A digital-integrated solution for a customised 3D design process of garments

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MANUELA AVADANEI
ANTONELA CURTEZA
IONUT DULGHERIU

SAVIN-DORIN IONESI
DIANA VIZITEU
EMIL-CONSTANTIN LOGHIN

ABSTRACT – REZUMAT

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We live in a digital era in which we have become accustomed to using digital applications to access services or purchase products for daily professional activities, communication/socialisation, or entertainment. The digital transformation of the industry (including the apparel industry) is based on a new approach: the model is developed digitally, presented to the customer, physically manufactured for use and then recorded and made available for purchase on digital platforms. The latter can stimulate connections between customers and manufacturers; in this way, the customer can make specific requests regarding the desired product, and the manufacturer can provide the customer with specific details. Information and communication technologies (ICTs) play a big role in the fashion industry. They are used for the design, production, and distribution of fashion items, communication, and even product co-design. This paper illustrates a method to develop business attire patterns for different professions where a dress code is required (management structures, banking, commercial activities, flight attendants, etc.) by automatically integrating 3D customer data (obtained through a 3D scanning process) and product information. Both product information (dimensions, materials and accessories, manufacturing conditions, e.g.) and information about the customer's body (size, posture, conformation) can be integrated into the conceptual development phase in a tailored (customised) way. The virtual interactive simulation of the product on the avatar representing the customer (virtual 3D prototyping) makes it possible to assess the appearance of the garment on the human body and whether the design requirements have been met.

Keywords: *customised business attire, 3D prototype, virtual simulation, garment patterns, smartphone scanning apps*

Soluție integrată de proiectare 3D a îmbrăcămintei personalizate

Trăim într-o eră digitală, în care ne-am obișnuit să utilizăm aplicații digitale pentru achiziții de servicii sau produse, pentru activitatea profesională de zi cu zi, comunicare/socializare sau pentru divertisment. Transformarea digitală a industriei bunurilor de larg consum (inclusiv cea a îmbrăcămintei) are la bază o nouă abordare: modelul este dezvoltat digital, prezentat clientului, este realizat fizic pentru utilizare și apoi este introdus în rețele online pentru distribuție. Pe platformele digitale, se creează conexiuni între clienți și producători; clientul poate interveni cu anumite solicitări pentru personalizarea produsului dorit, iar producătorul îi poate sugera detalii ale modelului, în avantajul clientului.Tehnologiile informației și comunicațiilor (TIC) sunt puternic integrate și în industria modei. Ele sunt utilizate pentru a proiecta și produce articole de modă, pentru distribuție, comunicare și chiar de co-creare a acestora. Integrarea cerințelor produsului (dimensiuni, materiale și accesorii, restricții de fabricație etc.), ale corpului clientului (mărime, postură, ținută) se poate materializa prin utilizarea unor soluții integrate de dezvoltare conceptuală a îmbrăcămintei, într-un mod personalizat și individualizat. Lucrarea prezintă o soluție de dezvoltare virtuală personalizată și individualizată a produselor de îmbrăcăminte pentru femei, specifice domeniilor de activitate ce impun un anumit cod vestimentar (diferite poziții de conducere/management, domeniul bancar, comercial, aviație etc.) cu integrarea automată a datelor clientului (obținute prin scanare 3D) și ale produsului. Proiectarea și simularea interactivă în spațiul virtual a produsului pe avatarul clientului permite analiza modului de potrivire al acestuia pe corpul purtătoarei și de verificare a modului de îndeplinire a cerințelor de conformitate impuse de model.

Cuvinte-cheie*: ținută de afaceri personalizată, prototip 3D, simulare virtuală, tipare produs de îmbrăcăminte, aplicații de scanare pe smartphone*

INTRODUCTION

In the apparel industry, customers look for various products that meet their personal needs. Because of the changing nature of fashion trends and market demands, the collections are numerous, and stores demand new models at a high-speed rate. This inevitably leads to the expansion of the variety of models and to the shortening of the life cycle of the products. This new orientation determines manufacturers to invest in advanced technologies that enable them to achieve the desired goal at a high level of quality and in the optimal amount of time [1–3].

Internet connectivity, the expansion of wireless communications, the development of artificial intelligence, and real-time data analysis are causing essential changes in the production of consumer

goods. Industry 4.0. is significantly changing the entire production process by unifying digital technologies and the internet with conventional industry in order to manufacture products as quickly as possible and to quickly adapt to market changes (digitalisation). From an economic point of view, industry 4.0. is an excellent opportunity for restarting and modernising production and of developing business models for new services and products. In this digital/virtual environment, textile companies have to diversify their production so that it includes both mass production (small orders) and customised production (products adapted to the customer's needs) [4].

Creating personalised apparel products (fashion products) is a very complex process because fashion trends are highly dynamic. This process is easier to carry out in the case of business clothing, sports and protective items, since in this case, the purpose of the product, its conditions of use, the design constraint (dress code) and the information about the client's body shape are known from the beginning. There is also the possibility of contacting the customer during the design phase to check whether the designed product is correct and whether it meets his/her expectations.

The following essential elements are considered in the initial stages of customising a garment model:

- the model details and structure;
- the list of all materials which are required for producing it;
- information about the wearers' body shape;
- the production and quality control stages;
- storage and delivery conditions.

This paper proposes a method to develop business attire patterns for different professions where a dress code is required (management structures, banking, commercial activities, flight attendants, etc.) by automatically integrating the customer data and product information.

Information about the customer's body is captured using 3D scanning apps (the customer photographs their body from exclusive angles, and the app then "stitches" the snapshots together). These data are used as initial information to develop the needed customised 2D patterns.

The company's designers work out the model patterns and 3D virtual prototype and then send it to the client.

With the real-time virtual fitting mobile apps, the customer can visualise and analyse the item dressed on his body, save the result and send it to the company. In this way, the prototype is validated, and the manufacturing process can begin.

During the personalised design process, the designer [5]:

- develops the structure and shape of the main geometric blocks (main elements) for the personalised design process of the components of the chosen garment;
- receives the 3D data, output data from the mobile apps and integrates them into the design scenario;
- modifies the shape of the main geometric blocks to obtain the pieces of the chosen model (for all the layers);
- creates the 3D virtual prototype and dress it on a corresponding virtual mannequin of the client;
- analyses the appearance of the product. If he/she finds problems with the fit or balance of the product on the body, he/she will make the necessary changes to solve the problems (2D pattern);
- sends the 3D information to the customer for validation/confirmation.

After validation, the designer sends the digital patterns that will be used in the manufacturing process. In addition to the garment fitting well and looking good on the customer's body, this solution is key to reducing post-industrial waste in the garment industry – the number of garments that do not fit the customer's body (rejected or unsold items).

ELEMENTS OF THE PROPOSED SOLUTION

The personalisation of the clothing design process can be carried out in two ways:

(a) Via a customised 2D design of the shape of the product components, which employs special tools provided by a CAD system, as well as customer data and the dimensional characteristics of the products. Afterwards, they can be exported into or imported from a 3D virtual environment in order to obtain the virtual prototype of the chosen model.

(b) By directly designing the shape of the components of the model on the virtual mannequin (3D design) by taking into account: the type and the position of the layers (for each product), the stylistic lines of the product, volumes, interactions between layers from the product structure or between layers and the virtual mannequin. Afterwards, one can extract the components of the model.

In method (a), the new shape of the model patterns (for a new client) is automatically generated by changing the initial data used in the design scenario, while in method (b), the design process is performed again on the new mannequin.

In this paper, method (a) is used to obtain customised patterns for a women's jacket (business style), which are needed to develop the integrated digital solution for a 3D design process for a customised model.

The different phases of the design process focus on the jacket and are carried out using the specific tools of the Gemini CAD system's made-to-measure mode [6, 7]. This module is designed so that the user can geometrically design and control the size of the garment pieces. The user has the possibility to change the structure of the initial data or the mathematical relations immediately; the shape of all the garment pieces is automatically reshaped.

The development of the main geometric blocks

The Made-to-Measure module of the Gemini CAD system allows the use of the geometric 2D design method to obtain the shape of the main elements of the product (main blocks). This module uses values

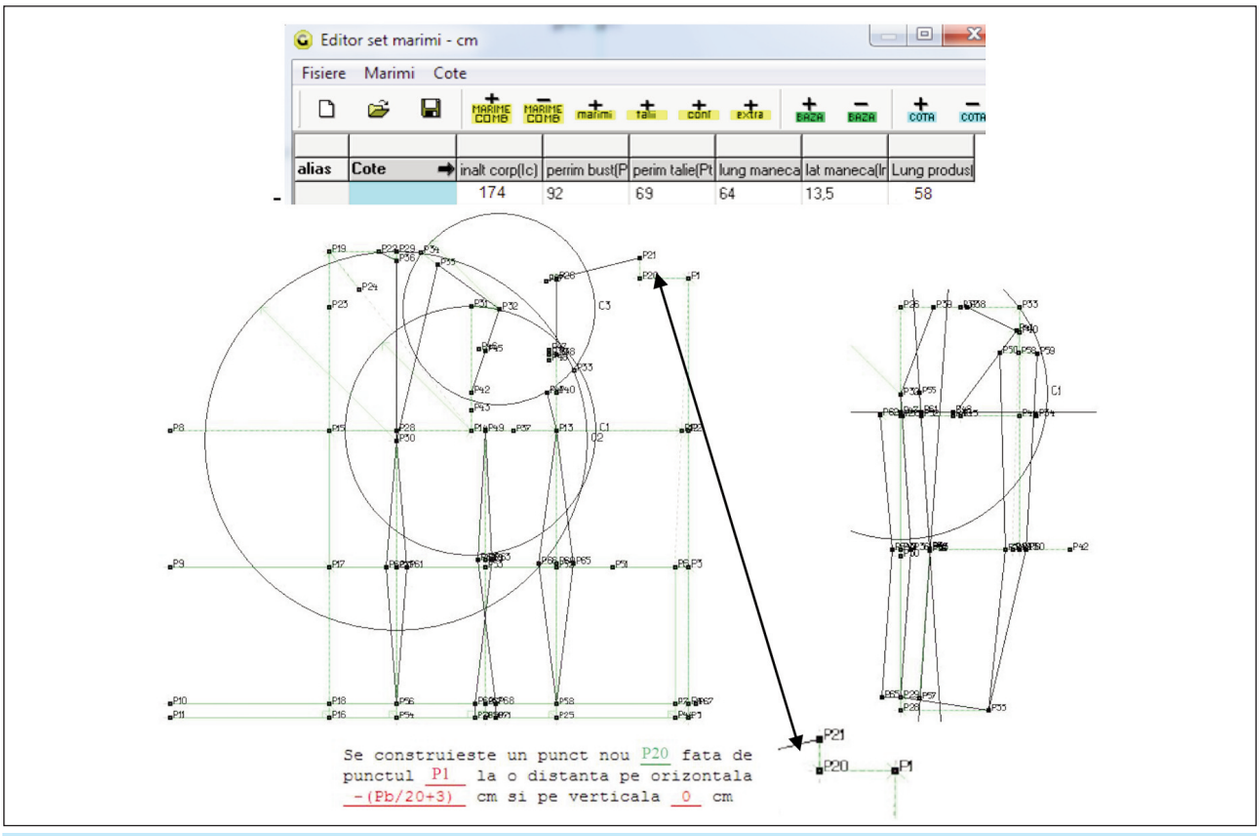

Fig. 1. The geometric layer of the MTM module

of specific body measurements of the customer, product measurements and style data (expressed by values of allowances and product characteristics). By using specific geometric functions, the mathematical relationships of the chosen design solution are transferred to the digital environment while maintaining the connection with the required output data [8–11].

For example, figure 1 shows the values of the client's body measurements necessary for the design process (personal data), the geometric layer on which the main patterns of the jacket are designed (front, back, side panel and sleeve), and it shows the relation that determines the position of the highest point of the back element (the base-neck point).

The basic block shown in figure 1 is used to design the pattern of the main elements for a woman's jacket with side panels (business style). The main steps of adapting the jacket block to the characteristics of the model are explained in the following sections of the article. The elaborated design scenario is flexible and can easily be altered/adapted to another scenario, e.g. a jacket without side panels but with a waist dart in the back.

Human body scanning

3D body scanning has two main applications in the apparel industry:

– monitoring population trends through anthropometric measurements in order to determine specific sizes by wearer group;
– developing computerised systems that integrate information from 3D scans into textile design applications.

With the advancement of artificial intelligence, special applications for mobile phones (smartphones) have also been developed in modern times. The scanning method with mobile apps is simple: the application takes photos of the person (front, back and side views). The images are then processed to create an avatar that reflects the customer's body measurements. When the avatar is created, the list of its measurements is also created (names and values, see figure 2). The client can store this information in the cloud (personal account) and reuse it anytime. Mobile scanning has one drawback: the process is

Fig. 2. Data about the human body obtained through scanning with mobile apps

not as accurate as stationary scanners. The accuracy of the information depends on the performance of the smartphone and the ability of the user to take good photos.

Personalise the blocks to get the patterns of the chosen business model

The main geometric blocks are suitable for designing the 2D shapes of the components of the jacket, a business style. This model can be considered a dress code for a flight attendant.

The necessary steps for obtaining the shape of the main elements are introduced in the geometric design layer. The designer receives the sketch of the model and then performs technical analysis to determine the steps that must be taken to produce the components of the model.

The customisation process requires the automatic transfer of the customer's measurements (obtained by scanning with mobile apps and stored in the personal cloud account) and specifications regarding the stylistic details of the product.

Figure 3 illustrates two customised models for women's jackets (business dress code) as well as the model sketches of the selected products.

The main steps for adapting the basic jacket block to the features of the model are:

– import the needed values of the client measurements;
– establish the new dimensions of the jacket model;
– change the shape of the upper contour lines (deep neckline) for both models;
– design the fastenings or closures systems (model a and b);
– design the upper yoke (model a);
– design the pockets patterns (model a);
– extract the model pieces.

Creation of the virtual 3D prototype

With the virtual prototypes, the user can check how the product looks on the virtual mannequin (avatar) and whether the chosen design solution is the right one. In the field of textile clothing, 3D solutions from well-known manufacturers such as Lectra, Optitex, Clo3D, 3dsMax, etc., are used.

The virtual 3D prototype of the jacket (model a, see figure 3) was created with the program 3dsMax. The 2D pieces of the garment model were imported in 3dsMax to create the virtual prototype. Figure 4 shows some work stages performed in 3dsMax [12, 13].

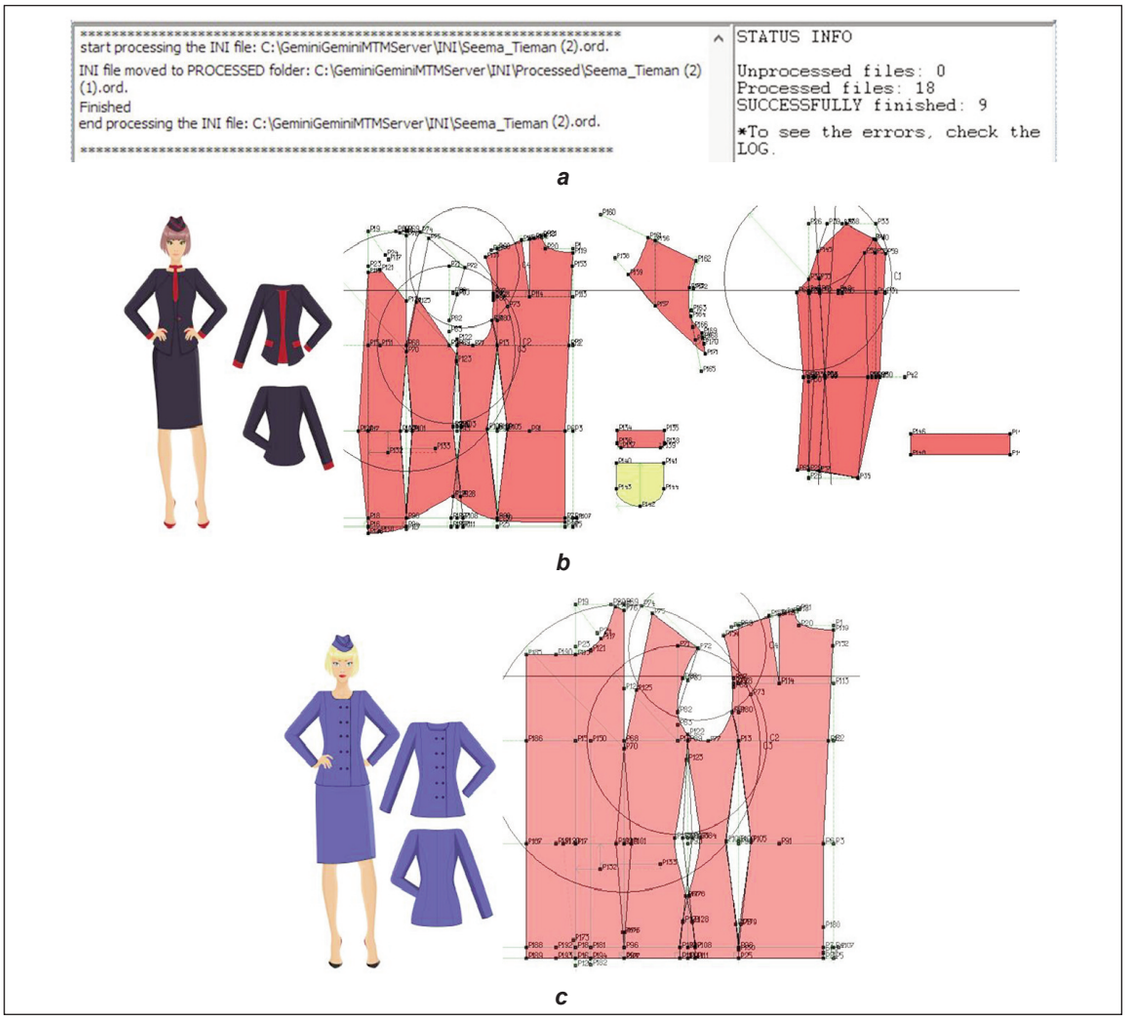

Fig. 3. Customised patterns of the selected models of jacket:
a – the automatic transfer of the customer measurements; *b* – women jacket-model a (design the yoke, fastening system, front pieces); *c* – women jacket-model b (fastening system, front pieces)

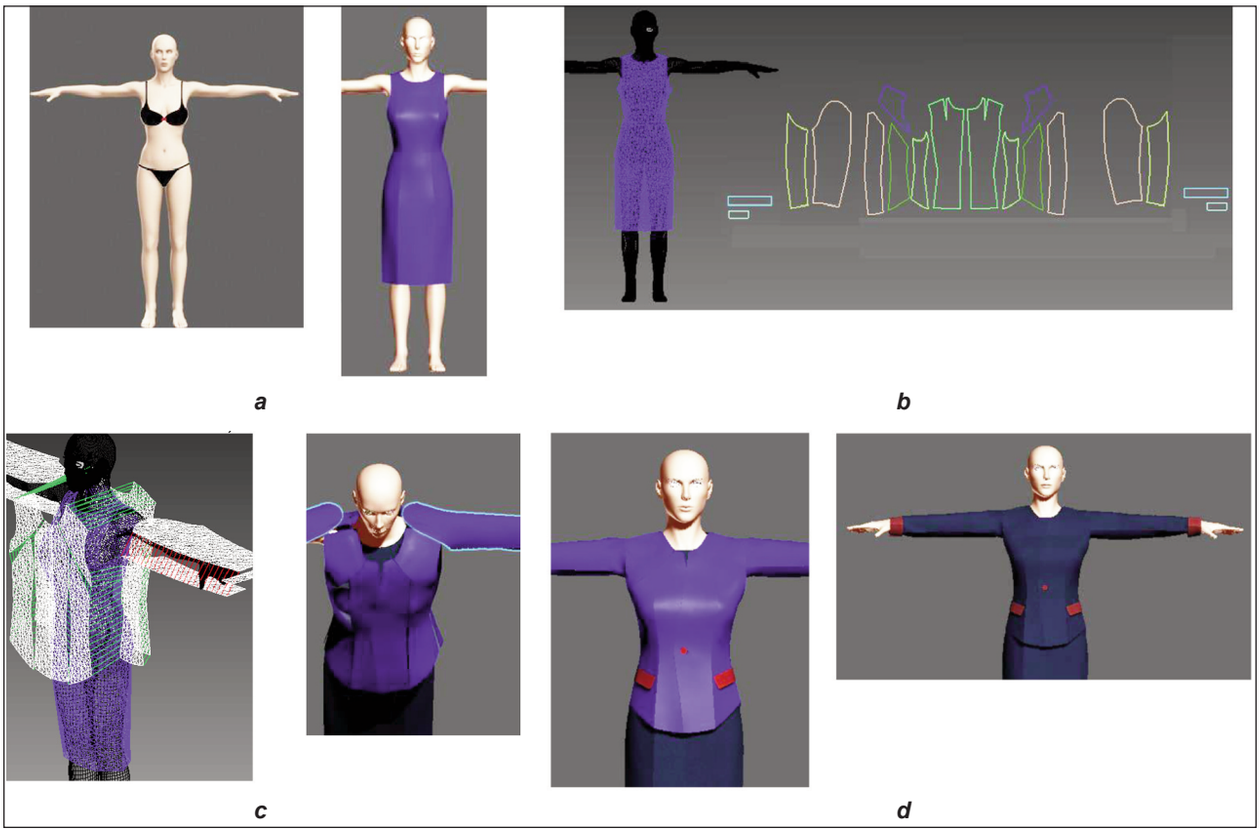

Fig. 4. The creation of the 3D virtual prototype (jacket):
a – dress the virtual avatar in a dress (as a formal business dress code); *b* – import the jacket pieces;
c – declare seam lines, simulation process; *d* – the final 3D virtual prototype, change the jacket colour

The validation of the prototype by the customer

The 3D scan application allows one to import images created by using the 3dsMax simulation program. In this way, the customer can visualise the product appearance on the body (fitting degree, balance, model details, general appearance, e.g.).

The software also enables the user to display the stress map, which depicts the stress areas that occur when the product is worn: red indicates stresses in the product (undersized pieces), blue means areas light product areas with and green is used in the case of a correct match [14].

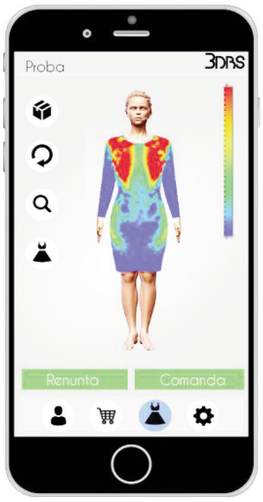

Fig. 5. Tension map

Figure 5, for example, shows a sample with fitting issues (the garment is undersized in frontal areas). In extreme cases, it is necessary to alter the pattern to solve the issues. The customer sends the information (figure 5) she saw on the mobile to the manufacturing company, and the designer fixes the identified problems. After a re-check, the customer has the option to complete the order.

By validating the 3D virtual prototype, its patterns become production patterns and are then used to obtain the physical product.

CONCLUSIONS

In recent years, the concept of online commerce (or e-commerce) has evolved. Increasingly many companies have adapted their marketing strategies to this business environment, while others have developed theirs solely on this basis (such as E-bay).

Online retailing offers customers a whole range of significant advantages, such as the very convenient option of purchasing goods from the comfort of their own home. As time has become an increasingly valuable resource nowadays, offering this option becomes a necessity. Moreover, online shopping covers an unlimited geographical area as opposed to a store that can only serve a relatively limited one. Thus, a customer can buy products sold on other continents and receive the purchased products within an amount of time that is specified on the website. Besides this, prices in many online stores are lower than in traditional ones, both as a promotional strategy and due to the fact that the cost of maintaining a website is much lower than the rent for a store and the salaries of salespeople.

It is necessary to carry out a comprehensive study in order to employ the virtual design method that relies on the interactive simulation of the product, raw materials, and the virtual mannequin in order to find

the optimal way of putting together the structural parts of the garment. The 3D simulation of the product worn on the body is carried out by developing complex mechanical models for collision, rendering, and animations. One example from the latter category involves the system consisting of the garment and the human body and is elaborated sequentially depending on the animation levels of the skeleton. In this context, the movement of the garment with respect to the surface of the body surface is simulated by using mathematical modelling depending on certain contact points between the body and the garment during the given process. If a designer develops basic blocks for the main category of garments (which can also be worn as business clothes), these blocks can be easily adapted to the model's characteristics and the client's body shape.

The mobile scanning apps are accessible to any customer (with a smartphone) and very useful for a virtual try-on. In this way, the customer can assess the appearance of the garment on his body (corresponding virtual avatar) and the details of the model and, if the result meets his requirements, place the manufacturing order.

The proposed digital integrated solution for 3D customised design can promote the production of business clothing, reduce the number of returned non-conforming products, and increase customer satisfaction. When a company develops new models in a virtual environment and submits them to the customer for approval, the consumption of raw materials, the cost of the manufacturing process and the amount of waste are reduced. This has a positive effect on the environment and also on customer satisfaction.

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Authors:

MANUELA AVADANEI, ANTONELA CURTEZA, IONUT DULGHERIU, SAVIN-IONESI DORIN, DIANA VIZITEU, EMIL-CONSTANTIN LOGHIN

"Gheorghe Asachi" Techical University of Iasi, Faculty of Industrial Design & Business Management, 29 Bld D Mangeron, Iasi 700050, Romania

Corresponding author:

MANUELA AVADANEI
e-mail:mavad@tex.tuiasi.ro