The Eurasia Proceedings of
Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2016

Volume 4, Pages 448-455

ICEMST 2016: International Conference on Education in Mathematics, Science & Technology

SIMULATION MODELS IN THE PROCESS OF DESIGNER'S EDUCATION

Oksana ZAKHARKEVICH
Khmelnitsky National University

Svetlana KULESHOVA
Khmelnitsky National University

Galina SHVETS
Khmelnitsky National University

ABSTRACT: The clothing industry is quickly becoming a high-tech industry due to rapid advances in technology which contribute to high quality design, cutting, stitching and finishing techniques. Furthermore, a designer today has to improve professional capability according to industry's requirements. The word 'designer' is a broad description covering many different functions. A designer in a large company may specialize in a particular area and be part of a team, whilst in a very small company a designer may have to perform all the above tasks. In both cases they could be handled by using computer aided design systems at each stage of the design process. Most of the stages are already presented by specific pattern design systems: and design process in them could be provided in two-dimensional or in three-dimensional space. A student is a future professional and his capability has to be considered accordingly to the future state of the science and technology. That is why, pattern design systems and virtual three-dimensional models of the garments must be used as designer's tool in educational process and they must be presented in all studied courses, though some stages of apparel design are not formalized yet. However, visual aids and handout materials are common useful facilities in professional education, and even if manufacturing does not use such simulation models they might be useful for the students. Our work is devoted to review of different virtual models of garments and their particular parts, as well as simulation models of the design process in sewing industry. Those models were developed by authors and are recommended for use as visual aids in educational process.

Key words: Simulation models, virtual model, three-dimensional design, running simulation

INTRODUCTION

The clothing industry is quickly becoming a high-tech industry due to rapid advances in technology which contribute to high quality design, cutting, stitching and finishing techniques. Hence, a dress designer today has to improve his or her professional capability according to industry's requirements.

Aldrich, W. (2008) showed that the word 'designer' is a broad description covering many different functions. A designer in a large company may specialize in a particular area and be a part of a team, whilst in a very small company a designer may have to perform all the above tasks. In both cases they could be handled by using computer aided design systems at each stage of the design process. Most of the stages are already presented by specific pattern design systems: and design process in them could be provided in two-dimensional or in three-dimensional space.

A student is a future professional and his or her capability has to be considered accordingly to the future state of the science and technology. That is why, pattern design systems and virtual three-dimensional models of the garments must be used as designer's tool in educational process and they must be presented in all studied courses, though some stages of apparel design are not formalized yet.

- Selection and peer-review under responsibility of the Organizing Committee of the conference
*Corresponding author: Oksana ZAKHARKEVICH-icemstoffice@gmail.com

However, visual aids and handout materials are common useful facilities in professional education, and even if manufacturing does not use such simulation models they might be useful for the students.

Stančić, Seljan, Cetinić, & Sanković (2007) say that simulation models could be used as a tool in education system, from primary and secondary school up to a high school system where the use of specific simulation models helps certain research helps in decision-making, or in the course relation to creation of simulation models.

There are many examples in literature that represent simulation models in garment industry which make it easier for students and teachers to explain and understand given lessons. The simulation model of the combing process (Ryklin, & Katovich, 2013) could be considered as instance of such a model, as well as a model of flexible module-type sewing lines developed by Mokeeva, Proforuk, Zaev, & Zybareva. (2002). Often simulations are used for assembly line balancing; examples of such models are described in Waldemar (2011) and Daniel, Amare, & Solomon, (2010). Zamyatina (2009) considers different types of simulation models and specifics of their building that could be applied in different fields of study and research. The specifics of development the simulation model of design process in clothing industry were shown in the previously published work (Zakharkevich, 2015).

However, as it persuasively shown by Dunne (2012), apparel design as a discipline and industry has often been characterized as highly resistant to change in processes. She considers that this is because of the extremely short product cycle and ever-increasing pressure to reduce costs and duration of the design process. Other product-producing industries such as consumer products or automobiles embraced 3D simulation and visualization technologies decades ago. By contrast, the apparel industry has been much slower to adopt even 2D CAD-based drawing systems for garment patternmaking.

At the same time, Dunne (2012) admits that although such 3D technologies may be only almost ready enough for industrial practice, as teaching tools they offer unparalleled advantages in shortening the trial-and-error feedback loop and enabling more effective visualization of the relationship between the 2D pattern and the 3D body/garment relationship. Thus, the use of simulations represents the natural way of “learn by doing”. Students use 3D simulations in order to understand complex system “garment-human body”.

Different categories of computer simulations in clothing industry in connection with the learning process are the main subject of the current study. Such simulation models interactively imitate the reality which would otherwise be very difficult (or very costly) to show to the learners.

METHODS

The models that provide the representation of real processes are the result of the simulation software further development. A new class of software called also simulation software enables users to rapidly build lightweight, animated simulations of some objects or processes, without writing code. There are a lot of software products which provide us with such ability; and in a particular case we have to choose that software package which allows us to reach the goal of a lesson or educational course.

Software for Design Process Simulation

Arena (Rockwell Automation) is the perfect tool to introduce students to the principles of simulation and all modern modeling approaches, and to teach them to apply it in apparel design. Arena is a very flexible modeling tool. It allows users to simulate problems in any kind of industry, including supply chain, logistics, manufacturing, healthcare, etc. Thanks to its unique adaptability, Arena alone can substitute many other tools. Arena’s visual development environment speeds up the model building process. Prebuilt object libraries allow users to create models by dragging and dropping elements from palettes. Besides that, one of the obvious advantages of Arena is that the student’s version of Arena software could be free downloaded from the official web site.

Design process simulation in apparel design is a model-based representation of technical and drafting processes in software. Basic prerequisites are a thorough knowledge of the properties of the particular types of garments and the specifics of their design, of logical sequence of drafting, and of mathematical models of design process.

Process simulation software describes processes in flow diagrams where unit operations are positioned and connected by streams. The entity-relationship model of the design process would be the base for the flow diagram in Arena.

Software for 3D Clothing Simulation

New developments in virtual reality are creating moving models and electronic fashion shows, or virtual store displays. It is now possible to access virtual models online and see them from all angles as they rotate in real time. The garment image can be remapped with any of the different fabrics shown on the screen. The aim is to reduce the number of samples made up in the design room.

Once a pattern is completed for a design, the next process is to create a made up garment sample, often before the decisions are made. At least four CAD suppliers are offering different versions of creating samples within a 3D environment. One of the most common systems in this field is Julivi Clo3D software.

RESULTS and FINDINGS

In order to achieve the main purpose of our work we need to select and describe a range of simulation models which could be used as visual aids for the dress designer education.

3D Clothing Simulation

3D clothing simulation is usually considered as one of two mutually inverse actions: putting on virtual clothes on virtual body or unfolding 3D mesh of virtual clothes into 2D planar form. In educational process the first method should be applied to garment simulation; and the second one is better to use for building the parts of virtual garments.

Garment Simulation

Usually the finished pattern is made up into fabric to check the proportions and shape. Garment samples are prototype garments that allow us to check the proportions of the garment and the quality of the garment fit. Nowadays designers often check garment fitting with 3D tools in CAD-systems by displaying virtual models of the garments on the screen (figure 1).

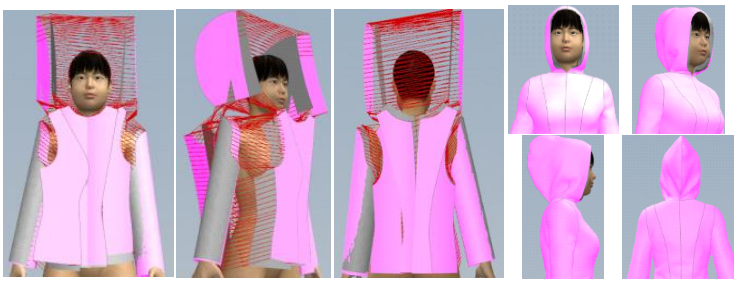

Figure 1. Virtual Reversible Garment in Julivi Clo3D Software

To see how well the garment fits, the customer can change the Rendering Style to one of the follows styles: "Stress Map", "Strain map". Stress is the tension to exert on a fabric per unit. Customer can see different tension of a particular body part of the avatar or its movement. Different tension is shown in different color and number (gf/cm^2) on the garment. The blue indicates areas that fit loosely; the red indicates areas that are tight. Strain is a geometrical measure of garment deformation exerted by external forces. Different tension appears in different color and percentage of deformation.

Often during the study process there is a necessity to compare two or more garment samples, and virtual models of the garments are particularly useful in this case. However, in Julivi Clo3D both rendering styles (stress and strain maps) reflect garment samples as uninterrupted color pieces of virtual cloth, and there is no possibility to compare precisely similar points in different samples because consumer can see just a color, and no mesh or points as it showed on the figure 2. That is why we have computed a minimal number of separate observations that allow to compare two or more garment samples with a confidence level not less than 95 %. Hence, any empirical study in which the goal is to make inferences about the similarity of garments samples or their parts – to compare constructions or design methods, – has to be conducted with the sample size that equals or is more than 110.

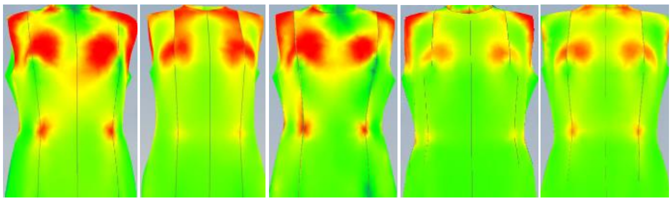

Figure 2. Stress-maps of the Virtual Garment Samples

Garment Parts Simulation

In order to provide understanding features of the relative position of the different garment pieces we developed 3D models of separate garment parts. Virtual models of the separate parts of the garments are presented by the figure 3 and figure 4. Sequence of building the 3D form of the pocket is considered as the alteration of the flat image into the 3D form by tools of the Rhinoceros software: Surface / Extrude Straight / Extrude Along Sub Curve. Sequence of building the virtual form of the hood was described in the previously published work (Zakharkevich, 2012).

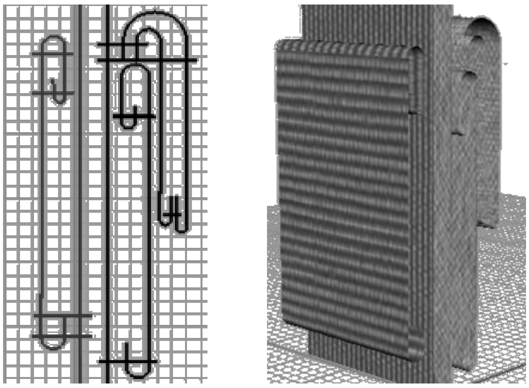

Figure 3. 2D and 3D Forms of the Pocket

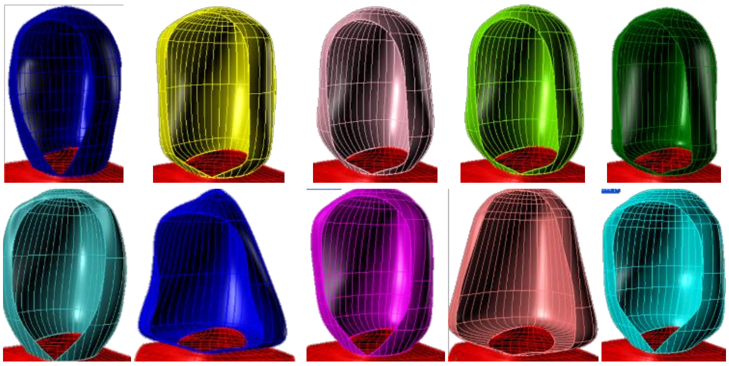

Figure 4. Virtual Samples of Hoods

Simulation Model of the Design Process in Sewing Industry

We assumed that designer might be able to draft any number of new garment designs based on the design of particular garment design that was successfully drafted before. As the instance for the simulation model we chose three garment types: an anorak, a coat, and a jacket.

Anorak – a waterproof jacket, typically with a hood, of a kind originally used in polar regions.
Coat – an outer garment worn outdoors, having sleeves and typically extending below the hips.
Jacket – an outer garment extending either to the waist or the hips, typically having sleeves and a fastening down the front.

Analysis of the design process in sewing industry and data base of transformation elements that were described in works of Zakharkevich (2013) and Zakharkevich, & Pochuprin (2014) were used as input dataset for the simulation.

Constructing a Flowchart Model

The entity-relationship model of the design process was formed, and this model was used as the base for the flowchart model (figure 5). In Arena simulation package, the flowchart represents the flow of entity in the system. Garment designs of the particular garment type are the entities in the model. All entities were represented as particular modules. Each module was described with some attributes, which could be changed for different sewing companies (table1 and table 2).

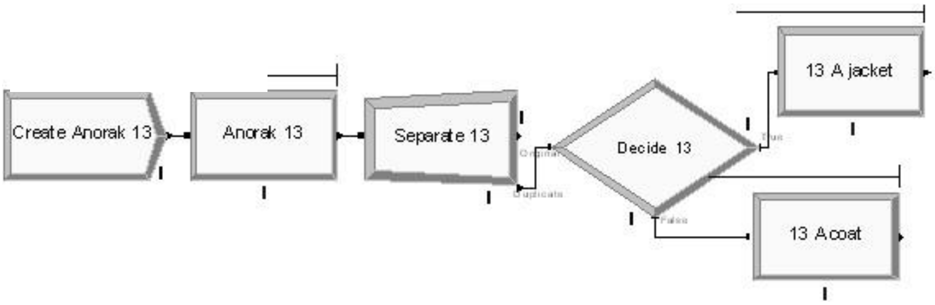

Figure 5. The Basic Fragment of the Flowchart Model

Table 1. Changeable Characteristics of the Modules of the Simulation Model

10	Function	Description of the module	Parameter	Parameter function	Description of the parameter	Specifics of the parameter
Create	Entities enter the simulation here	The necessity of drafting the garment design	Type	Type of forming the arrival flow	Method of determination a number of orders for drafting the garment design	Constant (average value) Schedule
			Value	Average time value between the entities arrivals	A time between orders to drafting the garment design	Constant (average value for the particular sewing factory)
			Schedule Name	Name of the schedule that defines frequency of the entities arrival	Name of the schedule that defines frequency and particularities of orders for drafting the garment design	Schedule 1
			Units	Time units for the time between the entities arrivals	Time units for the time between the orders for drafting the garment design	Day, hour
Process Anorak №A (Process Jacket №A; Process Coat №A)	An activity, performed by resources and requiring some time to complete	Development of the garment design documentation	Priority	Priority of the modules that use the same resource	Urgency of drafting the ordered garment designs	High, Medium, Low
			Resources	Resources, which would be working with the entities in the module	Number of designers	1 ÷ 5 (define for the particular sewing factory)
			Units	The time units for the numerical delay duration	The time units for the duration of drafting the garment design	Day, hour
			Allocation	Defining the urgency of accounting the cost characteristics	Defining the urgency of accounting the cost characteristics for the garment design documentation	Value Added (add the cost of developing of the garment design documentation)
			Delay Type	Distribution type of the delay of the entity in the module	Distribution type that reflects particularities of human work	Triangular
Separate №A	Duplicate entities for concurrent or parallel processing, or separating a previously established batch of entities	Duplicate files of the projects and/or garment design documentation that were drafted previously	# of Duplic	A number of duplicates of the incoming entities	A number of the garments designs that could be obtained by alteration the particular anorak design	Must be defined according to specifics of work on the particular sewing factory
Decide	A branch in entity flow	Description of the decision making process	Percent True	A value that defines the percent of the entities, which flow by the branch True	Percent that defines a number of the jacket designs	Must be defined according to specifics of work on the particular sewing factory

Resource	Definition of the resources and their features	Specifics of the designer work	Capacity	A number of resources that are in system	Number of designers	1 ÷ 5 (define for the particular sewing factory)
			Busy	A cost of processing by resource (per hour)	A cost of drafting the garment design by designer (per hour)	Must be defined according to specifics of particular case
			Idle	A cost of resource when the resource is not active	A cost of resource when designer is not busy with drafting	Must be defined according to specifics of particular case
Schedule	Schedule	Frequency of the entities arrival	Type	Schedule type	Schedule of the orders for the drafting of garment design	Arrival (schedule for the module Create)

Table 2. The Permanent Module Parameters of the Simulation Model

Module	Parameter	Parameter function	Description of the parameter	Specifics of the parameter
Create	Name	Module Name	Specified index of the anorak design	Create №A
	Entity Type	Entity Name	Specified index of the anorak design	Entity №A
	Entities per arrival	A number of entities per arrival	A number of designs, that make up a single order	5 (according to the result of analysis of the design process in sewing industry)
	Max arrivals	Maximal number of entities that could be formed by module	Maximal number of garment designs that could be ordered for drafting	Infinite
	First Creation	A moment, when first entity arrives into the model	A moment, when firm gets a first order for a draft of garment design	0,0
Process	Name	Module Name	The name of the garment	Anorak №A (Jacket №A, Coat №A)
	Type	Logic scheme of the module	Specifics of the drafting process of anorak design	Standard (without submodels)
	Action	Type of proceeding in the module	Operating procedure during developing designs of anoraks by designer	Seize Delay Release (designer is busy with drafting for a while and then stays idle for some time)
Separate	Name	Module Name	Specified index of the original anorak design	Separate №A
	Type	The method of distribution within the module entities	The method of distribution of the duplicated designs of the original anorak	Duplicate Original (Duplicate the anorak design documentation that was drafted previously)
	Percent Cost to Duplicates	Percent of original entities that must be duplicated	Percent of anorak designs that must be duplicated	100 %
Decide	Name	Module Name	Specified index of the anorak design	Decide №A
	Type	Type of decision logic	Definition of the numbers of coats and jackets	2-way by Chance
Resource	Name	Resource Name	Designer	Designer
	Type	Definition of the resources capacity	Definition of designers number	Fixed Capacity
	Schedule Name	Schedule Name	Schedule Name	Schedule 1
Schedule	Name	Schedule Name	Schedule Name	Schedule 1
	Time Units	The scale of the time axis in the graphics schedules	The scale of the time axis in the graphics schedules	Days

Running Simulation with Arena

Prior to run the model, we need to specify the run conditions including project information and the length of the simulation run. In particular case the length of the simulation run is a year.

Once the simulation starts to run, some animation will be displayed as the simulation progresses. As shown in the following figure, entities in a box shape (as specified in Entity data module) move from one module to another. Below each module, number of entities created in processing, and disposed are displayed. At the top of the Process module displayed is the status of the queue of the resource (number of waiting entities) with the entity pictures.

Besides that, two diagrams on the figure 6 reflect the number of the jackets designs, and the number of the coats designs.

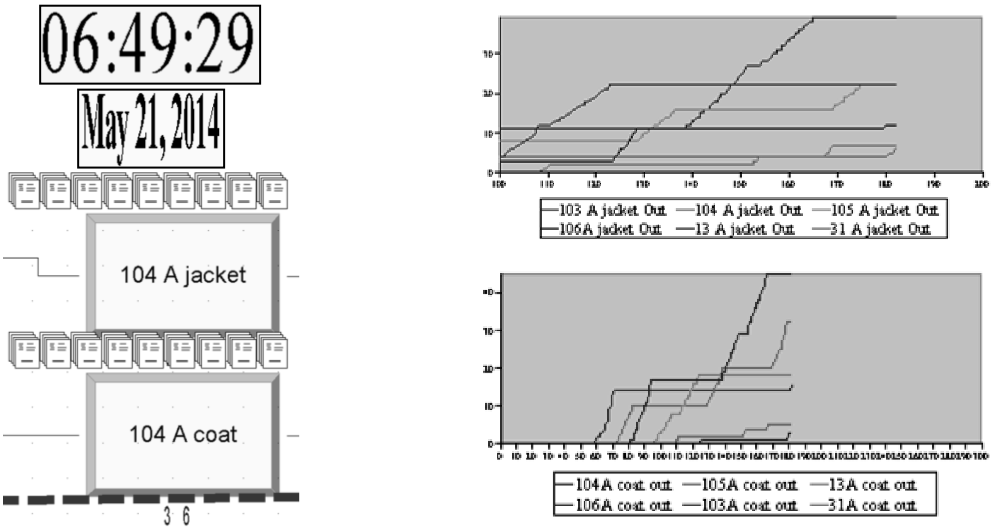

Figure 6. Fragments of the Model Window (Flowchart View)

At the end of the simulation run, a message box will prompt to ask you whether you would like to view the reports. Clicking "Yes" displays the reports as shown below. As a result of the simulation we can get the "Statistics Collection" and analyze some parameters of the design process. Among them are the time characteristics, the number of designers (busy, scheduled), the cost characteristics, the number in (out), and the instantaneous utilization, etc (figure 7).

Usage

Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
konstryktor	0.9995	(Insufficient)	0.00	1.0000
Number Busy	Average	Half Width	Minimum Value	Maximum Value
konstryktor	2.9986	(Insufficient)	0.00	3.0000
Number Scheduled	Average	Half Width	Minimum Value	Maximum Value
konstryktor	3.0000	(Insufficient)	3.0000	3.0000
Scheduled Utilization	Value			
konstryktor	0.9995			

Figure 7. Reviewing the Output Reports

CONCLUSION

Developed visual aids and handout materials are useful facilities in professional education, and even if manufacturing does not use such simulation models they might be useful for the students. That is why, pattern design systems and virtual three-dimensional models of the garments can be used as designer's instrument in educational process and they must be presented in all studied courses, though some stages of apparel design are not formalized yet.

Besides that, developed simulation model forms are the required premises for the further development of methods of the designer's training and for lowering the risk of making false decisions under the conditions of rapid changes of project situations.

RECOMMENDATIONS

We think that the issue of described simulation models in education of dress designer has at least three main aspects.

Firstly, simulation models can and, in our opinion, should be used as a complement to the process of education. Therefore, we can conclude that the simulation models can be used throughout the curriculum of future designers, from the beginning of the study to the very end of it. Thus, all kinds of 3D virtual models, from models of different parts of garments to the garment as a whole, as well as simulation models of technological/design processes in sewing industry and apparel design can be used.

Secondly, in our opinion, the curriculum should, at the higher levels of study, incorporate course(s) related to development of the simulation models. The simulation model of design process in sewing industry could be used to predict the results of the rapid change in the production of women's outerwear; hence it could be a basis for the development of the models that predict results of the rapid change in production of any other assortments of clothes. Obviously, the simulation model that we described in this work is not the only one to use in designer's education but it was used as a real instance of implementation of simulation models in education.

Thirdly, we think that some simulated models must be complemented by real objects, i.e. garments. Hence, students would be able to test their work by themselves even without the instructor. For instance, it was shown in the figure 8.

Figure 8. Virtual and Real Garment Samples

Thus, in our work we have described the 3D models of garments and 3D models of garment parts, as well as simulation models of the design process in sewing industry. Those models were developed by authors and are recommended to use as visual aids in educational process.

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