# 3D VIRTUAL PROTOTYPING OF FUNCTIONAL KNITTED GARMENTS FOR PERSONS WITH SPECIAL NEEDS

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The field of functional clothing is vast and varied, with each function having its own set of specifications, material needs, and corresponding technologies and methods. Garments for persons with special needs are part of the functional clothing category and are meant to improve the quality of life of those whose body shape, mobility or dexterity differs from the norms. Virtual prototyping of garments provides high potential for design, product development and marketing processes. This paper presents the virtual prototyping of functional knitted garments for persons with special needs (elderly people, people with disabilities, operational staff from defense/public order/security structures) highlighting the importance of personalization and its competitive advantages. The steps to develop the virtual prototypes were: i) 2D pattern design from data in the dimensional table of the model and in correlation with the real sizes of knitted garments using Pattern Design Software (PDS) from OPTITEX; ii) Simulation knitted garments prototypes on the avatar using Optitex 3D Suite Software; iii) Evaluating the fit of the product on the body. The possibility to check the aspect of the product and how it is matching on the 3D model of the human body, without requiring physical development of a prototype is the main advantage of the virtual prototypes. If the product does not fit properly on the 3D surface of 3D model (mannequin / avatar), the designer can easily modify the shapes of parts and then check the new shape by repeating the steps of 3D simulation process in virtual space.

Keywords: functional knitted garments, virtual prototyping, persons with special needs.

## INTRODUCTION

The design and customization of garments for people with atypical changes in conformation is relevant for research in the field of garments and constitutes a major challenge if we take into account the changes in conformation produced in recent years, due to: the obesity, which has become a major public health problem worldwide which led to problems with size matching and clothing products comfort; the aging of the population with the change in body shape after the age of 60, which represents an important factor at the European and world level, which imposes the reintegration of the elderly, in family life, associative and social life; activity at computer, a static activity that causes deviations of the spine, causing conditions such as scoliosis, kyphosis, kyphoscoliosis or spondylosis; various native or acquired disabilities during life (Gupta, 2011).

The CareKnits project aims to offer a wide range of methods, advanced technologies and tools dedicated to the design and manufacture of clothing adapted to the shape of the wearer by implementing, integrating and interfacing already validated digital technologies throughout the process from creation/ design to product realization.

Today, advanced computer simulation techniques and garments virtual prototyping are indispensable for the development of garments and their fitting on the 3D body models within a virtual environment, as well as real-time virtual clothes try-on (Jevsnik *et al*., 2012 and 2017).

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## EXPERIMENTAL

In order to design and manufacture functional knitted textile products intended for people with special needs, the anthropometric database of the Romanian population between the ages of 6 and 60+ was filtered, according to certain criterions. The data were obtained in the anthropometric surveys carried out by INCDTP between 2008 and 2014, in Bucharest, at the National Institute of Diabetes, Nutrition and Metabolic Diseases "Prof. Dr. N. Paulescu" and in other public institutions, through 3D scanning. Measurement was done with the 3D Body Scanner Vitus XXL Anthroscan. It contains a family of software modules (ScanWorX) for 3D body visualization and automatic processing and evaluation of anthropometric data.

### The Specific Anthropometric Database

The primary 3D anthropometric database of INCDTP contains 6150 scanned bodies of which: 2850 for children, girls and boys, 1800 adult subjects, women and men, 1500 obese and elderly subjects and 150 subjects from public order structures. Primary anthropometric database was filtered according to certain criteria (e.g., sex, age and Body Mass Index, etc.) to constitute the databases specific to people with special needs, namely Anthropometric database for: obese women; obese men; women aged 60+; men aged 60+; workers in public order structures.

Each anthropometric dimension of the specific databases was subjected to a one-dimensional statistical processing by calculating the statistical parameters for the main dimensions of the body (bust and hip girth, for women and chest and waist girth, for men). Dimensional typology selection (establishing body shape variants to be included in the anthropometric dimensions table) took into account the frequency of the investigated sample, different combination of possible value of main dimensions. Thus, frequency values bigger than 5% were selected. Determination of types body, for each group of people with special needs, was done by analyzing the frequency of the difference between Ps (hip girth) and Pb (bust girth), on women and Pt (waist girth) and Pb (chest girth), on men. The type bodies with the highest frequency were selected, and for them the sizes of the garments and the body dimensions that will be used in the design of the patterns, were established.

For people with severe physical disabilities and important changes in posture, a module of the ScanWorX software allows visualization of the scanned 3D body, visualization of the disability and manual retrieval of anthropometric dimensions in the areas of interest for pattern construction (Bruniaux *et al*., 2016; Nakić *et al*., 2019).

### Creation of Virtual Prototypes for People with Special Needs

Optitex Pattern Making - PDS software provided by INCDTP was used to create virtual prototypes of functional knitted products for people with special needs. The major advantage of this software consists in its perfect integration with the Optitex 3D

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design/modeling/simulation solution. Thus, the created patterns can be visualized on different body types by creating three-dimensional samples. Changes made to the patterns are automatically transferred to the virtual clothing model.

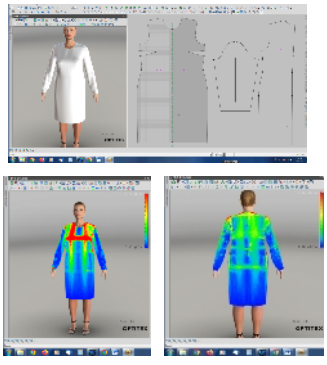
To create the virtual prototypes, the following steps were taken: development of the conceptual model adapted to the body type; 2D design of the basic patterns in accordance with the data from the size table or those taken from the avatar in correlation with the real dimensions of the knitted product using the Pattern Design Software (PDS) from OPTITEX; placing the 2D patterns on the parametrized mannequin/avatar with the help of the Optitex 3D Suite software, simulating their sewing; evaluating the fit of the product on the body; redesigning the 2D patterns after evaluating the body-product correspondence and resumption the verification of the correspondence; designing 2D model patterns and placing them on the parametrized mannequin/avatar; checking the appearance and body-product correspondence of the virtual model/prototype (Nakić *et al*., 2019).

In order to create the virtual prototype, functional knitted textile products were selected from the most common range, used by elderly people / obese people / with non-standardized atypical conformations / with different disabilities / operational personnel from defense structures / public order / security.

## RESULTS AND DISCUSSIONS

Based on the mentioned algorithm, 12 virtual prototypes of functional knitted textile products were made. In the following tables are exemplified five of them.

Table 1. Dress for the elderly female

| *Conceptual model* | *Parameterized mannequin and basic patterns: vB body type, size 48* | *Model patterns, virtual prototype on the body and checking the body-product fitting by viewing the tension map.* |
|---|---|---|
|  |  |  |

The model is designed for people of different sizes and body type vB. The virtual prototype made with model patterns when analyzing the degree of body-product fit, on the mannequin parameterized according to body type and size, using the tension map, shows a high pressure in the shoulder area (normal for a product with shoulder support) and breasts. After correcting the model patterns in the breast area, when resuming the product simulation, a correct positioning of the product on the body and a reduction of the tension exerted in the breast area were highlighted.

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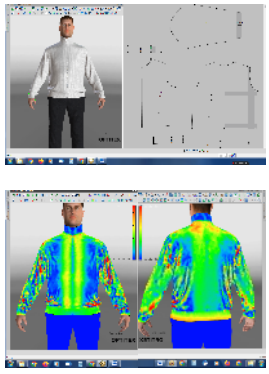
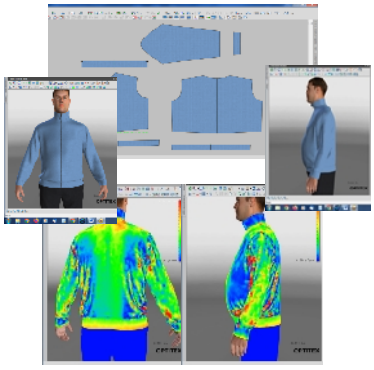
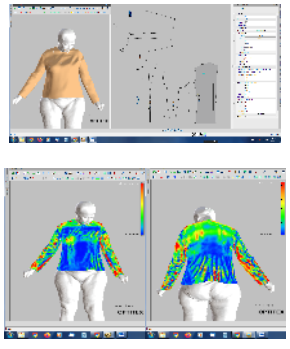
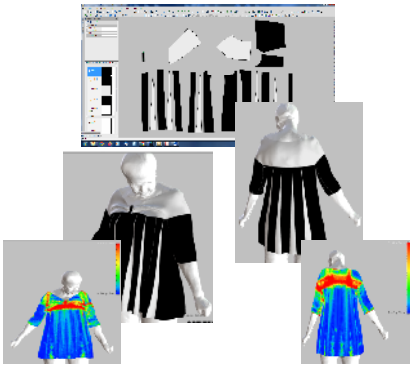
Table 2. Jacket for elderly men

| *Conceptual model* | *Parameterized mannequin and basic patterns: vD body type, size 56* | *Model patterns, virtual prototype on the body and checking the body-product fitting by viewing the tension map.* |
|---|---|---|
|  |  |  |

Visualization of the product made with the basic patterns, on the parameterized mannequin, indicates a proper placement and correct patterns. The analysis of the tension map of the product made with the model patterns, shows a good fit on the body without pressure on the body and sleeves well placed on the hands, without creases.

Table 3. Blouse for women with atypical conformation (developed hips)

| *Conceptual model* | *Avatar, its dimensions and basic patterns.* | *Model patterns, virtual prototype simulation on avatar, checking the body-product fitting by viewing the tension map.* |
|---|---|---|
|  |  |  |

A model with a flared line that masks the atypical conformation and boat neckline that gives the feeling of a balanced body has been designed. The body dimensions were taken from the avatar resulting from the scanning protocol. The analysis of the map of the pressure exerted by the prototype executed with the basic patterns shows the need to change the basic patterns, on the middle line of the back. The simulation of the body – product correspondence made with the corrected model patterns shows a tension exerted in the area around the neck and shoulders (the model is with a plate), normal due to the overlap of the materials.

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Table 4. Blouse / Dress for the person with advanced scoliosis

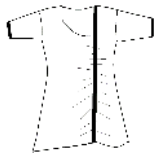
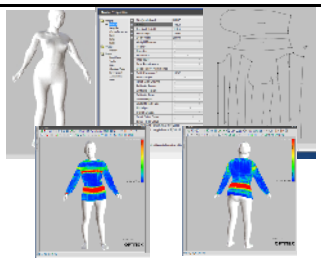
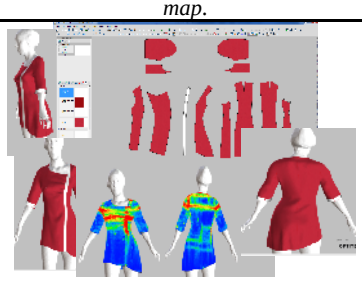
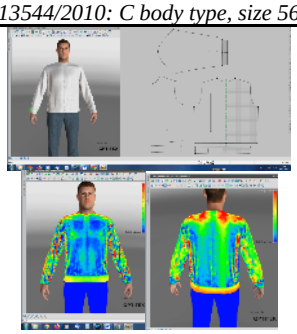
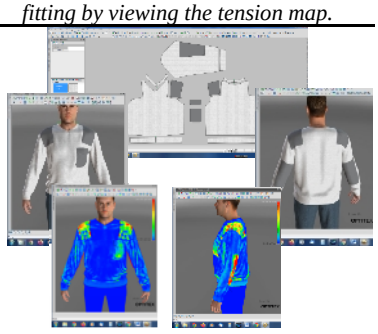
| *Conceptual model* | *Avatar, its dimensions and basic patterns.* | *Model patterns, virtual prototype simulation on avatar, checking the body-product fitting by viewing the tension map.* |
|---|---|---|
|  |  |  |
| The model is designed for people with major body asymmetry, in order to hide this problem. From checking the fit of the body-product made with the basic patterns, the high tension in the hip area and the asymmetry at the end of the product can be observed. The virtual prototype made with model patterns has a good drape. The end of the product is correct, masking the person's asymmetry. | | |

Table 5. Sweater for operatives in defense/public order/security structures

| *Conceptual model* | *Parameterized mannequin and basic patterns. According to SR 13544/2010: C body type, size 56* | *Model patterns, virtual prototype on the body and checking the body-product fitting by viewing the tension map.* |
|---|---|---|
|  |  |  |
| The basic patterns were designed for Body type C, Size 56, Height 182 cm using the dimensions from SR 13544/2010. The simulation of the fit of the product on the mannequin parameterized to the body dimensions shows a good fit with pressure in the shoulder area, which is normal for a product with support on the shoulders. In the area of the elbows, the jacket has reinforcements as a protection area against friction, a fact that stiffens a little and slightly presses the elbows. | | |

## CONCLUSIONS

The main advantage of virtual prototypes consists in the fact that clothing products can be designed to fit directly on a parametrized mannequin/avatar of a wearer, without it physically existing at the time of the trials and then transferred to production.

In a small number of steps, the shape and dimensions of the patterns, colors, types of knits and other parameters that influence the shape, appearance and comfort of clothing products can be changed.

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The use of 3D virtual prototyping offers many advantages as: the possibility to check the aspect of the product and how it is matching on the 3D model of the human body, without requiring physical development of a prototype; the reduction of the time to produce the first prototype; a significant reduction of the manufacturing costs; the reduction of waste; the possibility of diversifying the model – by combining or altering the textures of materials; the possibility of co-creation service; improved communication between the development and production departments; online promotion of the created model.

The results obtained in the design and creation of the virtual prototype, which included the function of modeling the product according to the technical characteristics of the materials, are used to define the technological parameters and programming of knitting machines of the functional knitted textile products.

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