3D SCANNING AND COMPUTER ANALYSIS OF MORPHOLOGICAL ASPECTS FOR AGRICULTURAL APPLICATIONS

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Abstract

In our research work we tested the conventional methods made moldboards.

Below the testing processes are presented, covering practical and mathematical applications. The used tools and the examined mouldboard will be presented. This article summarizes the objective and empirical results that can be gleaned from the results and conclusions.

Keywords

agricultural, 3D scanning, mouldboards, surface analysis, crop

Introduction

The mechanization of the agriculture was already significant from the end of the 19th century and this sector's technical development accelerated rapidly. Our topic's subject is the mouldboard which is an important component of the soil tillage plow. The mouldboard has got a special free surface. For editing these surfaces we have to use specified methods.

Modeling the surfaces or their numerical description is not as simple as the determination of an elementary geometry such as a description of a flat or a cylinder surface. However the editing of these multi curved surfaces can be divided into elementary geometrical sections. Before the appearance of the computer science, planning the mouldboard was based on handmade edits, then after finished the testing of the prototypes it was able to develop through experience.

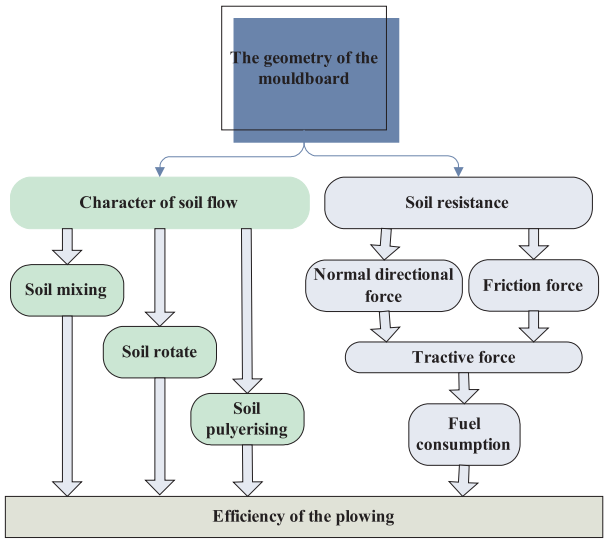


Figure 1. Effect of the mouldboard's geometry to the plow's efficiency

Nowadays with the high capacity computational background is not only possible to product a computing geometry, but testing the geometry of the mouldboard effect for the soil flow. The first picture represents the effect of the mouldboard's geometry to the plow's efficiency. All these requires to testing the geometry of the mouldboards. We made morphological tests in our own edits and geometric models, furthermore with digitizing the existing mouldboard we recognized the function of the definig parameters of the plow. Of imaging methods, the 3D laser scanning imaging method is used in the recent decades at testing the free surfaces after production. For the investigations we studied the preparation of the existing techniques than selected the most suitable system of tools and methods.

So the actuality of the topic is the research of the "old" conventional device with a "modern" geometric modeling tool.

Methods and materials

In our study we performed several practical measurements and scanning by different types of mouldboards, to lean on theoretical knowledge. The second figure demonstrate sub-elements of the research process in high scale.

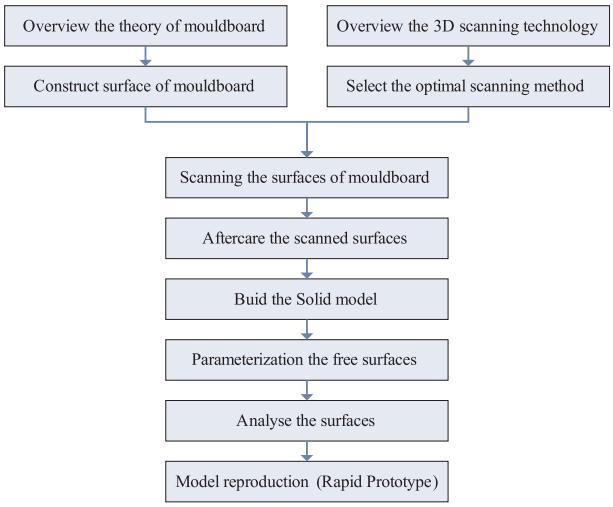


Figure 2. Sub-processes of investigation

Applied devices

To carry out the computerized testing was required to use a complex toolbox. In the process of digitalization we converted the analog signals to digital signals. In our researches we used several attributes, according to the current model. Besides the software's project files (*. stl) file extensions were used during the scanning and post productions. In the parametric editing system the CAD system's own (*. sldprt) extension was applied. For the math tests, determine the n-degree polynomials (*. obj) extension was used.

We used ZScanner 700 for the three-dimensional scanning of mouldboards, this can see upper. The laser scanner is a device which have two cameras, a laser unit and with an auxiliary light. This scanner can map digital surfaces with reference point. The device's accuracy is 50μm normal to the laser line and 100 μm parallel to laser. The scanner's available highest resolution is 0,2 mm.

As closing the research work, we prepared a real scale-model with a rapid prototyping manufacturing system. We used a ZPrinter 350 three-dimensional printer in this workflow, the third picture shows this device.

Figure 3. ZScan 700 and ZPrinter 350

Materials of the research

In our research work we tested four different kinds of mouldboards as is seems in the 4th picture. We were chosen for the tests the culture and the half-twisted mouldboards which are used in the Hungarian agriculture. These mouldboards are made by Kühne. The samples were old and new as well so we could observe the abrasion characteristics. We were digitized all the sample's surfaces, but we only defined the culture mouldboard's control curve.

Figure 4. The four different kinds of moudboard

The topic and the main goals of the research could be recorded if we know the necessary tools and methods. The final result of the research work is not just the determination of numerical results, but also a development of the method itself and an automatable process.

Based on these the desired goals can be fixed in the following three points.

– The numerical description of the mouldboard's surface.
– Compare an edited and a digitised mouldboard's parameters.
– To discover the limits and possibilities of the 3D scanning.

Research

Our investigations can be divided in three parts. To editing and scanning the mouldboard and the determination of the control curve. During the editing we have done the necessary calculations to the determinate the constructional sizes. We were made these starting from basic and empirical data. The geometric model's construction was made in CAD system. With the standard editing we wanted to set up a reference next to the digitized mouldboard. We would like to demonstrate the authenticity of modeling with this.

Mouldboard editing

In the standard editing should clearly define the type of soil and the type of machining. The first table includes these parameters. The width and depth of the plowing determinate the mouldboard's necessary sizes. Each angle range determinate the plow's character of tillage, the measurement of the rotate and pulverising.

Table 1. Basic parameter for mouldboard editing

The plowing depth	a= 270 mm
The width of the plow	b= 350 mm
Angel between the plow and the furrow	α= 30°
The angel of the main component	γ_0= 42°
The last component angel	γ_t= 47°

The following three equation (1. 2. 3.) illustrate the necessary contexts for the basic editing illustrated in figure number 5..

$$h = \sqrt{a^2 + b^2} = \sqrt{(270mm)^2 + (350mm)^2} = 442[mm] \quad (1)$$

The "h" as a diagonal slice of the soil, determines the necessary height of the mouldboard.

To rotate a suitable piece of soil, an accurately created bending radius is needed. Therefore the minimal and maximal bending rays had to be determined with calculation. With the calculation on picture number 5 can be editing the mouldboard's projection of working surface.

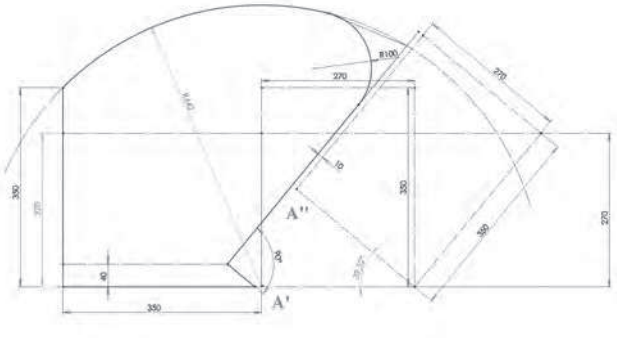
$$R_{\min} = \frac{b}{\left(\frac{\pi}{2} - \alpha\right) \cdot \cos\gamma_0} = \quad (2)$$

$$\frac{35mm}{\left(\frac{\pi}{2} - 0{,}52\right) \cdot \cos 42°} = 459{,}7\ [mm]$$

$$R_{\max} = \frac{b \cdot \sqrt{k^2 - 1}}{k^2 \cdot \left(\cos\alpha - \frac{\cos\gamma_0}{\sqrt{k^2 - \sin^2\gamma_0}}\right)} = \quad (3)$$

$$= \frac{35mm \cdot \sqrt{1{,}4^2 - 1}}{1{,}4^2 \cdot \left(\cos 0{,}52 - \frac{\cos 42°}{\sqrt{1{,}4^2 - \sin^2 42°}}\right)} = 667{,}7\ [mm]$$

In the editing can be seen the case of dimensional editing the mouldboard's surface can be performed by two surfaces. The closed surface specify the mouldboard's outer contour, the opened surface forms the working surface with the control curve and assistant components.



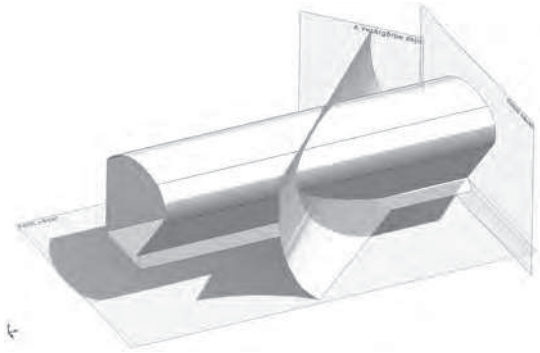


Figure 5. The edited culture mouldboard

Mouldboard scanning

The chosen mouldboards are made with the previously described editing procedures. Without documentation, the free surfaces with this digitizing procedure can be reconstructed in a unique way. For the digitalization the model's surface had to be matte, and had to be added the necessary reference points.

The model prepared by the laser scanner is build up from a point cloud in the first step, which can be converted to surface or solid models with the model-building steps used by Reverse Engineering as W. Wang (2011) describes it.

In picture number 6 there are four different kinds of mouldboard's rough surface. These are suitable for the production of solid models after the appropriate post production.

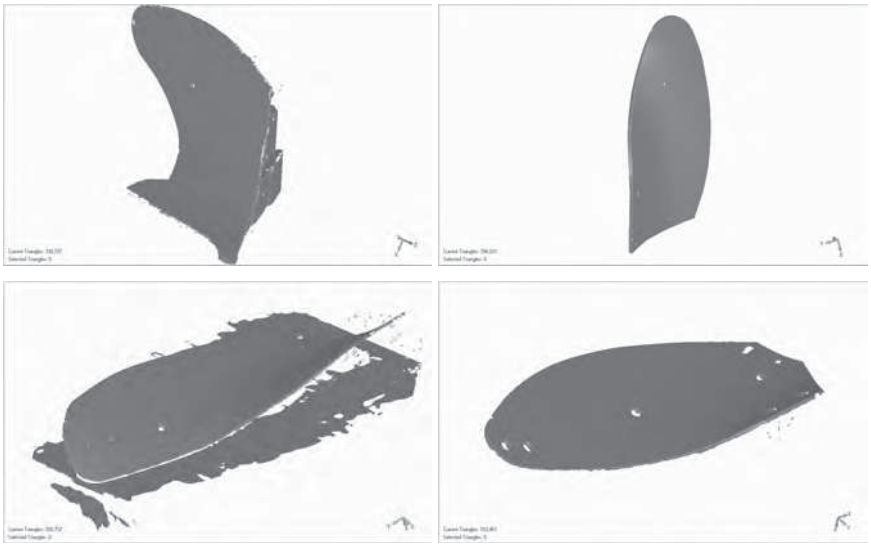


Figure 6. The four different kinds of scanned surfaces

There are not discussed the practical steps of scanning but it is important to note that the NURBS-based surfaces have been suitable from the triangulated surface models to product the relevant control curve. During the NURBS- based surface description each control points are special (W) which only locally influences the curve's editing. The rational based theory of the curve and surface description (P. Radhakrishnan, 2008) és (G. Farin, 2002) described as an interpolation, where the direction of continuous curves matching with weighted points.

$$P = (W_i X_i , W_i Y_i , W_i Z_i , W_i) \quad 4$$

Control curve editing

Based on the mouldboard's control curve can define the mixing, rotating and pulverizing (Bánházi J., 1984). The assistant components are turning around the control curve. At the case of culture mouldboards according to the editorial principles the mouldboard is located at 2 / 3. The plain engraving created here, gives the line of the control curve. On the left side of the 7th picture there is the edited, on the right side there is the scanned mouldboard's control curve's point recording. As the mouldboards have got continuously curved surfaces, the control curve can be described with second instance polynoms.

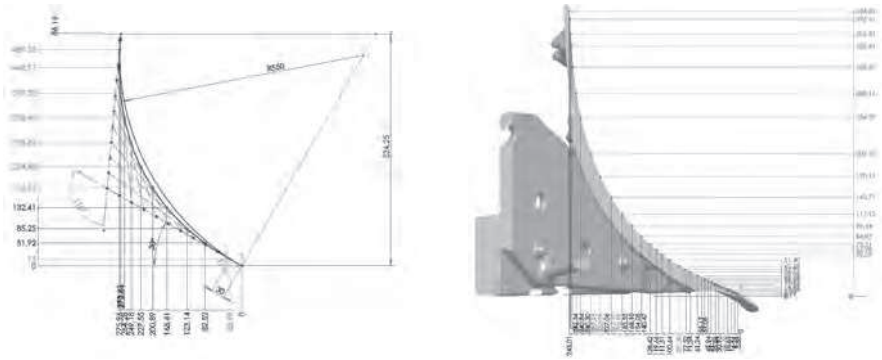


Figure 7. The point cloud

In the 8th picture are shown the polynomials are fitted to the points which are recorded in the surface. The diagram shows that the **horizontal** axis L (deepness of the parabola) and the **vertical** axis H (height of the parabola). When editing the mouldboard, the parabola of the control curve is characterized by with these parameters.

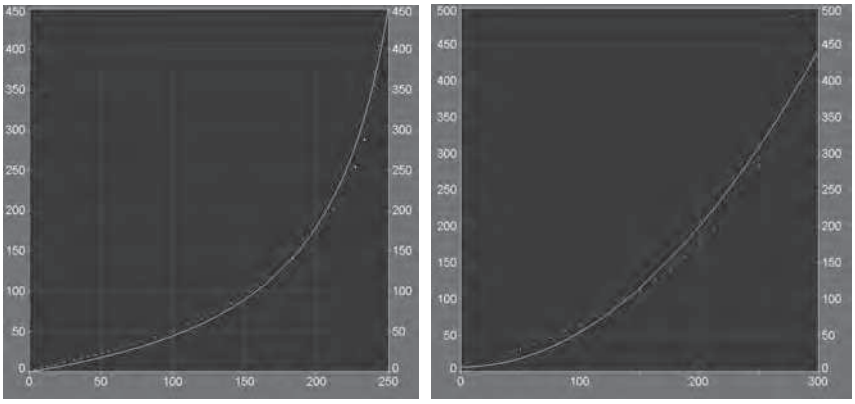


Figure 8. The control curves from scanned and edited mouldboard

To fitting the polynom we are using 100-100 points and 20 are control points all of these. The two following second instance equation shows that the two cultural designed surfaces can be characterized and comparable with their control curve.

Scanned: y = 0,00585x2 - 0,2548x + 0 R2 = 0,9653
Edited: y = 0,006x2 - 0,3x + 3,889 R2 = 0,9528

The differences of the deepness and highness suggests to the planned difference between depth and width of the plowing. The constant parameter of the equation describes the vertical axial position. With coordinate transformations both curve can fit to the 0, so depend on the y angle's rate of change comparable in the two cases.

Results

The test's objective results are the control curves describing second instance polynomials, equations. As we know the control curve the mouldboard become reproducible without documents and provide identification of export opportunities.

We proved the applicability of the digitization process with the similarity of the edited and digitized control curves of the mouldboards. The scanned control curve's: $y = 0{,}00585x^2 - 0{,}2548x + 0$ and the edited control curve's: $y = 0{,}006x^2 - 0{,}3x + 3{,}889$ character is similar.

For the mouldboards analysis and development we created a new modeling method during the test. Currently the system is able to semi-automatic process. A quick analysis is possible with it.

To complete the research work we created the digitized mouldboard's realistic model at M1: 5 scale, it can be seen in the 9th picture.

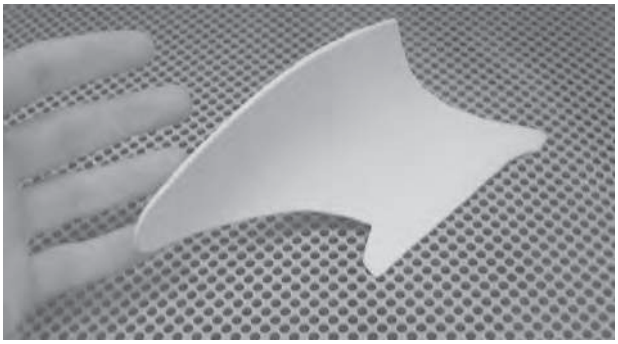


Figure 9. Scale-modell of the plow

Conclusions

This form of usage of the digitization process seems to be the optimal solution to product geometry of free surfaces like the mouldboard's surface.

The used method seems suitable to describe each control curves which is not a self-serving process, but also may be a well-written key for solving review and improvement problems. Taking this advantage it can be used during the operation monitoring and the abrasion rates are detectable along the surface. These mouldboards could be re-planable as the results of these improvements.

The further development of the used method could be the basis of optimization tasks based on genetic algorithm work surfaces.

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