ANNALS of the ORADEA UNIVERSITY.

Fascicle of Management and Technological Engineering, Volume VI (XVI), 2007

STEPING ROBOT

Gődri ALEXANDRU, Ioan STROE
Universitatea "Transilvania" din Braşov, e-mail stroei@unitbv.ro

Abstract: The mobile robots have offered the support of impressive results in almost all areas. The foot's number is an important element and affects mostly the next proprieties: stability and energetic efficiency. The paper presents the study of a stepping robot with six foots. The actuating is realized through a motor, and the free transmission uses mechanisms with gear wheel. A controller realizes the actuation and the control. There are presented: the constructive shape, the stepping diagram and the 3D-ensemble design of the six-foot stepping motor.

Key words: robots, stepping robot, orthogonal, locomotion function

1. INTRODUCTION

The researches, in the area of mobile robots, have began in the 50's, but the fascination of this area have appeal long time before even though the technological support of that time haven't permitted spectacular results.

The current researches are clearly oriented to the implementation of the performing robotic structures, using the new technologies, which facilitates both the mechanical part structure and the force or the intelligence.

An analysis of the researches in this area shows a clear increase of the approached subjects numbers and a clearly orientation, a research direction concentration to the most prestigious universities and research institutes.

The complexity of the animal world offers the best field for an authentic scientific research. Starting from the new obtaining composite technologies of new materials and until the control with genetic algorithm (based on the evolutionary principles), the mobile robots had offered the support of great results in almost all domains.

The area of animal world offers by its diversity the best and the perfect solutions for the implementation of a robotic structure. We just have to imitate it, appealing to the technological support that we have and to the qualitative solutions which bring us near to the animal world [3], [4].

2. ELEMENTS CONCERNING THE STEPPING ROBOTS DRIVING

The stepping robots driving impose the knowledge of the vehicle possibilities for the trajectory determination of the body and foots in the stepping phase.

The driving of this robots maybe accomplished on two levels. At the superior level, the robot is managed, in its working universe, by a remote controller or following a clearly road, defined given to an initial point in this universe. At local level, the locomotion function is being realized.

It is convenient that at superior level, the positions and the orientations, of the robot, to be established by the planned trajectories (by decomposition in line segments and in circular arcs).

The trajectory generator supplies the robot positions and orientations corresponding to an elementary displacement at a sampling period τ.

When this segments are covered there will be **generated parametrical** the intermediary current points that are necessary in the engendering of the position references for the actuating elements. The elementary displacement can correspond to a stepping cycle.

The fixed reference and the elementary displacements are presented in figure 1

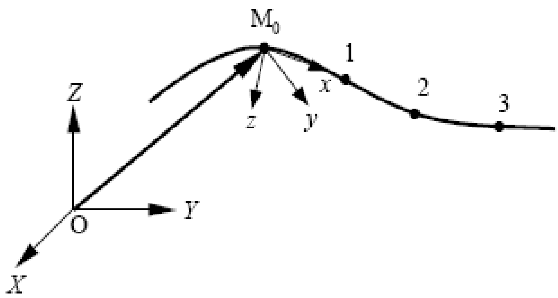


Fig. 1 The fixed reference and the elementary displacement

The homogenous matrix H characterizes the position and the orientation in point M(x,y,z).

$$H = \begin{bmatrix} cos\,\varphi & -sin\,\varphi & 0 & X \\ -sin\,\varphi & -cos\,\varphi & 0 & Y \\ 0 & 0 & -1 & Z \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad (1)$$

An elementary displacement carries the vehicle mass point (considered characteristic point and the origin of a Cartesian reference attached) from a point M_0 in a destination point crossing a trajectory segment.

For an elementary displacement on a circular arc, there are considered, a circle $C(x_c,y_c)$ in the reference M_0 (fig.3) and two points, M_1 – intermediate and M_2 – the arc's extremity

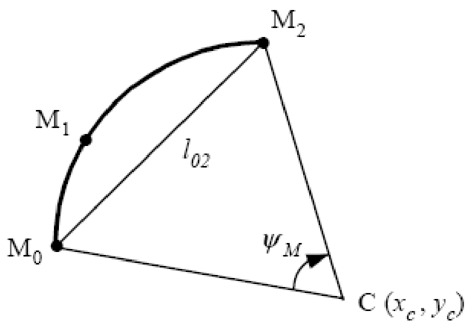


Fig.2 Elementary displacement on a circular arc

$$x_c^2 + y_c^1 = R^2$$
$$(x_1 - x_c)^2 + (y_1 - y_c)^2 = R^2 \qquad (4)$$
$$(x_2 - x_c)^2 + (y_2 - y_c)^2 = R^2$$

The system's solution

$$2x_1x_c + 2y_1x_c = x_1^2 + y_1^2$$
$$2x_2x_c + 2y_2x_c = x_2^2 + y_2^2 \qquad (5)$$

leads to the discovery of the central circle coordinates (x_c,y_c) and of its radius R.

For the circle's arc engendering with the parameter Ψ, in the space $[0,\Psi_M]$ the parameter Ψ_M must be determined. Solving the triangle CM_0M_2, figure 3 we will obtain the span l_{02} and the central angle Ψ_M:

$$l_{02} = \sqrt{x_2^2 + y_2^2} \tag{6}$$

$$\psi = 2tg^{-1} \frac{l_{02}}{\sqrt{4R^2 - l_{02}^2}} \tag{7}$$

Being given the tangential velocity $v_t = \frac{ds}{dt}$ and using the finite difference it is obtained:

$$\Delta\Psi = v_t \frac{T}{R} \tag{8}$$

where: $\Delta\Psi$ is the step of the parameter Ψ, for the circle's arc engendering at a sample period T.

The position references can be engendered through the equations:

$$x = \pm R(l - \cos\Psi)$$
$$y = R\sin\Psi \tag{9}$$

where the sign "±" depends on the way in which the arc circle is crossed.

When the extremities of the segments M_1 and M_2 are reached, this will become M_0 for the next segment. The position references for the locomotion function will be determined, while the segment (with a current point M) is being crossed, by sampling with a period T<<τ.

3. THE DESIGN OF THE STEPPING ROBOT WITH SIX FOOTS

A basis conditions, imposed as early as the design phases, is the robot stability.

The stability of the stepping robots must be studied differently:

- walking – dynamic stability;
- stationary – static stability.

The structure's diversity is very big. The most usual structures are the 2d structures.

The mechanical structures of the animals are adjusted to there necessities. the foot's number is an important element because it affects many proprieties of the stepping robot.

In figure 3 is presented the scheme of the stepping robot with six foots presented by the authors. The actuating is realized through two engines, and the transmission is using mechanisms with gear wheels. a controller realizes the command and the control.

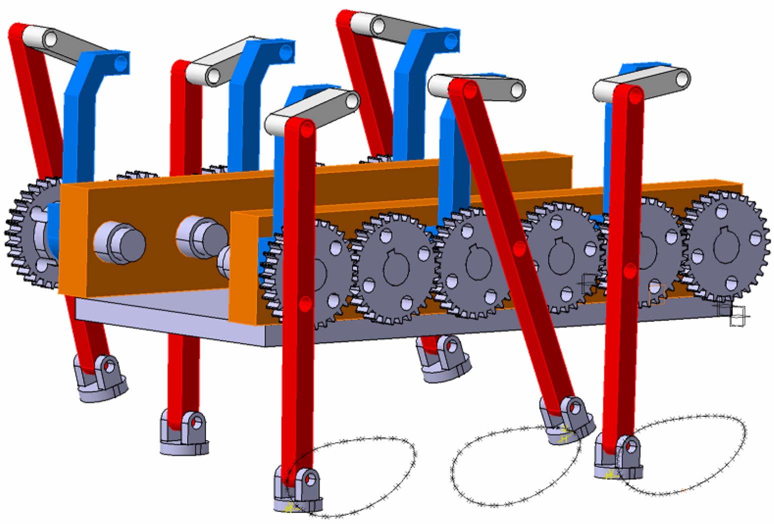
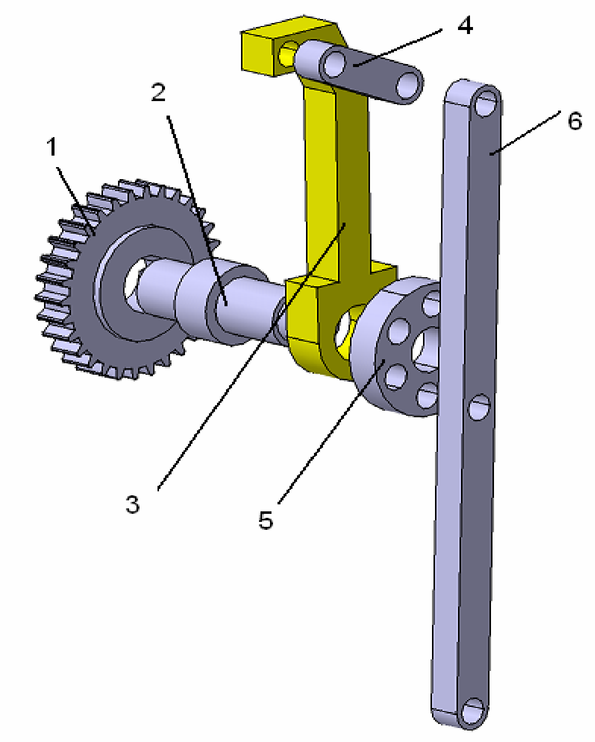


Fig.3 The scheme of the stepping robot with six foots

The robot's foots are driven by the gear wheels and these are working three-by-three. The foot pairs 1, 3 and 5 respectively 2, 4 and 6 are moving simultaneous realizing the robot stepping. The robot's foot is a quadrangular mechanism of type 4R, figure 4.

In figure 5 there is presented the stepping diagram of the robot. The stepping is realized in the periods $t_1 \ldots t_4$ corresponding the foot actuating.



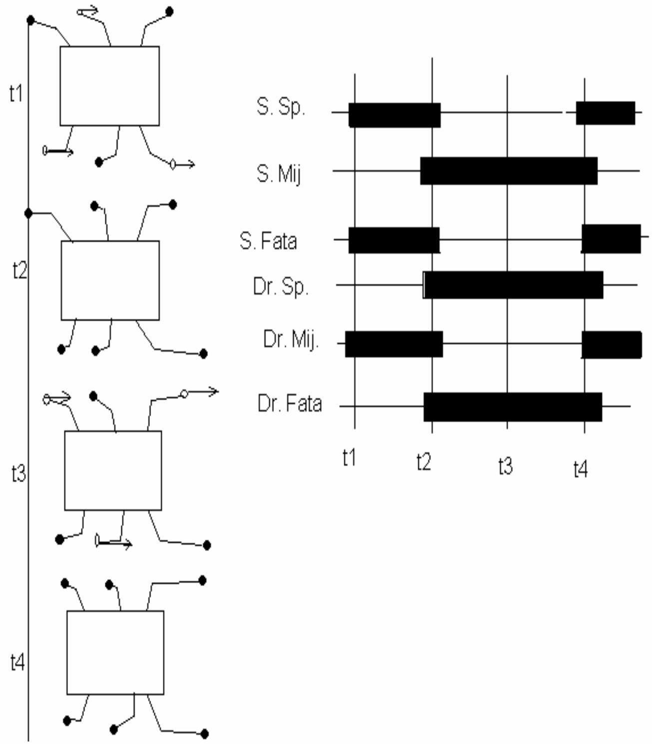


Fig. 4 Mechanism of type 4R.

Fig. 5 The stepping diagram

4. CONCLUSION

The assembling mode of stepping robot's foots has an important role concerning the stepping. Using different reduction ratio in the actuating systems, an optimal variant for the robot's stability can be obtained. As the robot stepping is slower, the robot's stability is better.

The execution errors and the assembly errors lead to the robot's instability.

The use of the quadrangular mechanism, in the foot structure, allows the description of the tiller curves when the stability function is chosen. Thus a pull, without the body control position, had been realized.

Using the 2D structures and the actuating with rotary engines, the working space is in acceptable limits.

5. REFERENCES

1. Beom, H.R. Cho, H.S. A Sensor – Based Obstacle Avoidance Controller for a Mobile Robot Using Fuzzy Logic and Neural, Network WWW
2. Dudita, Fl., Diaconescu, D. Optimizarea structurala a mecanismelor. Editura Tehnica, Bucurasti 1987.
3. Robin, R. Murphy, Introduction to a Robotics. MIT Press 2000.
4. Ulrich, N. Mobile Robotics: A Practical Introduction. Springer – Verlag 2000.

Mind Storm Robotics Invention System, User Guide. The Lego Group, 1999.