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Applied 3D Virtual Try-On for Bodies with Atypical Characteristics

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Abstract

The manufacture of clothing using real body measurements is based on user's new profile, on their own desire for individualization through purchased garments but also on the results of the anthropometric surveys which have shown great variability in morphological types, especially for women.
Research conducted by the authors focused on the application of 3D virtual try-on in pattern alterations for "women trousers". To achieve the objectives of the work, bodies with atypical characteristics were selected from the database resulting from 3D scanning of the Romanian women population. In the study, it was found that many women have different sizes for the two hip contours (left-right), differences being in the range 1.5 to 4.5 cm.
Based on these considerations a method of completion of the patterns for trousers has been developed and applied, by 3D simulation of the body-garment.
This paper brings contributions to clothing design technology by 3D virtual try-on, taking into account the body shape of the users.

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Keywords: virtual; try-on; atypical; body; clothing

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1. Introduction

The competitive pressure of globalization is causing textile and garment manufacturers to lower production costs, increase their efficiency and to create leaner value-adding processes. To be able to cope with these changes, measures must be implemented, including the improvement of the internal organization, and the establishment of co-operations with external organizations to create a continuous supply–demand network. As a result, production logistics as well as information and communication technologies have gained importance, in order to keep job functions requiring higher qualifications within Europe [1,2].

Clothing must respond to various quality requirements expressed by users. In this area, the dimensional and shape correspondence between the user's body and the garment is essential in order to ensure the normal state of comfort while wearing the product and at the same time is a decisive factor in the purchasing of the product by the users.

At present, in our country and worldwide, there are two major systems of clothing manufacturing:

- Industrial clothing manufacture system;
- Individual/customized clothing manufacture system [3, 4].

In *industrial clothing manufacture system*, the information required in constructive design is offered by legislation reflecting morphological particularities of the population, for which the clothing is designed. In this production system, clothes are developed for *standard body types*, recommended by the present dimensional typology.

Research conducted by marketing experts has shown that frequently, high quality industrial products are kept in the stores for a long time because they do not meet the dimensional requirements of the users [5]. It is noted that permanently there are users with deviations from the standard dimensions and shape, which are used for standardized industrial clothing. When wearing an industrial clothing by users that have position, sizes and conformation which are different from the standard ones, defaults will appear between the body and the product, such as the appearance of uneven surface (pleats, folds), limiting the movement of body segments and reducing the buying demand for these products [6,7,8,9].

In *individual clothing manufacture system*, the relationship between the designer and the user is most commonly a direct one, the pattern designer is able to perform anthropometric body measurements on those clients, relevant to the type of product and absolutely necessary for the model design. In these circumstances, clothing corresponds with clients' wishes, but has higher production costs. As present, clothing companies have orders for manufacturing the models using specific dimension charts used by different clients and it is necessary to provide flexibility to the design process by developing and archiving information on the morphological characterization of the human body. Innovative alternative to create a complete and comprehensive database is represented by 3D body scanning, which is a modern technology for anthropometric investigation, providing a large amount of information about subjects' body sizes, information that allows the improvement of individual clothing manufacture system [10].

Individual pattern design system requires anthropometric research directed towards knowledge of morphological indicators for characterizing the shape and body dimensions of investigated subjects.

In this context, the main objective of this paper is to develop an innovative technology of pattern design for atypical bodies, in order to obtain an adequate correspondence between the shape of the studied body/subject and the clothing product, at the level of support surfaces.

To address the objectives of the work the following steps were performed:

- subject selection from the database constituted by 3D scanning of teenage population in the country, through the anthropometric survey conducted in 2010;
- morphological analysis of the subject to identify the possibility of a body classification in the standard types, provided in the current anthropometric standard [11];
- development of design variants for the basic pattern for trousers (product with waist support, which was studied);
- 3D virtual simulation of body-garment system, for the studied design variants;
- analysis of the tensions map and gathering the necessary information in patterns remodelling, in order to adapt them to the shape and body dimensions of the subject;
- completion of design variant that provides the best body-product correspondence.

2. Morphological analysis of the studied subject

According to the study objectives, a body was selected from the body database obtained by 3D scanning, which has certain features of position and conformation (Figure 1) [12]:

- the body is bent forward and therefore buttocks prominence is more evident than in a body with normal position;
- body asymmetry (left/right) is seen in the following body regions: the level and lean of shoulder line, the placement of scapula prominence, the waist line, the placement of hips prominence;
- position of the legs is slightly in X.

Anthropometric dimensions that support the above mentioned are presented in Table 1.

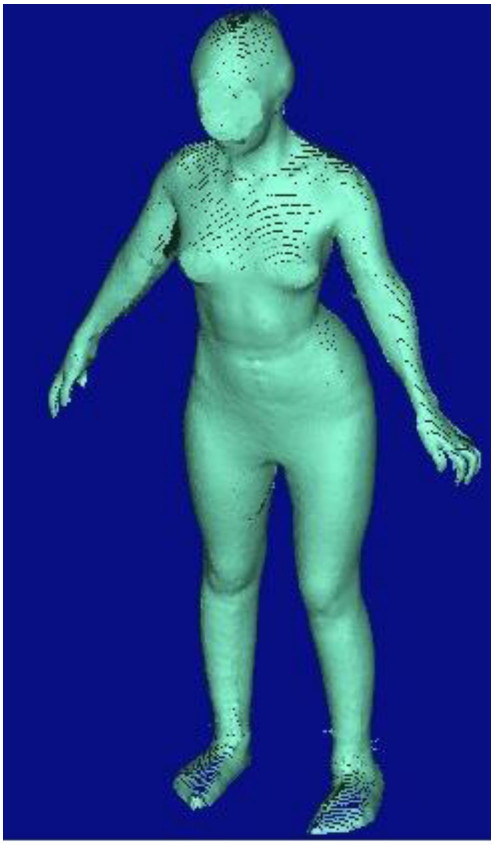


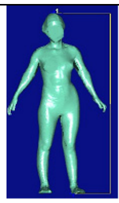
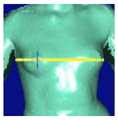
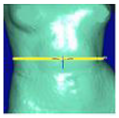
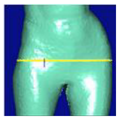
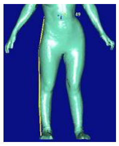
Fig. 1. Image of scanned subject.

From the analysis of the values presented in Table 1, the following conclusions resulted:

- according to the values of Ic and Pb the subject fits in the body type: Ic = 146 cm; Pb = 75 cm [9];
- the subject presents asymmetric pelvis: on the left side, the contour waist-ground length is higher by 4.9 cm, compared with the same contour measured on the right;
- hip perimeter of the subject under study is higher by 5 cm compared with the standard value corresponding to the body type that fits the subjects;

In conclusion, the studied subject presents an atypical form of the pelvis and lower limbs, for which products with waist support (skirt, trousers) subject to industrial manufacture will not lead to a good match between the body and the garment [13,14].

Table 1. Anthropometric dimensions for characterizing the selected subject.

No.	Symbol	Significance of anthropometric size	Visualization	Value (cm)
1	Ic	Body height		142.8
2	Pb	Bust circumference		76,4
3	Pt	Waist circumference		63,3
4	Ps	Hips circumference		85
5	LlatT-Sol (left)	Sideseam (left)		94.3
6	LlatT-Sol (right)	Sideseam (right)		89,4

In order to ensure suitable correspondence of these types of bodies with clothing products support with waist support, a specific design method is proposed, including the verification of the adopted solution by 3D virtual try-on in order to complete in successive stages the patterns shape of trousers product.

3. 3D virtual simulation and completion of the patterns of trousers for the studied subject

3.1. Elaboration of initial variant (Variant V1) and evaluation of the body-product correspondence

The basic pattern for the product under study was designed according to the geometric algorithm [14] for the body type that the main dimensions, body height (Ic) and the bust circumference (Pb) fit the tested subject (variant V1). Due to the lower limbs (position X), the authors has selected the trousers with straight silhouette.

These reference patterns were designed using the commands and functions of the GEMINI CAD system, using *Made to Measure* (MTM) application. The main steps of obtaining the key elements of the product (front and rear) are the following [7,15,16,17,18]:

- introduction of the initial data necessary for basic patterns design, according to the chosen algorithm (Figure 2);

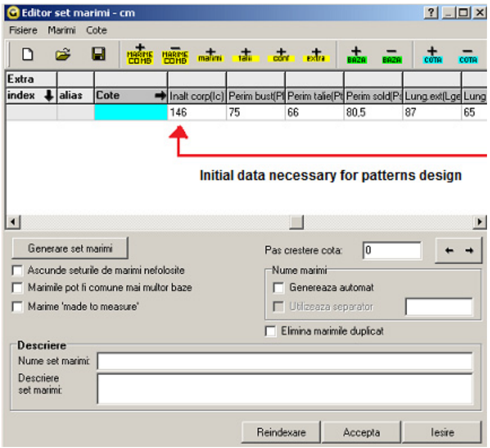


Fig. 2. Introduction of initial data.

- establishing the position of a reference point in the work area (geometric layer of the drawing), implicitly noted with P1 (Figure 3);
- editing the mathematical relations, according to the chosen design algorithm for positioning the main points of the pattern (Figure 3);
- drawing the contour of the product element and modelling the contour lines, using magnetism with the points of geometric layer (Figure 4).

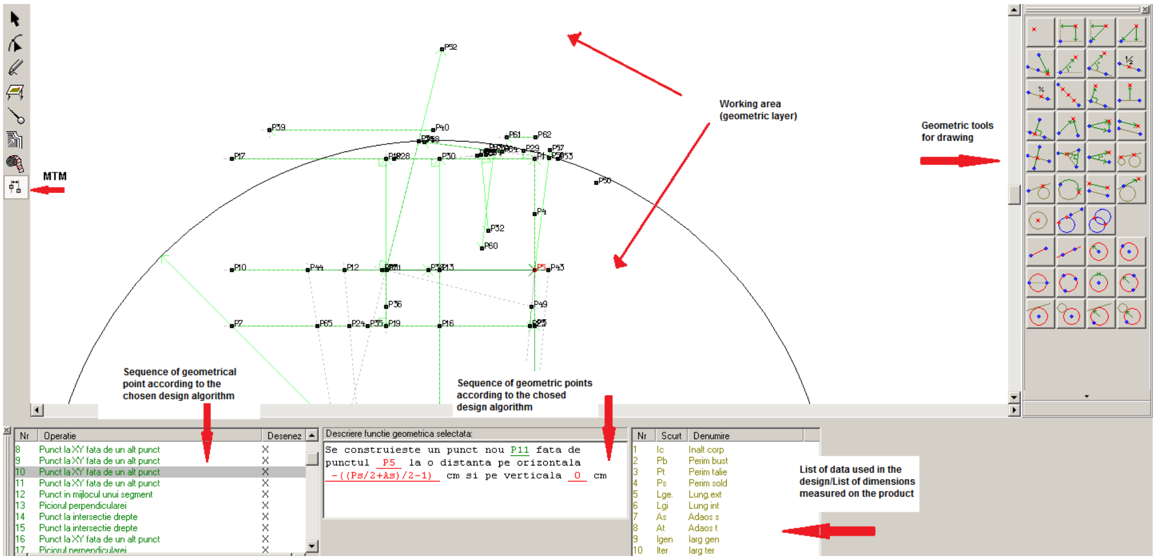


Fig. 3. Designing patterns in MTM GEMINI CAD.

After modelling and completion of the shape of the contour lines, the length of some longitudinal contour lines for front and rear elements was verified: the lengths of the product on outer and inner seam. The file containing the patterns of front and rear main elements of the product “trousers” was saved and then exported for 3D simulation, in order to verify the body-product correspondence.

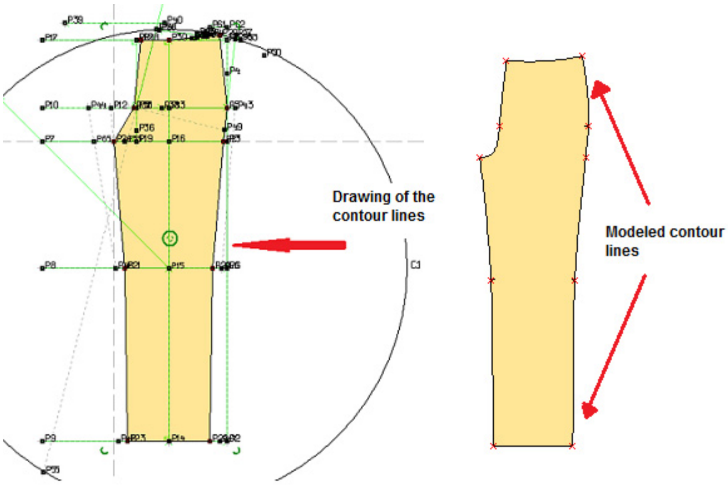


Fig. 4. Basic patterns for variant V1.

3D virtual try-on was performed using OPTITEX system, according to the following steps:

- importing the selected subject's body;
- importing the product elements and positioning them in the proximity of the mannequin;
- defining the assembly lines between the product elements;
- choosing the type of material of which the product can be made by specifying its characteristics;
- 3D simulation of the assembly process of the product elements and evaluation of the body-product dimensional correspondence through the tension map analysis.

By analysing the images of clothed body (Figure 5) the following conclusions resulted:

- patterns of the main front and rear elements of the product are not proper for the pelvis, because their dimensioning was based on the standardized hip circumference which is significantly lower than that of the subject;
- analysing the tensions map, it can be seen that in the supporting surface area (the back side), the product does not properly cover this part of the body, the material is highly strained (red colour); this type of product which is manufactured in accordance with the standardized values of the representative body type, dressed and worn by such a subject will be destroyed (broken) because of the tensions developed during the wearing period;
- the placement of the product on the waist is will not provide convenience and comfort in the wearing period.

Fig. 5. 3D try-on of the designed product through variant V1 (front and rear).

In the case of the analysed subject, due to the atypical pelvis, the product such as trousers designed and manufactured using the industrial system in accordance with the sizes of the body type CT (146-75) [10] will not meet the dimensional correspondence of the tested subject.

Therefore, design variant V2 that uses specific values of anthropometric dimensions taken from the body surface is proposed.

3.2. Development of pattern variant (Variant V2), simulation and evaluation of the body-pattern correspondence

In the case of variant V2, the pattern of trousers was developed using the specific values of the analysed subject for the waist circumference (Pt) and hip circumference (Pș). To obtain the form of the main elements of the product, MTM application of GEMINI CAD system was used. Since the design algorithm was the same as in variant V1, the main contour points of the pattern are anchored in the geometric layer, by modifying the initial data (mentioned above) new final forms of the product elements were re-generated. 3D simulation was performed by covering similar steps as in variant V1 (Figure 6).

In these circumstances, it looks like the design patterns would lead to a better correspondence between the body and the product at the supporting surface level. This is not the case because the body has a pronounced asymmetry, the left side being more prominent than the right side. Also, the different placement level of prominent point of the hip is noticed, resulting in an incorrect alignment of the product to the waist line.

In conclusion, the longitudinal contour lines for the left side of the body contour require processing (Figure 1).

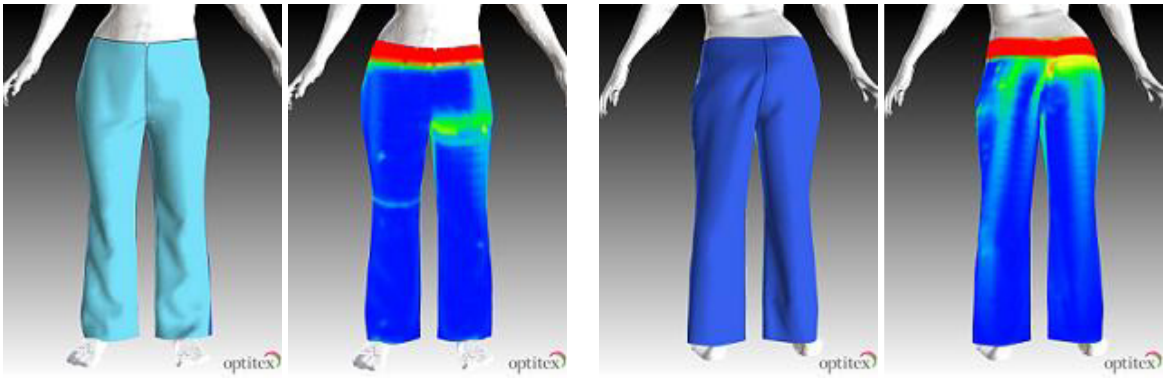


Fig. 6. 3D try-on of the designed product through variant V2 (front and rear).

3.3. Remodeling of pattern (Variant V3), simulation and completion of the patterns in accordance with the real shape of the body

The modeling the longitudinal contour lines (left side of the product) is applied to patterns of variant V2 using the Gemini Pattern Editor of GEMINI CAD system, based on specific data of the body specified in Table 1. Increase of the outer contour line length is achieved in successive stages, from the walking line or slit to the waist line (Figure 7).

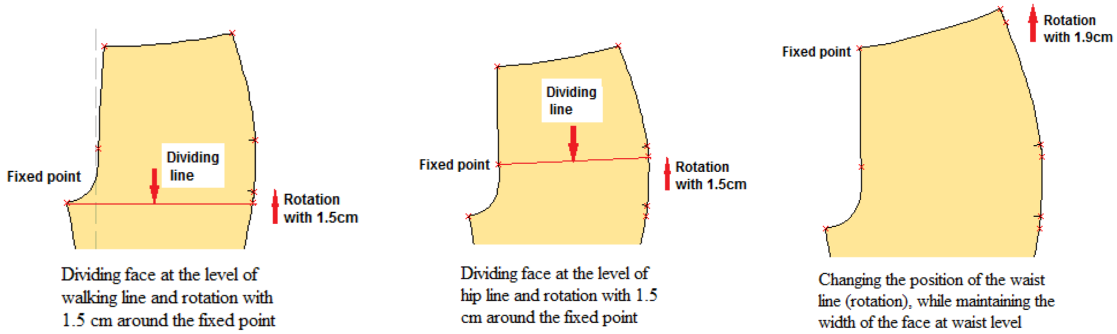


Fig. 7. Modeling stages applied to the front element.

After modelling, the outer stitch length was measured and compared with the value of the sideseam (Table 1).

The processing of the back (on outer contour line) is carried out in a similar manner to the face.

After completion of the shape of product elements, the obtained file is saved in the database and then the steps of 3D simulation in OPTITEX system shall be performed.

The product thus obtained is in equilibrium with the tested subject, it covers properly the pelvis. By the adopted design solution (Variant V3), the product thus developed will be in equilibrium with the body and it will meet the requirements of comfort and dimensional correspondence needed in the wearing process (Figure 8).

Conclusions

The paper is in line with the research carried out worldwide that presents the applications of virtual 3D modelling technology for testing and completion of the patterns for clothing products.

The research was conducted in order to ensure body-garment correspondence for subjects with morphological features which are different from the typical ones, such as body position, asymmetrical shape of the pelvis, hips unequally developed, who are not able to purchase clothing from the retail network.

Fig. 8. 3D try-on of the designed product through variant V3 (front and rear).

The working method presented in this paper demonstrates that the technique currently used (CAD, simulation programs) allow professionals from the domain of clothing production to adopt design solutions that significantly reduce the time and cost for developing patterns for atypical bodies. It can be noted that pattern designers must know and use all the facilities of the CAD systems, in order to become more cost effective for users with such morphological problems to use these specialized services, in other words to be possible to provide industrial-scale manufacture of clothing in accordance with customers' morphological characteristics.

In this context, this paper proposes and develops an innovative technology accessible to pattern designers from the clothing companies equipped with CAD systems, using information about the body shape, resulting from 3D body scanning, in order to design patterns for atypical bodies.

The novelty, the theoretical and experimental results of this work can be summarized as follows:

- Research on morphological characteristics of the subject and identification of the deviations of its anthropometric dimensions from the standard ones.
- Setting initial data from the anthropometric protocols resulting from body scanning, necessary in basic pattern design for the product type under study.
- Design basic patterns using commands and functions of the GEMINI CAD system, application of *Made to Measure* (MTM) that gives high quality to flat surfaces of trousers product elements.
- Developing testing methodology through 3D virtual simulation of body-product correspondence, for three design variants of the patterns of trousers.
- Completion of the contour for the patterns of trousers in the case of the body variant under study was done gradually, testing for this purpose three design variants that differ in the amount of information on the tested body. So, in design variant V1, the deviation in terms of body-product correspondence was investigated, if patterns were designed based on anthropometric dimensions of the body type that apparently can fit the tested subject. It was found that this design variant is completely inadequate, so the subject cannot wear the products created for typical bodies. In variant V2, specific dimensions of the tested subject were introduced such as waist and hip circumference, defining dimensions for the pelvis commonly used in sizing patterns for trousers. But the asymmetry of pelvis of the tested subject, greater prominence of body side contour on the left side influenced the design results, meaning that again the product does not provide correct fitting for both left/right sides of the body. In these circumstances, a remodelling was developed, namely only the processing of the front and rear element on the left side, by using the techniques of surface pivot in order to adapt the outer seam contour line corresponding to the body shape.

The working methodology presented in this paper can be used in the completion of the patterns for other types of bodies and clothing products by the professionals working in the clothing industry, so that people with atypical body benefit from clothing products that will respond to a higher level of requirements imposed by specific shape of the body.

Acknowledgements

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References

[1] H-S. Park, From Automation to Autonomy - a New Trend for Smart Manufacturing, DAAAM INTERNATIONAL SCIENTIFIC BOOK 2013, Chapter 03,2013, pp. 075-110.
[2] G. Zulch, H. I. Koruca, M. Borkircher, Simulation-supported change process for product customization – A case study in a garment company, Computers in Industry, no. 62, 2011, pp. 568–577.
[3] M. Yuwei, P.Y. Mok, J. Xiaogang, Computer aided clothing pattern design with 3D editing and pattern alteration, Computer-Aided Design, no. 44, 2012, pp. 721-734.
[4] H.Q. Huang, P.Y. Mok, Y.L. Kwok, J.S. Au, Block pattern generation: From parameterizing human bodies to fit feature-aligned and flattenable 3D garments, Computers in Industry, no. 63, 2012, pp. 680-691.
[5] L. Jituo, L. Guodong, Customizing 3D garments based on volumetric deformation, Computers in Industry, no. 62, 2011, pp. 693-707.
[6] E. Filipescu, M. Avadanei, E. Filipescu, C. Niculescu, S. Olaru, General aspect concerning human body characterization, 16th International Conference, Structure and Structural Mechanics of Textiles STRUTEX, ,TU Liberec Czech Republic, ISBN 978-80-7372-542-6, 2009.
[7] P. Nicolaiov, A. Florea, C. Loghin, Specific Innovation Approaches in Garment Manufacturing Companies, Buletinul AGIR, ISSN 1224-7928, no.1, 2013, pp. 168-172.
[8] M. Avădanei, C. Loghin, I. Dulgheriu, 3D pattern design of products with special destination, International Symposium in Knitting and Apparel ISKA 2013, 21-22 iunie 2013, Iaşi, Romania, ISSN 2069- 1564, 2013, pp. 173-180.
[9] M. Avădanei, I. Dulgheriu, R. D. Cezar, Virtual design patterns ballistic protective vests, Industria Textila, ISSN 1222–5347, vol. 63, nr. 6, 2012, pp. 290–295.
[10] H. Chowdhury, F. Alam, D. Mainwaring, J. Beneyto-Ferre, Tate M., Rapid prototyping of high performance sportswear, Procedia Engineering, Volume 34, 2012, pp 38–43.
[11] Standard - SR 13546:2012. Clothing. Body dimensions for children between 6 and 19 years old.

[12] E. Filipescu, C. Budulan, M. Avădanei, Researches concerning the anthropo- morphological peculiarities of female population, 5th International, Conference TEXSCI 2003, June 16-18, 2003, Liberec, Czech Republic, ISBN 80-7083-711-X, 2003, pp.501-504.
[13] E. Filipescu, C. Budulan, C. Loghin, M. Avădanei, Assuring clothing quality by improving basic sizing patterns, Proceedings of the International Symposium "Optimizing processes - a prerequisite to increase the quality of textile products", 9 – 10 May 2002, Iași, Romania, ISBN 973-8075-25-4, 2002, pp. 277-282.
[14] M.Avadanei, E. Pintilie, E. Filipescu, E. Filipescu, New perspectives in modeling 3D virtual garment products in the context of the process of "mass customization" and customize their, National Conference on Virtual Learning CNIV, Iași, ISBN 1842-4708, 2009, pp. 156-162.
[15] E. Filipescu, M. Avadanei, Structura si proiectarea confectiilor textile, Ed. Performantica, Iasi, 2007, pp. 67-75.
[16] P. Nicolaiov, C. Loghin, I. Ionescu, The projection of manufacturing flexibility in the field of garment company's agility, Proceedings of the 3-rd International Textile, Clothing and Design Conference, 8-11 oct.2006, Dubrovnik, Croatia, ISBN 953-7105-12-1, 2006, pp. 471-476.
[17] S.Olaru, E. Spânachi, E. Filipescu, A. Salistean, Virtual fitting – innovative technology for customize clothing design, Procedia Engineering, no. 69, 2014, pp. 555-564.
[18] E. Pintilie, G. Ciubotaru, M. Avădanei, Computer-aided design of clothing, Performantica Publishing, Iași, ISBN 973-730-259-1, 2006.