

A Novel Manipulator for a Stone Protector of Stony Soil Tillage Implement

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Abstract. This paper studies a novel manipulator for a stone protector of stony soil tillage implement. According to the virtual reality technology based method, the composition technology of the virtual model of the novel manipulator is described in detail. This virtual model is used for the compilation of a video clip which simulates the motion of the model. The obtained results and a special computer program, realizing the virtual reality technology based study of the working process of the novel manipulator, can be useful for real time manipulator designers.

Key words: Agricultural machinery, field tillage machines, virtual reality technology, modelling, manipulator, stone protector

INTRODUCTION

Olt, Heinloo (2009) have studied a virtual model of a stone protector with safety device DEICLG (Fig. 1). They have examined the process of switching on the safety device DEICLG, when the point M meets an obstacle and cannot move to the left, as in Fig. 1.

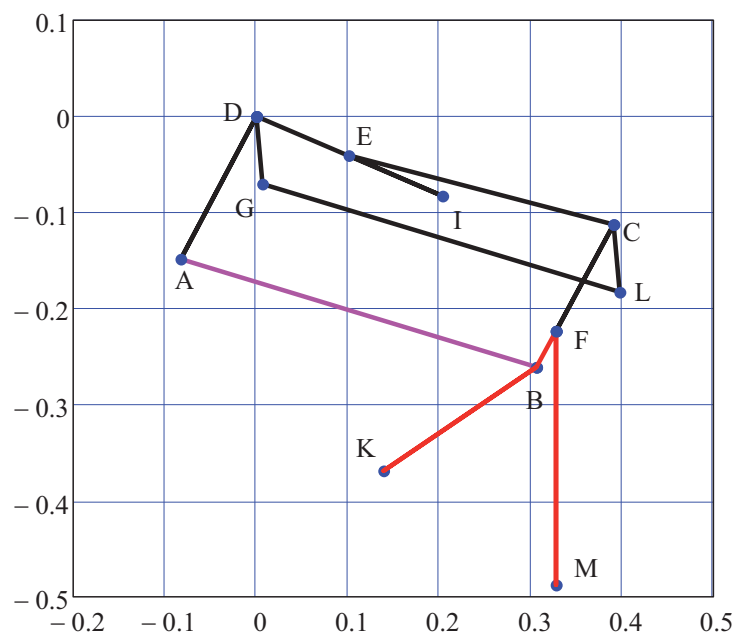


Fig. 1. Manipulator with the safety device DEICLG for a stone protector.

The virtual reality technology based method, used in the paper by (Olt & Heinloo, 2009), has earlier been used in studies on the working processes of elements of agricultural machinery by (Heinloo et al., 2005), (Heinloo & Olt, 2006), (Heinloo, 2006), (Heinloo & Leola, 2007) and reviewed by (Heinloo & Leola, 2008).

This paper presents the results of studying the motion of the novel virtual manipulator (Fig. 2) for a Stone Protector of Stony Soil Tillage Implement. In Fig. 2 the points A and K are moving in a straight line and the point M in a prescribed curve.

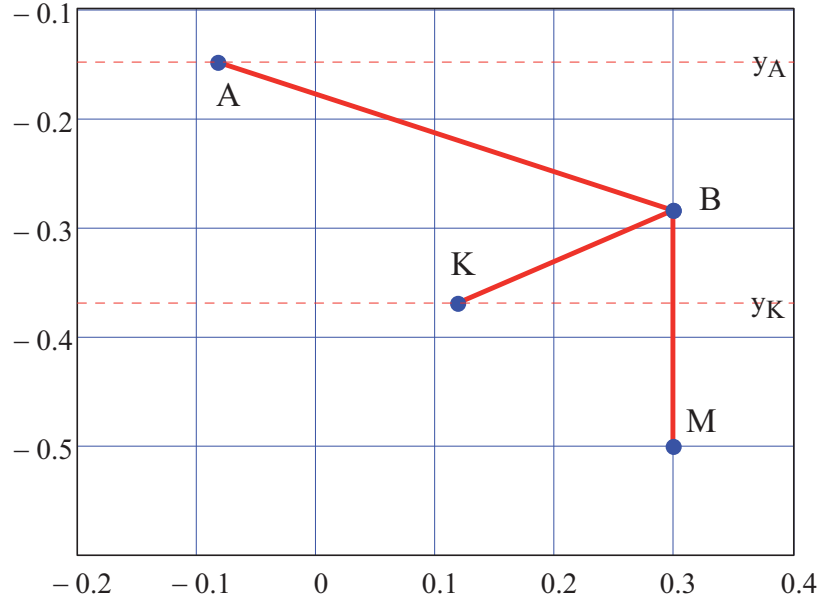


Fig. 2. Virtual model of the novel manipulator for stone protector.

CREATION OF VIRTUAL MANIPULATOR

To create a virtual model of a special manipulator ABKBM, let us suppose that the links AB and KBM (Fig. 2) have the following dimensions: $l_{AB} = 0.405$ m, $l_{KB} = 0.200$ m, $l_{BM} = 0.216$ m, $l_{KM} = 0.223$ m and at the initial position, the co-ordinates of the pivots A, B and points K, M have the following co-ordinates: A(-0.082 m, -0.149 m), B(0.299 m, -0.284 m), K(0.118 m, -0.369 m), M(0.299 m, -0.500 m). The vectors

$$x = \begin{pmatrix} A_{x0} \\ B_{x0} \end{pmatrix}, \quad y = \begin{pmatrix} A_{y0} \\ B_{y0} \end{pmatrix}, \quad x' = \begin{pmatrix} K_{x0} \\ B_{x0} \\ M_{x0} \end{pmatrix}, \quad y' = \begin{pmatrix} K_{y0} \\ B_{y0} \\ M_{y0} \end{pmatrix},$$

where A_{x0} , B_{x0} , K_{x0} , M_{x0} are initial x-co-ordinates and A_{y0} , B_{y0} , K_{y0} , M_{y0} – initial y-co-ordinates of points A, B, K, M, drawn in the worksheet of the Computer Package Mathcad novel virtual manipulator at the initial position (Fig. 2).

MOTION SIMULATION OF VIRTUAL MANIPULATOR

Let us suppose that the trajectory of the point M is given by the equations

$$\begin{aligned} X_M(\tau) &= M_{x_0} - a\tau, \quad g(\tau) = h \sin(10\tau - 1) - b, \\ Y_M(\tau) &= g(\tau), \text{ if } g(\tau) \geq -b, \text{ else } g(\tau) = -b, \\ &\quad (1) \end{aligned}$$

where

$$g(\tau) = h \sin(10\tau - 1) - b.$$

Here M_{x_0} is the initial x-co-ordinate of the point M (Fig. 2), τ – a no dimensional parameter of this trajectory, $a = 2$ – constant with the dimension m, $h = 0.12$ m – the height of the virtual stone, $b = 0.5$ m – the parameter that determines the position of the virtual stone underground. The trajectory of point M, determined by the formulas (1), is modeling the profile of a virtual field with a stone (Fig. 3).

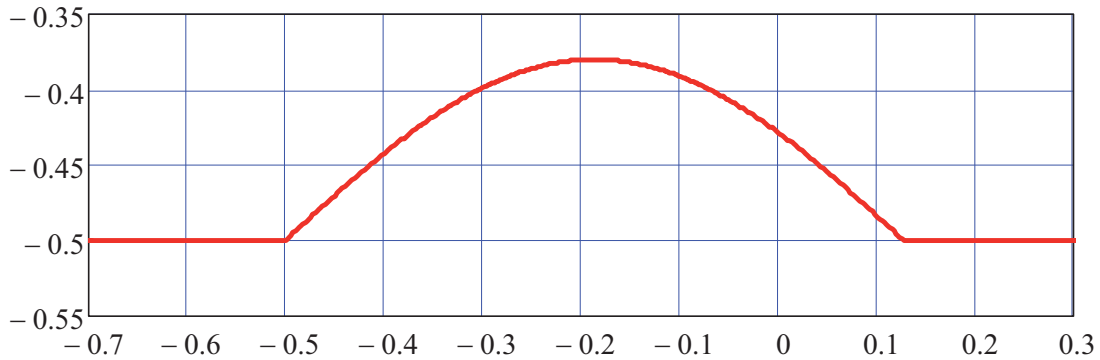


Fig. 3. Supposed trajectory of the point M (Fig. 2), modelling the profile of a virtual field with a stone.

The co-ordinates B_x, K_x, B_y , and the parameter τ at the moment of the time t can be found out from the following system of nonlinear equations:

$$\begin{aligned} (B_x - A_{x0} + vt)^2 + (B_y - A_y)^2 &= l_{AB}^2, \\ [K_x - M_x(\tau)]^2 + [K_y - M_y(\tau)]^2 &= l_{kM}^2, \\ (K_x - B_x)^2 + (K_y - B_y)^2 &= l_{KB}^2, \\ [B_x - M_x(\tau)]^2 + [B_y - M_y(\tau)]^2 &= l_{BM}^2, \\ &\quad (2) \end{aligned}$$

where $v = 2 \text{ m s}^{-1}$ is the given velocity of the point A, supposed to be connected to the tractor. To simulate the motion of the virtual stone protector let us define the new vectors

$$x(t) = \begin{pmatrix} A_{x0} - vt \\ B_x(t) \end{pmatrix}, \quad y(t) = \begin{pmatrix} A_y \\ B_y(t) \end{pmatrix}, \quad x'(t) = \begin{pmatrix} B_x(t) \\ K_x(t) \\ B_x(t) \\ F_x(t) \\ M_x(t) \\ F_x(t) \end{pmatrix} - s(t), \quad y'(t) = \begin{pmatrix} B_y(t) \\ K_y \\ B_y(t) \\ F_y(t) \\ M_y(t) \\ F_y(t) \end{pmatrix},$$

By the use of these vectors the video clip, showing the motion of the virtual stone protector (Fig. 2), was created. To show several frames from this video clip in the worksheet of the Computer Package Mathcad, we have defined the following vectors:

$$\begin{aligned} X &= \text{augment}(x(0), x(0.1), x(0.2), x(0.3)), \\ X' &= \text{augment}(x'(0), x'(0.1), x'(0.2), x'(0.3)), \\ Y &= \text{augment}(y(0), y(0.1), y(0.2), y(0.3)), \\ Y' &= \text{augment}(y'(0), y'(0.1), y'(0.2), y'(0.3)). \end{aligned}$$

Here the function *augment* (A, B, C...) returns the matrix, formed by placing vectors A, B, C... from left to right in the worksheet of the Computer Package Mathcad. Fig. 2 shows the created virtual model at the moment of the time t at $t = 0$ s. Fig. 4 shows the positions of the virtual manipulator in the process of overcoming a virtual stone. At that the arrows show the velocities of the points A, K, M and the pivot B (To see the motion simulation of the virtual manipulator, click on Fig. 4 in the online version of this paper).

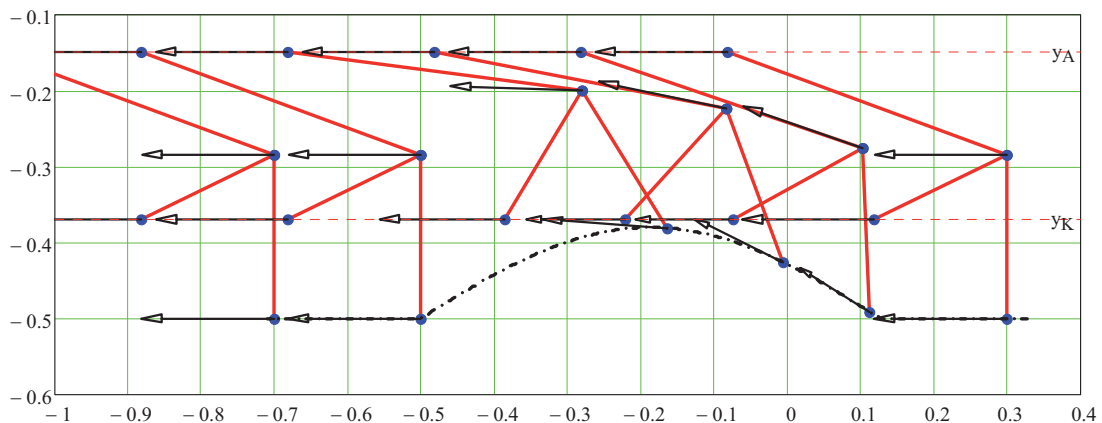


Fig. 4. Positions of the virtual manipulator while overcoming a virtual stone.

Let us now consider a case where the point M (Fig. 2) cannot move to the left. In this case instead of the system (2) the co-ordinates B_x, K_x, B_y, M_y in dependence of the time t must be found out from the following system of equations:

$$\begin{aligned} (B_x - A_{x0} + vt)^2 + (B_y - A_y)^2 &= l_{AB}^2, [K_x - M_{x0}]^2 + [K_y - M_y]^2 = l_{KM}^2, \\ (K_x - B_x)^2 + (K_y - B_y)^2 &= l_{KB}^2, [B_x - M_{x0}]^2 + [B_y - M_y]^2 = l_{BM}^2, \end{aligned} \quad (3)$$

Fig. 5 shows that in this case the manipulator lifts the point M up (To see the motion simulation of the virtual manipulator, click on Fig. 5 in the online version of this paper). At that the arrows show the velocities of the points A, K, M and the pivot B (To see the motion simulation of the virtual manipulator, click on Fig. 5 in the online version of this paper).

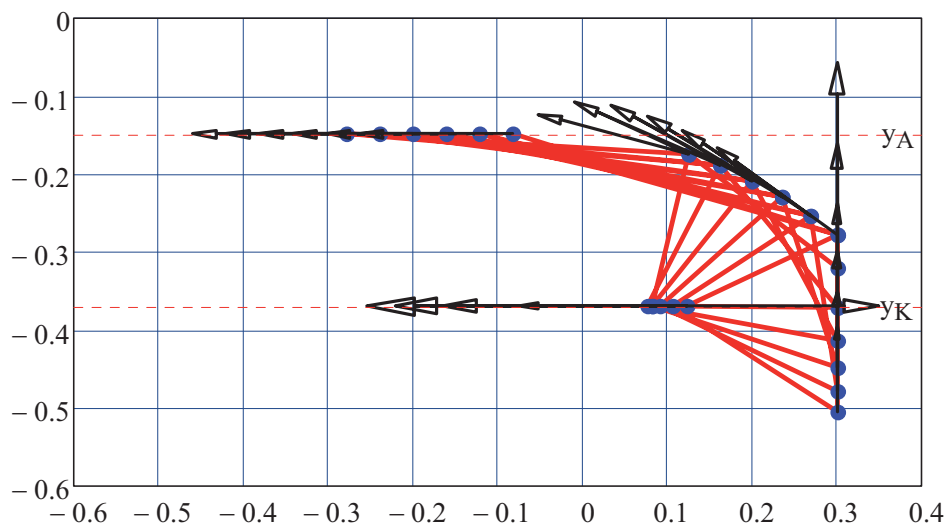


Fig. 5. Positions on the virtual manipulator when the point M (Fig. 2) cannot move to the left.

CONCLUSIONS

The paper concludes that the manipulator in Fig. 2 can be used as a stone protector for stony soil tillage implement. It is able to free a working tool from behind an obstacle and protect the working tool from damage.

The paper has also demonstrated the possibility of creating the manipulator in Fig. 2, three points of which are moving along the prescribed lines.

REFERENCES

- Heinloo, M., Leola, T., Veinla, V. (2005) Synthesis of the Manipulator for the Scraper of a Press Manure Removal. **In:** CIGR Ejournal, vol. VII, 15 p.
- Heinloo, M., Olt J. (2006) A Method of Virtual Reality for Creating a Disk-Ridging Tool. **In:** CIGR Ejournal, vol. VIII, 21 p.
- Heinloo, M. (2007) A Virtual Reality Technology Based Method for Study the Working Process of a Blueberry Harvester's Picking Reel. **In:** CIGR Ejournal, vol. IX, 12 p.

- Heinloo, M. Leola, T. (2007) Development of Virtual Reality Technology Based Analysis and Synthesis of a Planar Manipulator. *Proceedings of the 12-th World Congress in Mechanism and Machine Science*. Besancon (France) 17–21, 6 p.
- Heinloo, M., Leola, T. (2008) Review on Development of Virtual Reality Technology–Based Methods for Design of Agricultural Machinery. **In:** *Proc. Int. Conference AgEng2008*, Hersonissos (Crete), 12 p.
- Olt, J., Heinloo, M. Virtual Reality Technology Based Study of the Working Process of Stone Protectors for Stony Soil Tillage Implements. **In:** *XXXIII CIOSTA- CIGR V Conference*, Reggio Calabria (Italy), 2009 pp. 541-545.