase ;
- un second filtrage adaptatif de ladite commande de déplacement ($X(t_n)$, $Y(t_n)$) afin d'attribuer à ladite quantité de contrôle une valeur proportionnelle à l'accélération du déplacement manuel d'utilisateur lorsque ledit système de pointage de cible (2) est dans une condition de poursuite.

2. Système de pointage selon la revendication 1, dans lequel ledit moyen électronique d'aide au pointage (22) est pourvu d'un filtre adaptatif (23) et est configuré afin de modifier la fonction de transfert dudit filtre adaptatif (22) en fonction de la condition de fonctionnement de remise en phase/de poursuite dudit système de pointage de cible (2).

3. Système de pointage selon la revendication 2, dans lequel ledit moyen électronique d'aide au pointage (22) est configuré afin de réaliser ledit premier filtrage adaptatif, lorsque ledit système de pointage (2) est dans une condition de fonctionnement de remise en phase, amenant ledit filtre adaptatif (23) à avoir une première fonction de transfert de premier ordre unipolaire, ou en variante ledit second filtrage adaptatif lorsque le système est dans une condition de fonctionnement de poursuite, amenant ledit filtre adaptatif (23) à avoir une seconde fonction de transfert de second ordre bipolaire.

4. Système de pointage selon la revendication 3, dans lequel ledit moyen électronique d'aide au pointage (22) comprend un module d'aide au pointage (22), qui est configuré afin de déterminer une transition du système de pointage (2) de la condition de fonctionnement de remise en phase à la condition de fonctionnement de poursuite et vice versa ; au cours de chaque transition du système de pointage (2), ledit module d'aide au pointage (22) modifie les coefficients dudit filtre adaptatif (23) de sorte que celui-ci atteigne les valeurs fournies par ladite première ou seconde fonction de transfert, selon une fonction temporelle continue prédéterminée.

5. Système selon la revendication 4, dans lequel ladite quantité de contrôle correspond à une vitesse de contrôle ; ladite commande de déplacement comprend des positions manuelles associées au déplacement manuel fourni par l'intermédiaire dudit moyen de commande manuel (15).

6. Système selon la revendication 5, comprenant un module compensateur (24), qui est capable de recevoir ladite vitesse de contrôle de déplacement à partir dudit module d'aide au pointage (22) et fournit, en tant que sortie, une vitesse de contrôle saturée ; ledit module d'aide au pointage (22) étant capable de déterminer ladite transition de la condition de fonctionnement de remise en phase à la condition de fonctionnement de poursuite et vice versa, en fonction de ladite vitesse de contrôle saturée.

7. Système selon la revendication 6, dans lequel ledit module d'aide au pointage (22) détecte une transition dudit système de pointage (2) de la condition de fonctionnement de remise en phase à la condition de fonctionnement de poursuite lorsque la condition suivante se produit : la condition de fonctionnement réalisée par le système de pointage (2) correspond à la condition de fonctionnement de remise en phase et la vitesse de contrôle saturée, obtenue au cours du dernier filtrage réalisé par ledit filtre adaptatif (23), est inférieure à un premier seuil de vitesse.

8. Système selon la revendication 6, dans lequel ledit module d'aide au pointage (22) détecte une transition de la condition de fonctionnement de poursuite à la condition de fonctionnement de remise en phase lorsque la condition suivante se produit : la condition de fonctionnement réalisée par ledit système de pointage (2) correspond à la condition de fonctionnement de poursuite et la vitesse de contrôle saturée durant le dernier filtrage réalisé par ledit filtre adaptatif (23) est supérieure à un second seuil de vitesse.

9. Système selon les revendications 7 ou 8, dans lequel, lorsque ledit module d'aide au pointage (22) détecte une transition du système de pointage (2) de la condition de fonctionnement de poursuite à la condition de fonctionnement de remise en phase, il permet que ledit filtre adaptatif (23) soit configuré pour implémenter les équations suivantes :

$$a1) \quad Vx(t_n) = (1 - \alpha_x) \cdot V_{sx}(t_{n-1}) + \alpha_x \cdot X(t_n)$$

$$a2) \quad Vy(t_n) = (1 - \alpha_y) \cdot V_{sy}(t_{n-1}) + \alpha_y \cdot Y(t_n)$$

dans lequel $X(t_n)$ et $Y(t_n)$ correspondent aux commandes de déplacement associées à des positions correspondantes fournies audit moyen de commande de fonctionnement manuel (15) le long d'un axe X et respectivement d'un axe Y à un temps d'échantillonnage t_n ; $Vx(t_n)$ et $Vy(t_n)$ correspondent aux vitesses angulaires fournies, en tant que sortie, par ledit filtre adaptatif (23) au temps d'échantillonnage t_n ; et α_x est le coefficient de la fonction de transfert du filtre adaptatif (23) associé à la quantité $X(t_n)$ dans la première configuration ; alors que α_y est un coefficient dudit filtre adaptatif de premier ordre (23) associé à la quantité $Y(t_n)$ dans la première configuration.

10. Système selon les revendications 7, 8 ou 9, dans lequel, lorsque le module d'aide au pointage (22) détecte une transition du système de pointage (2) de la condition de fonctionnement de poursuite à la condition de fonctionnement de remise en phase, le module d'aide au pointage (22) permet que ledit filtre adaptatif (23) soit configuré pour implémenter les équations suivantes :

$$b1) \quad Ox(t_n) = \alpha_x \cdot X(t_n) ;$$

$$b2) \quad Oy(t_n) = \alpha_y \cdot Y(t_n)$$

dans lequel $Ox(t_n)$ et $Oy(t_n)$ correspondent aux déplacements fournis audit moyen de pointage optique (8) au temps t_n ;

$$c1) \quad Vfx(t_n) = Vfx(t_{n-1}) + (\beta_x/T) \cdot X(t_n) ;$$

$$c2) \quad Vfy(t_n) = Vfy(t_{n-1}) + (\beta_y/T) \cdot Y(t_n)$$

dans lequel α_y , β_x et α_x , β_y sont les coefficients dudit filtre adaptatif (23) dans ladite seconde fonction de transfert ; T est l'intervalle d'échantillonnage de la commande de déplacement ; $Vfx(t_n)$ et $Vfy(t_n)$ correspondent à des vitesses angulaires non saturées filtrées par ledit filtre adaptatif (23) au temps (t_n) ;

$$d1) \quad Oxp_{n+1/n} = Ox(t_n) + Vfx(t_n) \cdot T ;$$

$$d2) \quad Oyp_{n+1/n} = Oy(t_n) + Vfy(t_n) \cdot T$$

dans lequel $Oxp_{n+1/n}$ et $Oyp_{n+1/n}$ correspondent aux déplacements transversaux et d'élévation dudit moyen de pointage optique (8) au temps (t_{n+1}) bien qu'évalués au temps précédent t_n ;

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$$e1) \quad Vx(t_n) = Oxp_{n+1/n} / T$$

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$$e2) \quad Vy(t_n) = Oyp_{n+1/n} / T$$

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- 11.** Char d'assaut (1) comprenant un système de pointage de cible (2) selon une quelconque des revendications précédentes.

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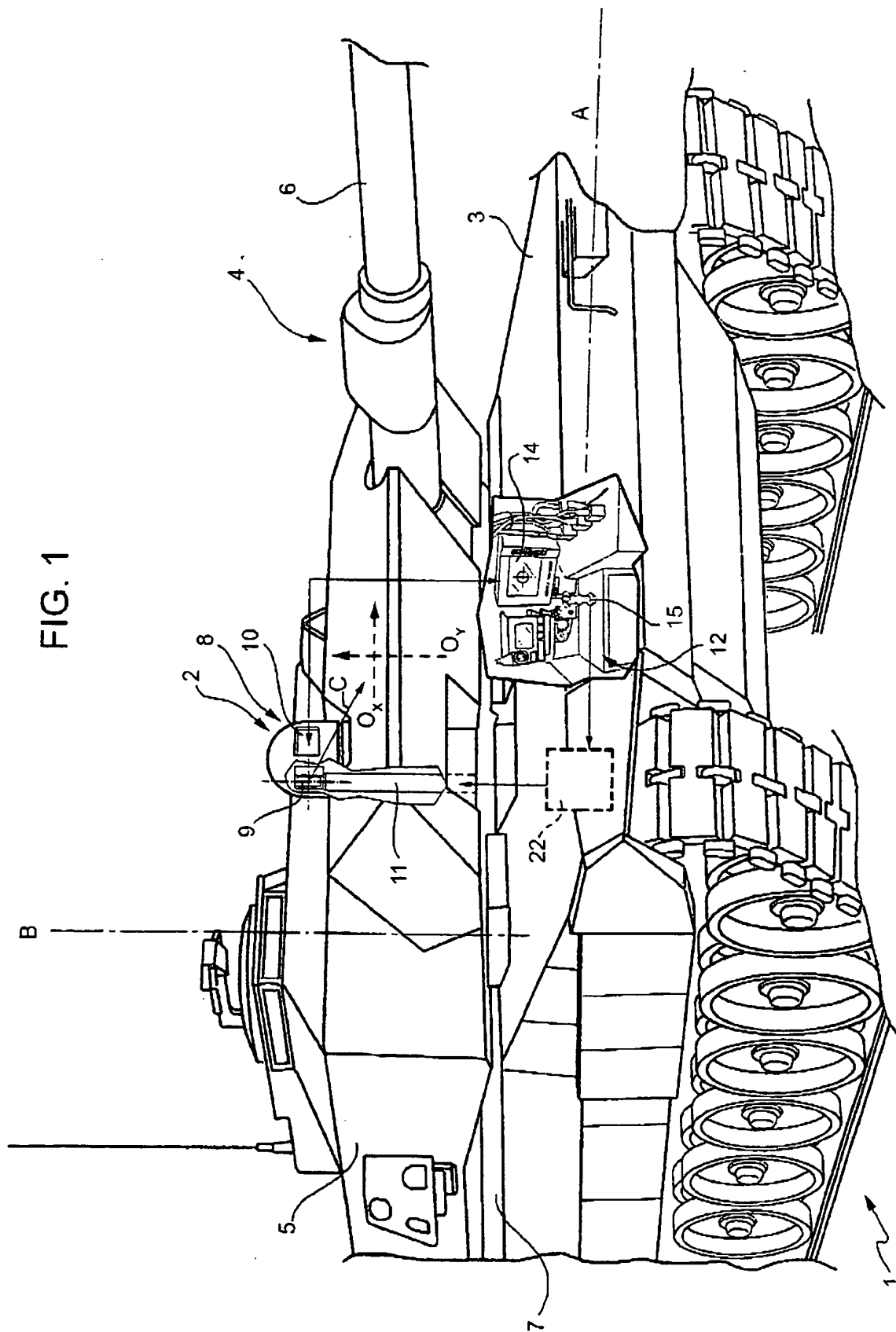


FIG. 2

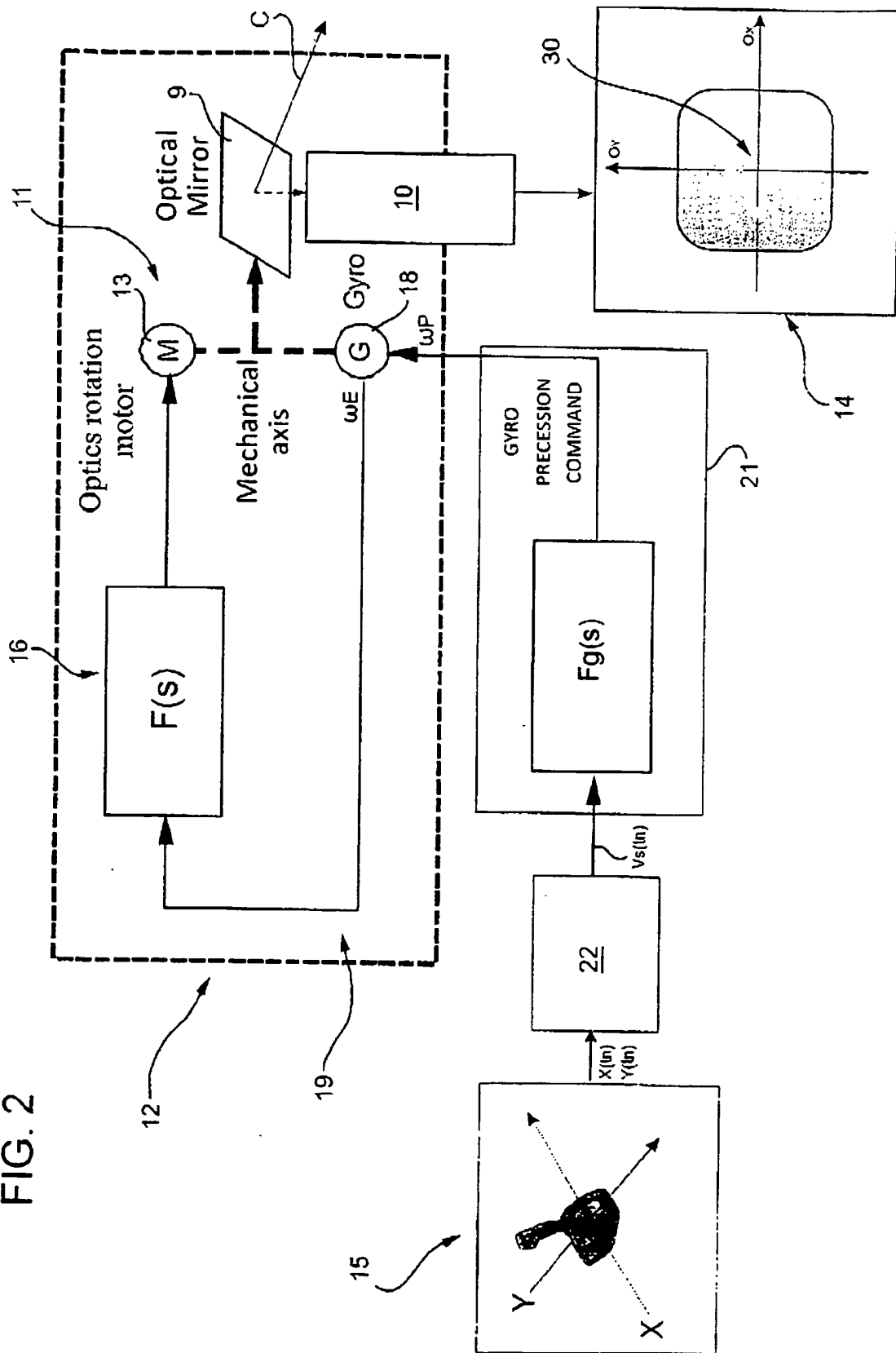


FIG. 3

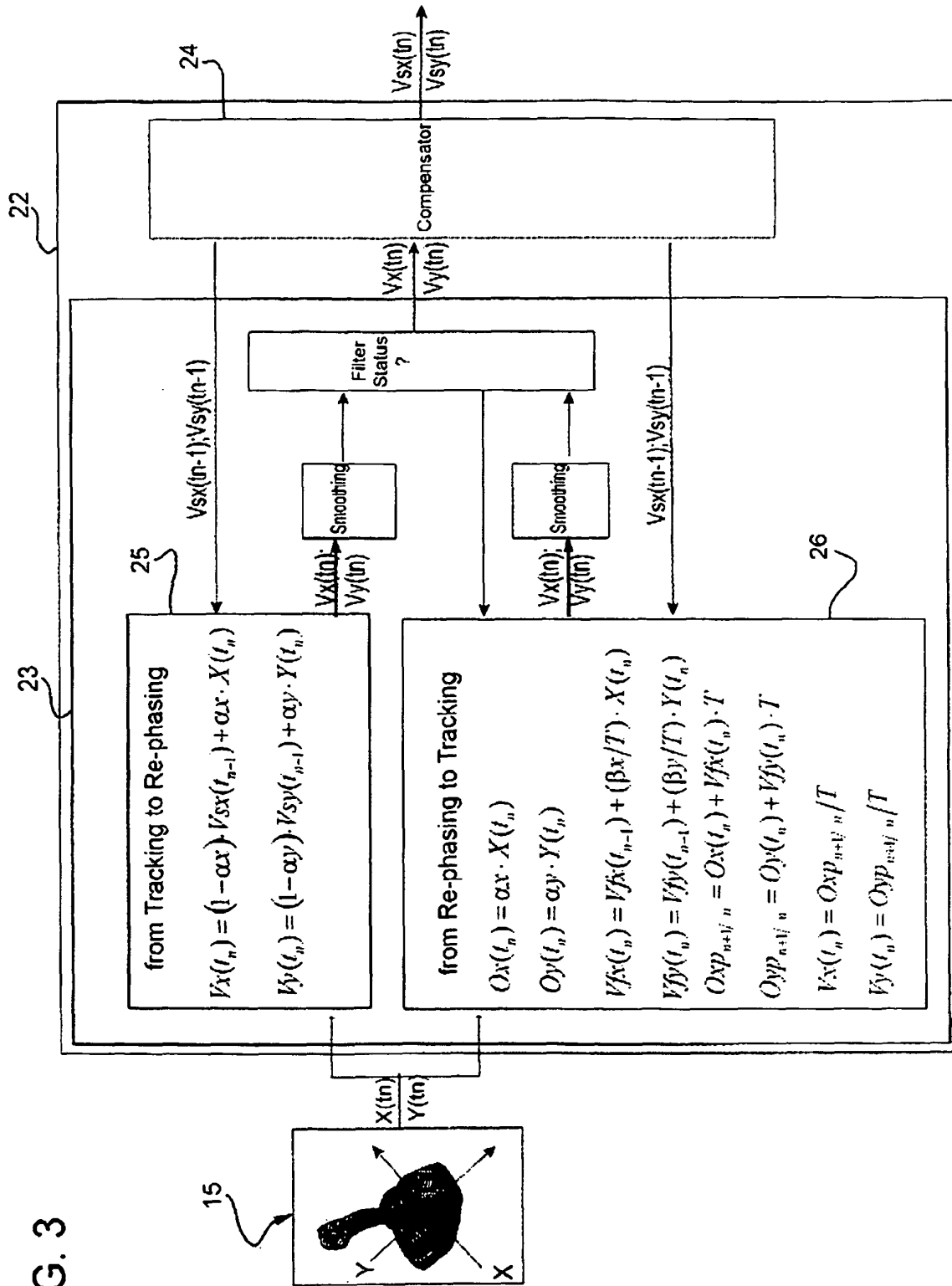


FIG. 4

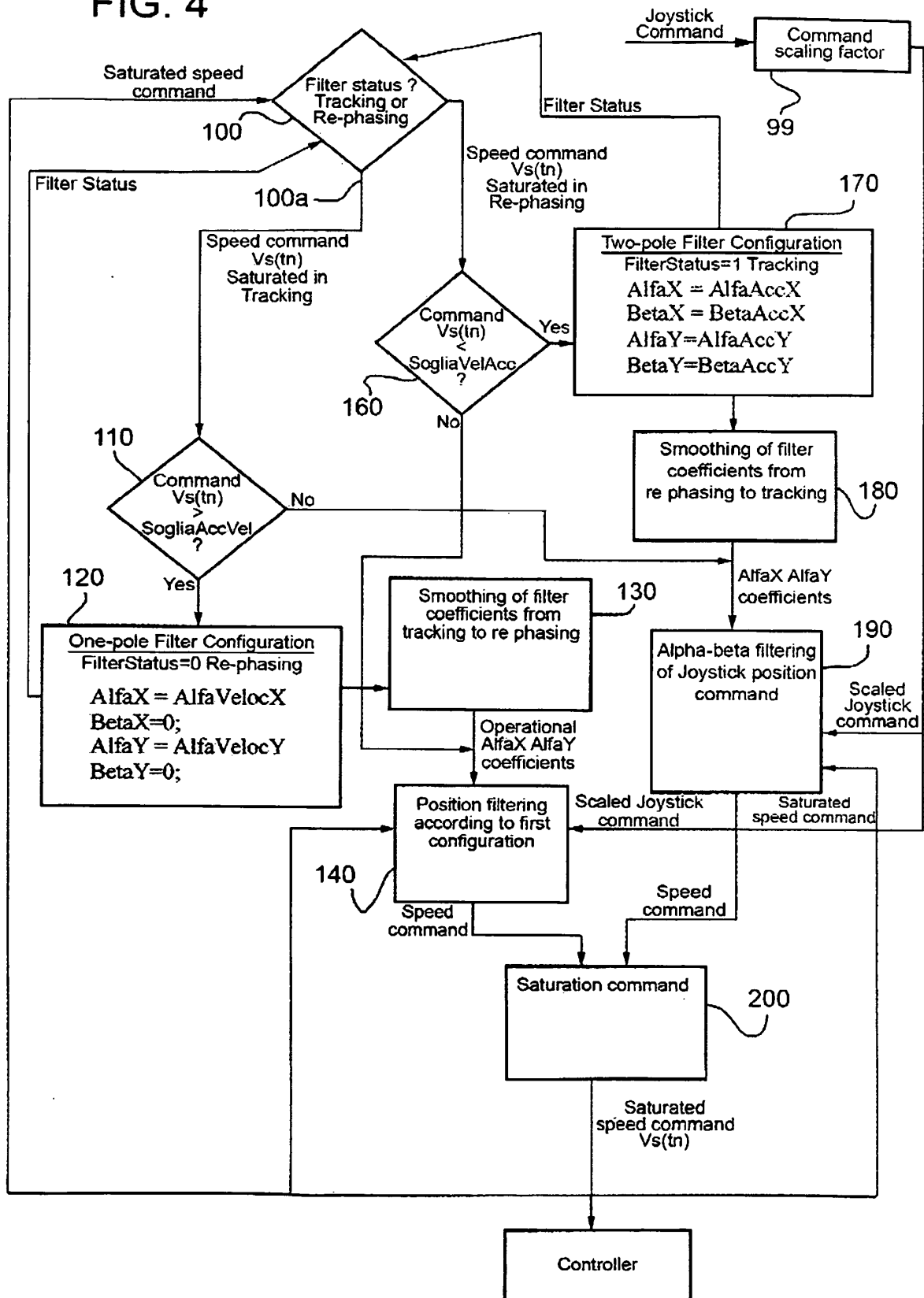


FIG. 5

