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NEW CONCEPT OF A MOBILE ROBOT USED IN CAR INSPECTION

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Abstract: The objective of this paper is to present a conception of a mobile robot constructive solution that can be used in the technical inspection of cars, running under applicable laws. The motion of the proposed concept is realized by two motor, situated on each side of the system. Also, the papers presents a geometric modeling of the mechanism which have an important role in orientation of the camera, and the geometrical control functions for orientation of the camera.

Key words: inspection, geometrical control functions, kinematical constraints.

1. INTRODUCTION

The goal of the paper is to present a conception of a mobile structure, able to help the human operator in cars inspection. The concept of the mobile robot should be able to move on a trajectory set by an operator and remote control under a car. Also will collect data and send information to a computer in the form of image files or movie, after wise, the files will be reviewed by an inspector, which will conclude about the state of the car. The mobile robot should provide information on the following aspects necessary for the inspection:

- the existence of superficial or deep corrosion in the chassis or the resistance of the vehicle inspected;
- highlighting of leaks, corrosion and traces of smoke along the exhaust system;
- brake fluid leakage at joints or trail braking system;
- loss of oil in the engine and gearbox, or differential (for cars with rear-wheel drive or all-wheel drive);
- leaks, cooling system leaks;
- detection games in suspensions, the latter is performed using hydraulic driven plates that are fitted as a car service for that purpose.

2. ARCHITECTURE OF INSPECTION ROBOT

A mobile robot needs locomotion mechanisms enabling it to easily move through

the environment. There are a variety of possibilities of movement, which requires the choice of means of transport design, an important aspect of mobile robots. Most vehicles are not able to control three degrees of freedom independently due to the nonholonomical constraints.

For inspection of the cars, there is considered a conception of a mobile structure, presented in Fig.1, characterized by a differential shift, commonly used in moving mobile robots. The structure is equipped with pan-and-tilt camera, characterized by two degrees of freedom, consisting in two rotations as can be seen from Fig.1.

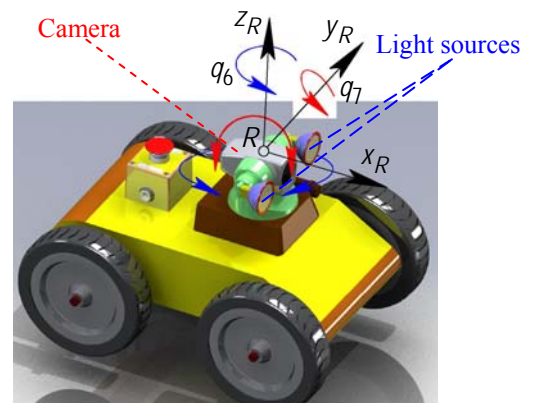


Fig. 1 - The orientation of light source and camera

On the bracket that supports the camera is fixed the light source, consisting of two bulbs, whose movements are identical with the motion of the camera.

3 MOVEMENT OF INSPECTION ROBOT

The drive wheel is done in pairs, so that the two wheels on each side are driven by a motor. Thus, the proposed differential robotic system is characterized by four wheels, powered by two engines on each side of the structure. Based on these considerations, a straight line movement of the movable mechanical structure is obtained when the pair of wheels on one side rotates at the same speed and in the same direction, with the other pair of wheels on the opposite side (see Fig.2) .

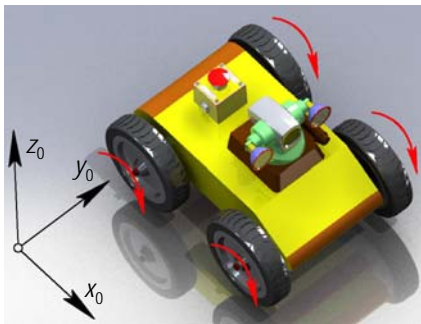
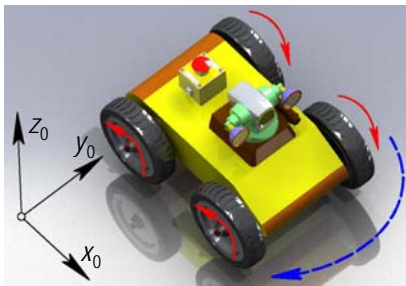
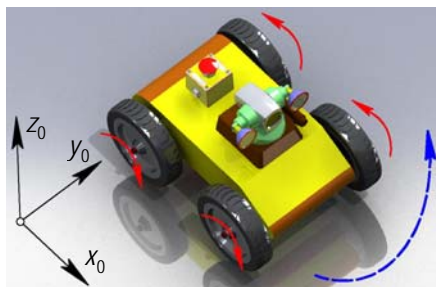


Fig.2 – Straight line motion of the inspection robot

The orientation of the robot is achieved by moving the robot wheels on one side in one direction, for example, the movement of the other two wheels in the opposite direction, as can be seen in figure 3.



a. Turning right



b. Turning left

Fig.3 – The orientation of the inspection robot

Thus the desired trajectories can be obtained by changing the angular speed and/or direction of the wheels on each side.

4 GEOMETRIC MODELING OF CAMERA ORIENTING MECHANISM

The camera orientation is achieved by a pan and tilt mechanism, pan being a horizontal plane rotation, tilt representing a rotation in the vertical plane. The camera, attached to the platform with respect to the mobile platform, has two degrees of freedom, represented in figure 4.

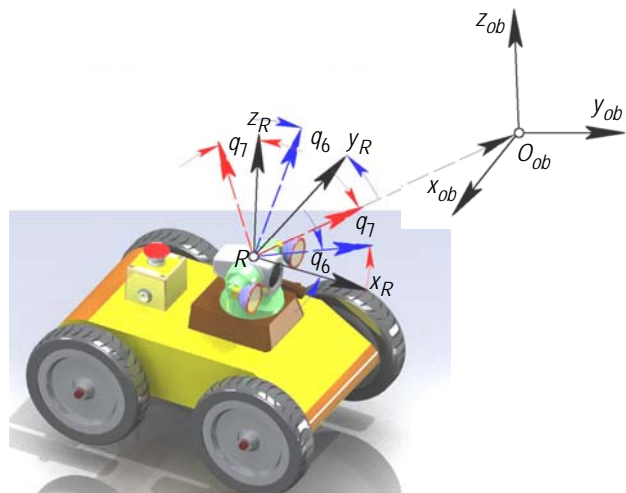


Fig. 4 - Degrees of freedom of the robot's camera

The position vector attached camera system {C}, with respect to the mobile system {R} is:

$${}^R \bar{p}_C = [{}^R x_C \quad 0 \quad {}^R z_C]^T; \quad (1)$$

There is considered the system {0b} attached to a body viewed by the camera. The position of the system {0b} with respect to the camera is given by:

$${}^C \bar{p}_{Ob} = [{}^C x_{Ob} \quad {}^C y_{Ob} \quad {}^C z_{Ob}]^T; \quad (2)$$

The orientation of the camera is achieved by two independent rotation around the axes z and y, rotations represented by the matrix [1],[2]:

$$R(\bar{z}_C; q_6) = \begin{bmatrix} c q_6 & -s q_6 & 0 \\ s q_6 & c q_6 & 0 \\ 0 & 0 & 1 \end{bmatrix}; \quad (3)$$

$$R(\bar{y}_C; q_7) = \begin{bmatrix} c q_7 & 0 & s q_7 \\ 0 & 1 & 0 \\ -s q_7 & 0 & c q_7 \end{bmatrix}$$

where $c q_i = \cos q_i$, and $s q_i = \sin q_i$.

The rotation matrix expressing the orientation of the system $\{C\}$ with respect to $\{R\}$ is given by the following form [2]:

$${}^R_C[R] = R(\bar{z}_C; q_6) \cdot R(\bar{y}_C; q_7) \quad (4)$$

$${}^R_C[R] = \begin{bmatrix} c q_6 \cdot c q_7 & -s q_6 & c q_6 \cdot s q_7 \\ s q_6 \cdot c q_7 & c q_6 & s q_6 \cdot s q_7 \\ -s q_7 & 0 & c q_7 \end{bmatrix}.$$

The position of system $\{Ob\}$ in relation to the mobile system $\{R\}$ is determined using the following relationships:

$$\begin{aligned} {}^R\bar{p}_{Ob} &= {}^R\bar{p}_C + {}^R_C[R] \cdot {}^C\bar{p}_{Ob} = \\ &= [{}^R x_C \ 0 \ {}^R z_C]^T + {}^R_C[R] \cdot [{}^C x_{Ob} \ {}^C y_{Ob} \ {}^C z_{Ob}]^T. \end{aligned} \quad (5)$$

$${}^R p_{Ob} = \begin{bmatrix} {}^R x_C + {}^C x_{Ob} \cdot c q_6 \cdot c q_7 - {}^C y_{Ob} \cdot s q_6 + {}^C z_{Ob} \cdot c q_6 \cdot s q_7 \\ {}^C x_{Ob} \cdot s q_6 \cdot c q_7 + {}^C y_{Ob} \cdot c q_6 + {}^C z_{Ob} \cdot s q_6 \cdot s q_7 \\ {}^R z_C - {}^C x_{Ob} \cdot s q_7 + {}^C z_{Ob} \cdot c q_7 \end{bmatrix}$$

$${}^R p_{Ob} = [{}^R x_{Ob} \ {}^R y_{Ob} \ {}^R z_{Ob}]^T \quad (6)$$

Knowing the position of the object $\{Ob\}$ with respect to $\{R\}$, the position with respect to fixed reference system results using the following expression [1],[3]:

$${}^0\bar{p}_{Ob} = \bar{r}_p + {}^0_R[R] \cdot {}^R p_{Ob}; \quad (7)$$

In keeping with Fig. 4, the expression (7) is rewritten as follows:

$${}^0\bar{p}_{Ob} = \begin{bmatrix} {}^0 x_{Ob} \\ {}^0 y_{Ob} \\ {}^0 z_{Ob} \end{bmatrix} = \begin{bmatrix} x_p \\ y_p \\ 0 \end{bmatrix} + {}^0_R[R] \cdot \begin{bmatrix} {}^R x_{Ob} \\ {}^R y_{Ob} \\ {}^R z_{Ob} \end{bmatrix} \quad (8)$$

$${}^0\bar{p}_{Ob} = \begin{bmatrix} x_p + {}^R x_{Ob} \cdot c q_3 - {}^R y_{Ob} \cdot s q_3 \\ y_p + {}^R x_{Ob} \cdot s q_3 + {}^R y_{Ob} \cdot c q_3 \\ {}^R z_{Ob} \end{bmatrix},$$

expression which expresses the position vector of the object $\{Ob\}$ with respect to a fixed reference system [5].

5 GEOMETRICAL CONTROL FUNCTIONS FOR ORIENTATION OF THE CAMERA

Knowing the position reference system $\{Ob\}$ attached to the object, presented by ${}^0\bar{p}_{Ob} = ({}^0 x_{Ob} \ {}^0 y_{Ob} \ {}^0 z_{Ob})^T$, respectively the position and orientation of the mobile robot with respect to fixed reference system, further there will be determined the angles for camera orientation. First is determined the position of camera with respect to the fixed reference system, as follows [4]:

$$\begin{aligned} {}^0\bar{p}_C &= \bar{r}_p + {}^0_R[R] \cdot {}^R\bar{p}_C = \\ &= \begin{bmatrix} x_p \\ y_p \\ 0 \end{bmatrix} + {}^0_R[R] \cdot \begin{bmatrix} {}^R x_C \\ 0 \\ {}^R z_C \end{bmatrix} = \\ &= \begin{bmatrix} x_p + {}^R x_{Ob} \cdot c q_3 \\ y_p + {}^R x_{Ob} \cdot s q_3 \\ {}^R z_{Ob} \end{bmatrix} \end{aligned} \quad (9)$$

Using the input data and the relationship (9), there is determined the position of the object, in respect with the reference system $\{C\}$ as [1],[4]:

$${}^C\bar{p}_{Ob} = {}^0_C[R]^T \cdot ({}^0\bar{p}_{Ob} - {}^0\bar{p}_C); \quad (10)$$

where

$${}^0_C[R] = \begin{bmatrix} c q_3 & -s q_3 & 0 \\ s q_3 & c q_3 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} c q_6 & -s q_6 & 0 \\ s q_6 & c q_6 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} c q_7 & 0 & s q_7 \\ 0 & 1 & 0 \\ -s q_7 & 0 & c q_7 \end{bmatrix}$$

$${}^0_C[R] = \begin{bmatrix} c(q_3+q_6) \cdot c q_7 & s(q_3+q_6) \cdot c q_7 & -s q_7 \\ -s(q_3+q_6) & c(q_3+q_6) & 0 \\ c(q_3+q_6) \cdot s q_7 & s(q_3+q_6) \cdot s q_7 & c q_7 \end{bmatrix}$$

and

$${}^0\bar{p}_{Ob} - {}^0\bar{p}_C = \begin{bmatrix} {}^0 x_{Ob} - x_p - {}^R x_{Ob} \cdot c q_3 \\ {}^0 y_{Ob} - y_p - {}^R x_{Ob} \cdot s q_3 \\ {}^0 z_{Ob} - {}^R z_{Ob} \end{bmatrix}.$$

On the basis of figure 1, it can be observed that the axis x_C is oriented to the reference system $\{Ob\}$, hence the position vector ${}^C\bar{p}_{Ob}$ has projection only on x_C axis. By equaling the projections on axes y_C , respectively z_C , obtained from the relation (10), to zero, there are obtained the generalized coordinates q_6 and q_7 .

6. CONCLUSIONS

The concept of mobile system used for inspection of the cars, presented in the paper, has differential movement commonly used in the case of the mobile robots. The drive of the wheels is done in pairs, so that the two wheels on each side are driven by a motor. Thus, the proposed differential robotic system is characterized by four wheels, powered by two motors on each side of the structure. To achieve robotized inspections, the mechanical system is equipped with a camera and a light source, indispensable in the inspection process.

O nouă concepție de robot mobil utilizat în inspecțiile auto

Rezumat: Obiectivul acestei lucrări este de a prezenta o concepție a unei soluții de robot mobil, care poate fi utilizat în inspecțiile tehnice ale automobilelor, efectuate în conformitate cu legile în vigoare. Deplasarea conceptului propus, este realizată prin intermediul a două motoare, situate pe fiecare parte a sistemului robotic. De asemenea, se prezintă modelarea geometrică a mecanismului de orientarea a camerei și a sursei de iluminare, precum și funcțiile geometrice de control pentru orientarea camerei.

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The papers also contain a geometric modeling of camera orienting mechanism, and the geometrical control functions for orientation of the camera.

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