The 8th International Scientific Conference
eLearning and software for Education
Bucharest, April 26-27, 2012
10.5682/2066-026X-12-066

ADVANCED VIRTUAL FOOTWEAR DESIGN, BY RENDERING SHOE MODELS, INSTEAD OF DRAWING

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***Abstract**: Taking one step further in specialized footwear CAD applications, is generating the base shoe model, instead of interactive drawing. This original technique, treats a shoe design as a parametrical form, by associating modelling mathematical laws with each classical design step from the theory. By implementing this concept in computer programming, the research finalized with an innovative and powerful software for education, just reliable for eLearning, but research goal now has changed, and tries to develop the practical side of design, more oriented to eSupport.*

***Keywords:** rendering shoe models, footwear parametrical design*

I. INTRODUCTION

1.1. Scenario

After a negotiation meeting, a manufacturer owns the right to produce tracking boots over the next production season. However, the external negotiator is about to leave early in the morning, next day, and before signing the contract, there are needed samples. Bought sides agreed on sending the samples as soon as they are ready, through a courier service, but the manufacturer wants to surprise the negotiator, and give him the samples until he leaves.

There is needed to prepare all the footwear parts as soon as possible, and send them to the production line to obtain the tracking boot sample.

Considering he has all the materials he needs, the boot is send to the design department. Here, a model designer can figure it out only by looking at the boot what type of last should be used. So, he executes the special design software, and performs the following actions :

- loading the adeqvate last (*few seconds*);
- loading a specific construction net for this type of footwear (*instantaneous*);
- measures practical dimension on the real boot, and, using *special tools*, he replicates them into the computer (*half an hour for complex models; also, time decreases if data base contains a similar product*);
- once the design is ready, again, using *special tools*, parts are being individualized, and sent to the cutting machine (*half an hour for complex models*).

Using rapid prototyping, the tracking boot model is ready to enter on the production line in almost one hour. Manufacturing duration may vary, and correction might be necessary, so the final pair will be sent back to the design department for comparing with the original one and make necessary adjustments. In this way, the cycle starts again. Generally, during an 8 hour shift, there can be 3 such cycles, and one complex model, might be replicated in 12-16 hours.

Samples manufacturing duration is highly dependent on the design quality (*designer experience and software versatility*).

1.2. Research background

Developing a new concept for footwear design has started within the research department of *GH. ASACHI – Technical University of Iasi from Romania, faculty of Textile – Leather and Industrial Management*. The main reasons that started these research are, as follow :

● *actual software issues* – actual applications for footwear doesn't generally behave as expected, and sometimes they seem to be more oriented to reveal analytical results instead of practical ones.

● *designing speed* – generally, expert designers don't use software to create shoes, because there are practical methods much faster for that. To accomplish this, in the last years a new method was provided within the CAD applications, the *parametrical drawing*; these method create constrains between geometrical elements, but using it for shoes is not yet relevant, and generally the method is like a *lot of effort for less comfort*.

Research *tried and succeed* with eliminating this software issues, and also designing speed has been drastic reduced.

1.3. Paper concept idea

This paper provides a review of eLearning domains regarding a concept method for designing footwear. Information contained within this paper is intended to be useful for eLearning academics and practitioners, and hope that findings stimulate further research and development.

Paper's concept idea is focused on briefing this new design method, and how the final product – the software – can be useful for teacher, students and manufacturing.

1.4. Paper structure

In the following sections are listed main questions that triggered research direction, and so, our approach. Also, there are described research key concepts and examples to sustain them. The critical analysis provides information about research relevance. Finally, the main conclusions are revealed, and also directions for future work.

II. RESEARCH MAIN QUESTIONS - TRIGGERING the RESEARCH DIRECTION

The effort involved in these research had been guided by the following questions, grouped by research stages.

Stage 1 – review on actual CAD systems

● what is the difference between actual softwares for footwear design ?

● are all this differences real necessary ?

- *if YES, then there should be an application capable of managing all this differences …*
- *if NO, then what is the best approach ?*

● how relevant are the actual software approaches ?

Stage 2 – research goal

● what are the main challenges that a footwear design software should accomplish ?

- *base model designing;*
- *base model grading;*
- *estimation of needed material for manufacturing;*

● because each challenge might have different methods, which method is most suitable for a challenge ?

Stage 3 – software development

● what tools should be created to generate the desired methods ?

● what algorithm should be used to implement a tool into source code ?

● what architecture should be used to implement an algorithm ?

● which are the optimal domains for the architecture routines (*testing*) ?

● how can the architecture be changed to improve overall performance ?

● which variables should remain private, and which variables should the operator be able to acces through the software interface ?

● can there be designed a friendly interface ?

Stage 4 – critical analisys

● is the software reliable for mass-customization ?

● the software actions are more related to theory or to manufacturing ?

● can the software perform as eSupport or only as eLearning ?

● is there a complementary technology that might increase effectiveness of this software ?

● is this research suitable for manufacturing automatization ?

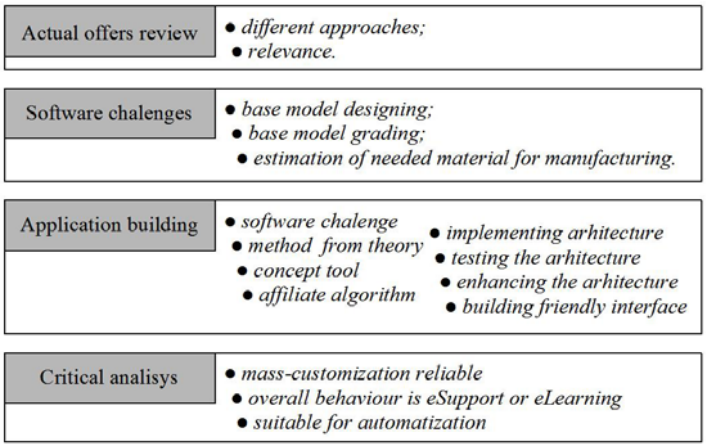


Figure 1. Steps of footwear design software development

III. APPROACH

After reviewing actual stage of footwear design, including software solutions, scientific and technical papers, professional journals, theory methods and web postings, there had been developed a concept method for shoe design, and also a software had been build to implement this new method. In addition, informal discussions with footwear designers had been used to rafinate the final product.

IV. RENDERING SHOE MODELS

a. Difference between designing by direct draw and by renders

The main difference is about the amount of work that an operator must supply when designing footwear; for example :

● *designing by direct draw* – the operator uses the available tools on the software interface to create the final design; generally, there are used tools for drawing geometrical elements (because each draw consists in rows of lines, circle, arches, sPlines, etc ..), and tools for editing (such as copy, delete, move, etc …)

● *designing by rendering* – the operator doesn't need to use classical tools, but he must provide exact values (numbers) for modelling; in this way, the interface doesn't have tools at all, and looks more like a control panel.

To accomplish this, for each theory stage of footwear design had been created routines, build on mathematical laws, in such way that they can model the initial theory stage. To achieve different behaviours within a stage, the main parameters for the mathematical laws is allowed to be changed by the designer through the interface.

In this way, for each design stage, there are request modelling parameters.

The originality of this product, is not that there had been used complex mathematical laws, but how current formulas can be chained together to deliver a faster design stage.

b. Classical footwear design stages and corresponding rendering

To illustrate how rendering design performs, will be short briefed the classic design theory stages and the corresponding software usage, for the model shown in figure 05.

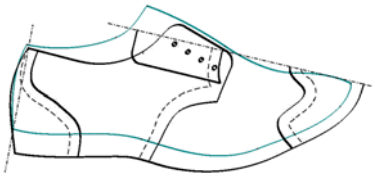


Figure 2. Classic shoe base model design for men

● Stage 1 – *setting the heal height*

Considering the medium last copy obtained (through 3D scanning, etc), during this stage the last is inserted inside the main reference system, rotated in such a way that the heal hight is equal with the final product heal height.

The operator is asked only for the absolute heal height value, and last insertion within the reference system is performed by the software.

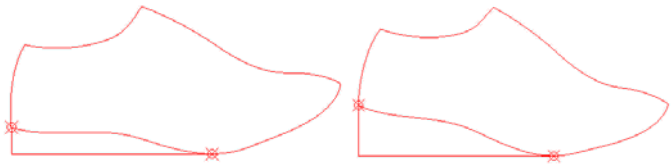


Figure 3. Footwear design by rendering – setting the heal hight (several layouts)

● Stage 2 – *the 5 base lines*

Theory suggests 5 base lines to be drawn over the last, at exact positions, as fractions of the last length. These lines contain important anatomic points, and they are vital for a healthy design.

The operator might adjust these lines positions by providing a value for a correction parameter; the lines are drawn by the software.

Figure 4. Footwear design by rendering – the 5 base lines (several layouts)

● Stage 3 – *specific construction net*

Depending on the design base model, there are specific construction net, to help creating the shoe parts (there is one specific net for shoes, one for boots, one for trackings, etc …).

The operator might adjust these lines positions, by editing correction parameters; the specific construction net is draw by the software.

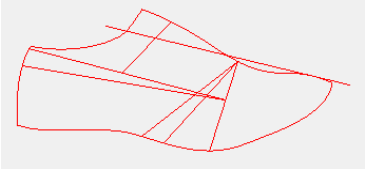


Figure 5. Footwear design by rendering – specific construction net

● Stage 4 – *spare contour*

Manufacturing shoes require a spare material under the last, to ensemble the upper flexible part with the rigid one (sole), that takes direct contact with the walking surface.

This spare is drawn through specific points under the last, which are at variable distances, depending on the relative position on the last; these distances are provided by theory, and also depend on the manufacturing process.

The operator is not required to determine this points exact position, but to provide their relative location on the last and corresponding offset distance; thus, the final points are calculated by the software, and also the perpendicularity on the main symmetry axis is verified.

Figure 6. Footwear design by rendering – spare contour (several layouts)

● Stage 5 –*parts design*

For each part, there is a control panel that allows access to modelling values. By changing these values, several design layouts can be obtained.

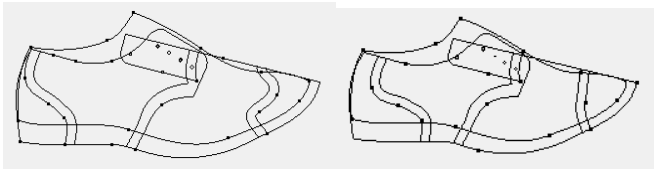


Figure 7. Footwear design by rendering – parts design (several layouts)

● Stage 6 – *parts detailing*

After base design completion, is required to detail the individual parts, for future processing, such as grading or nesting. Again, there is no need to use classical recommended tools (such as breaking, merging, rounding, grouping, etc); the parts detailing stage is performed by the software.

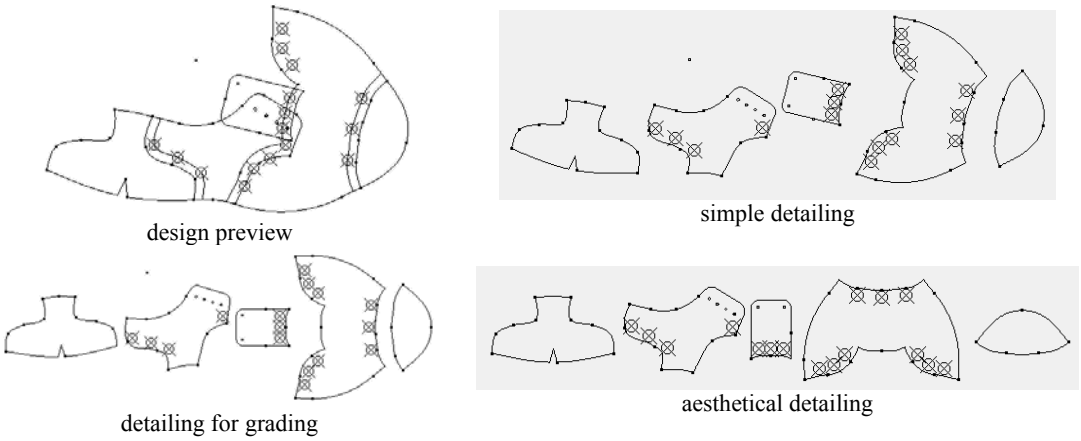


Figure 8. Footwear design by rendering – parts detailing (several layouts)

c. Rendering general usage manual

Through rendering, a base design can be obtained only from the last in less than a few seconds, and also, within 5 minutes can be obtained different model variations. With such a design

method, the operator work is drastical reduced, but, for better results, he should master the arts of footwear designing.

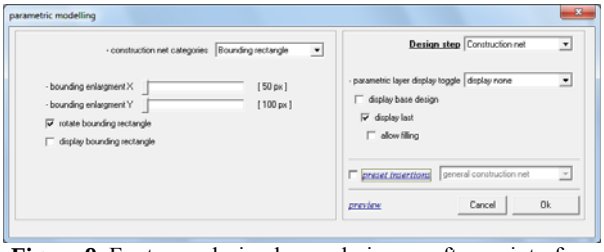
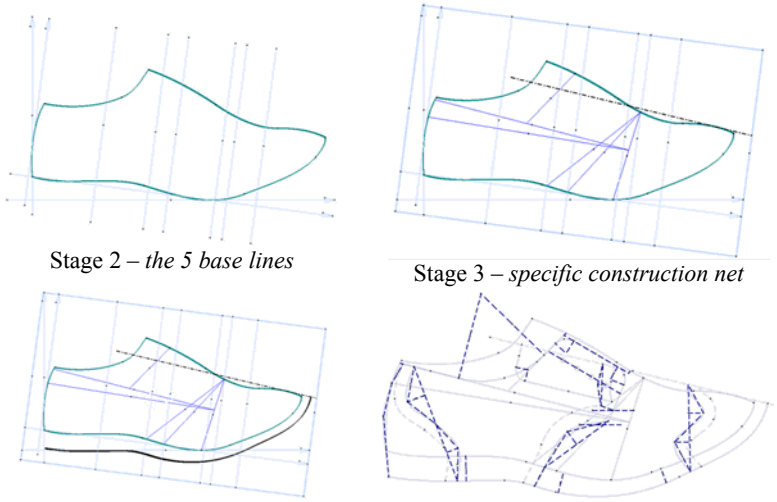


Figure 9. Footwear design by rendering – software interface

The interface allows access to each individual *design stage (step)*, where specific parameters for that stage can be modified, to obtain different layouts. The number of different final designs is the produce of all different stage layouts.

Is is not necessary to use the render until the final stage, rendering can be stoped at any intermediate stage, for different purposes, such as continuing with classical draw design.

Also, for faster usage, there are *preseted insertions*, which can stop the render at common design stages. In addition to modelling controls, there are other objects that control the graphical enhancements.



Stage 2 – *the 5 base lines*

Stage 3 – *specific construction net*

Stage 4 – *spare contour*

parametrical layer

Figure 10 . Footwear design by rendering – preseted insertions

d. Advantages for elearning Academics and Practitioners

● this concept product illustrates a *new method for designing footwear*, totally different if compared with actual software solutions, because it uses absolute values for modelling shoes, and *doesn't require editing tools*;

● eliminating actions with editing tools, rendering footwear design delivers *huge time economy*; complete designing duration is less then few seconds (~2-3 seconds) (normally needed to acces the first editing tool);

● this huge time economy *prevents users from losing focus*; because they reach faster the final design, there is more time to examine it, instead of losing time with drawing;

● because entire drawing is done by the software, the *users time and energy are saved*;

● *quick learning tool*; such a concept software can help teachers to expose better the design idea, and also helps students to understand it faster. Because each theoretical design stage is reflected by the software, changing the layout for a initial stage is faster than ever reflected into the final design.

Rendering several designs increases the number of shown / viewed exemples, an so the design method is better understood.

V. CONCLUSIONS

Initial goal of research had been reached : developing a new method (concept) for footwear design, based on rendering, that is able to generate a complete customized shoe model in less then few seconds (practical, duration is instantaneous).

This concept method *proved to be a powerful eLearning tool*, because this new approach on design is like a hybrid between actual theory concepts and educational computer software.

However, research department future goal is to release a new version, oriented to eSupport, rather than eLearning; developing on this direction is now at it beginnings, but yet had been proposed two future stages:

- integrating render methods as specific footwear design tools inside the drawing editor;
- presenting the future product, as β-release, to footwear / textile software manufacturers.

Acknowledgements

This work was carried out with financial support of the project EURODOC „*Doctoral Scholarships for performance research in Europe*", funded by the *European Social Fund* and the *Government of Romania*.

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