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COMPUTER AIDED OPTIMIZATION OF QUALITY INSPECTION METHODS FOR COMPLEX MODELS USED IN BIOMECHANICS

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Abstract: *The paper presents the way in which different methods that ensure the quality inspection for some complex models with application in Biomechanics were applied and evaluated. In our research, the object for study as Biomechanical model was a primary model for a human foot of a normal subject without locomotion disabilities. The aim of the research on the model quality inspection methods optimization refers to find a flexible and efficient solution to obtain the CAD model of some orthopedic elements which could be prototyped, adjusted and adapted to the shoes of some subjects with stability or locomotion disability.*
Key words: *flatfoot, mould model, scanning, quality inspection*

1. INTRODUCTION

Due to the fact that nowadays Biomechanics is a domain which presents more and more interest, we found that a study on the human stability and locomotion parameters correction could be very actual and full of benefit. Our research will refer to the prosthesis and orthesis of the human foot, for the stability and locomotion rehabilitation and correction. For different type of accidents (fractures, tissue hurting), a very high bio-compatibility of the used materials when developing some prosthesis is a very important problem. The researchers Wintermatel and Mayer (1999) extended the bio-compatibility definition as two main types: intrinsic and functional biocompatibility. The first one refers to the resistance of the prosthesis from the point of view of corrosion and mechanic behavior. The second type of prosthesis biocompatibility refers to following characteristics: bio-stability, surface and deep structural composition. Taking into account the bio-compatibility of materials composing prosthesis, in the present the research consists into developing different solutions. One of these is refers to the rapid prototyping, using different bio-compatible and resistant materials, the method being very flexible for any type of prosthesis (Burghilde, 2003). On the foot orthesis, the actual researches refer to develop some innovative solution to correct himself the stability and locomotion parameters progressively.

2. RESEARCH OBJECT

Taking into account the actual researches on the foot prosthesis and orthesis, the aim of our study is to develop a rapid, efficient and non-expansive solution on the rapid prototyping of foot orthesis, like sole parts, that will be disposed progressively on the shoes, to help some persons with stability or locomotion disabilities to correct the specified parameters. Our research issue is to generate the virtual models and than to perform the rapid prototyping for a progressive orthesis family for the human foot posture correction. The progressive orthesis family refers to a range of orthesis, same type, having progressive dimensions, which can be adapted on the flatfoot persons' shoes, due to the fact that the flatfoot disease can lead to different locomotion or stability problems. That means that the human subject will progressively correct its flatfoot by disposing to his shoes some orthesis beginning with small dimensions and, if necessary, continuing with increased orthesis dimensions.

3. THE RESEARCH STEPS

Our research invokes the following steps:
1. The human foot mould model realizing, providing from a person with flatfoot;
2. The mould model scanning to generate its CAD virtual model;
3. The obtaining and modeling of a virtual foot orthesis based on the CAD foot model, previously generated by scanning;
4. The behavior simulation of the modeled foot orthesis for different static and dynamic environment conditions (standing, walking);
5. The rapid prototyping of the modeled and tested (by simulation) foot orthesis;
6. The repeating of the procedure consisting in modeling, simulation and prototyping, in order to obtain other symmilar orthesis with increased scalled dimensions which compose an orthesis family.
7. The foot progressively correction of the human subject's flatfoot, by adapting his shoes with prototyped orthesis having progressive dimensions.

The paper describes the present level of our research, the first two steps, namely the mould model obtaining and its scanning for the CAD profile generating. In order to find more quickly the better method, for the beginning we proceeded to obtain the foot mould model providing from a human subject without locomotion or stability diseases.

4. THE FOOT MOULD MODEL OBTAINING

The first step of our research was to realize a first mould model of a human foot (figure 1), of a normal, without stability or locomotion disabilities subject. Concerning the materials composing the first model, in our research we found that the combination: gypsum (45%), water (50%) and adhesive for buildings (5%) was the best from the point of view of the expenses and surface quality to be examined by scanning.

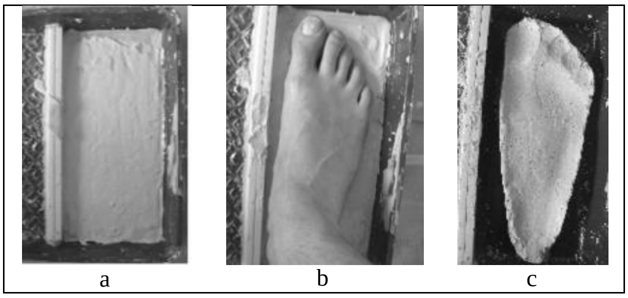

Fig. 1. The phases to obtain the first mould model of a human foot without stability and locomotion disabilities.

5. THE FOOT MOULD MODEL SCANNING

The reason of scanning the first mould model is to generate a CAD model to be further analyzed in order to conceive a first virtual orthesis based on it. The virtual orthesis will be tested by simulation in different static and dynamic conditions.

For the model scanning we used two different methods, the issue of our study in this phase being to establish method is better from the following point of view: scanning accuracy, necessary scanning time, the obtained CAD virtual model.

The first method refers to the using of a coordinate measuring machine, *DEA GLOBAL Performance* (Italy), with the the measuring accuracy of 0.001 mm (Braun et al., 2009; Demian et al., 1991; DEA Global).

The second method invoked the use of a 3D handy scan with laser beam, *EXAScan 30144* (Canada), having the resolution of 0.05 mm (***, 2008).

The mould model scanning using the first method, with the coordinate measuring machine was made by touching point by point the probe's surface. To perform the model scanning, the *PC-DMIS* software interface of the measuring machine was used (Wilcox Associates). As an option to scan, we have choose the *Patch* method, with the increment of 4 mm for x and y axis (figure 2). In our research we found that the scanning increment equal to 3 or 4 mm for both axe is optimum by the point of view of accuracy and efficiency.

Due to the irregular geometrical form, in order to ensure a proper scanning we proceeded to establish 7 distinct areas ($S_1 \div S_2$) for scanning (figure 3).

The graphic result after the model scanning in a cloud of points (figure 3), compatible with the CAD environment, which will be forwardly processed and modeled.

The second method for scanning invokes a non-contact with the model's scanned surface. For this reason, as a first step, we have calibrated the scanner, in order to increase its scanning accuracy and to establish properly the sensor's measuring range.

After that, we proceeded to scan the model's entire surface, respecting the necessary measuring distance. As a result we obtained virtual model (figure 4) that will be imported and modeled in the CAD environment.

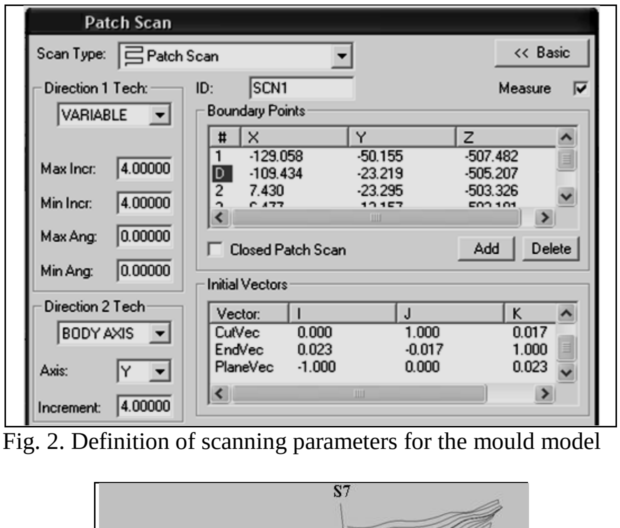

Fig. 2. Definition of scanning parameters for the mould model

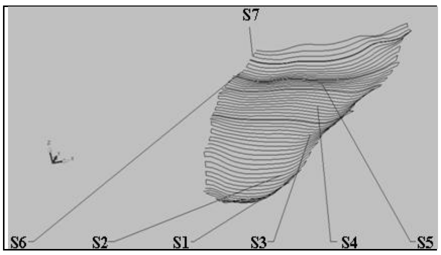

Fig. 3. The graphic results after scanning using the coordinate measuring machine, *DEA GLOBAL Performance*

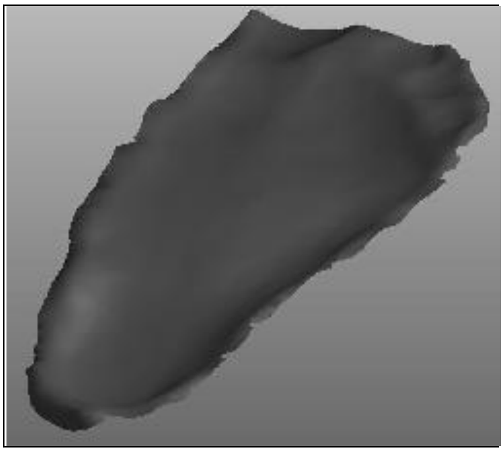

Fig. 4. The graphic results after scanning with the 3D handy scan, *EXAScan 30144*

4. CONCLUSION

When scanning, two different calibration methods were used: the *manual* and the *auto adjust* calibration. The manual calibration means to establish the proper distance scanning while adjusting by software the scanning resolution. The auto adjust calibration method refers to the scanner auto-calibrating by software. The scanning operation was made successfully using each of calibration metods. In the 1st case, the accuracy was very high, the necessary time for scanning being about 11 min. For the 2nd case, the necessary time was about 5 min, but for the complex areas (for example the fingers area) the obtained image quality was not enough high. In our research the area of interest excludes the complex zones, like fingers area or outside borders. For this reason we found that, for this kind of application, the scanner auto-adjust calibration method is better by the point of view of scanning efficiency.

For the future, our research will be focused on the CAD modeling of a foot orthesis, which, furtherly, will be simulated for different static and dynamic conditions which appear in real situations (standing, walking and runing). The research will continue also for human subjects with some disabilities, like flatfoot and stability or locomotion diseases.

5. ACKNOWLEDGEMENTS

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