Design of an interactive fashion recommendation platform with intelligent systems

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ABSTRACT – REZUMAT

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With the increase in customer expectations in online fashion sales, greater integration of fashion recommender systems (RSs) allows more personalization. Design decisions rely on personal taste, as well as many other external influences, such as trends and social media, making it challenging to adapt intelligent systems for the fashion industry. Different methods for recommending personalized fashion items have been proposed, however, the literature still lacks an approach for recommending expert-suggested and personalized items. In this research, an interactive web-based platform is developed to support personalized fashion styling, focusing on users with diverse body shapes. To merge the user's taste and the expert's suggestion, the proposed methodology in this research combines genetic algorithms and machine learning techniques allowing the system to access expert knowledge (including external influences) and incremental learning capability, by adapting to the user preferences that unfold during interaction with the system.

Keywords: *fashion styling recommendation, personalisation, female body shapes, web-based platform, genetic algorithms, artificial neural networks, incremental learning*

Proiectarea unei platforme interactive de recomandare a articolelor de modă cu sisteme inteligente

Odată cu creșterea așteptărilor clienților în vânzările de modă online, integrarea sistemelor de recomandare a articolelor de modă (RS) facilitează procesul de personalizare. Deciziile de design se bazează pe preferinţele personale, precum și pe multe alte influențe externe, cum ar fi tendințele și rețelele sociale, ceea ce face dificilă adaptarea sistemelor inteligente pentru industria modei. Au fost propuse diferite metode de recomandare a articolelor de modă personalizate, cu toate acestea, în literatura de specialitate lipsește încă o abordare pentru recomandarea articolelor sugerate și personalizate de experți. În cadrul acestui studiu, este dezvoltată o platformă interactivă web pentru a sprijini stilul personalizat de modă, concentrându-se pe utilizatorii cu diverse forme ale corpului. Pentru a îmbina preferinţele utilizatorului și sugestia expertului, metodologia propusă în acest studiu combină algoritmi genetici și tehnici de învățare automată, permițând sistemului să acceseze cunoștințele de specialitate (inclusiv influențe externe) și capacitatea de învățare incrementală, prin adaptarea la preferințele utilizatorului care se desfășoară în timpul interacțiunii cu sistemul.

Cuvinte-cheie*: recomandare de stil de modă, personalizare, forme ale corpului feminin, platformă web, algoritmi genetici, rețele neuronale artificiale, învățare incrementală*

INTRODUCTION

Despite the specific challenges involved, fashion products constitute a major category for e-shopping. Within current circumstances in the e-commerce sector, customers expect both personalized experiences and expert opinions regarding fashion trends [1]. With the dramatic increase in online sales in recent years, intensified by the COVID-19 pandemic, it is increasingly important to offer styling recommendations and options for interaction with customers on virtual platforms. In a personalized virtual platform, virtual tools and assistants take on the role held by sales advisors in a physical store [2]. They can provide both design/technical and social/service support based on customers' unique needs [3].

Integration of artificial intelligence (AI) in fashion includes multifold levels in the supply chain [4]. Virtual assistance and fashion styling purposes at online retail points are commonly provided by Recommender Systems (RSs) to improve user satisfaction through personalization and interaction.

Most current online styling recommendation platforms use fashion recommendations from human agents, such as online stylists, friends, and celebrities, and data is provided based on the user's input. There are some examples with automatic system recommendations using machine agents, but the number of these examples is limited, and they are generally based merely on user history data [5]. There is a gap in the literature concerning fully personalized fashion recommendation systems merging user's taste and expert's suggestion, and there are few commercial examples of such a system.

The main aim of our research, therefore, was to develop an interactive web platform for fashion

styling recommendations. The unique approach in this research aims at developing a fully personalized method that fuses users' fashion preferences with a mix of human and machine experts' recommendations employing intelligent decision-making systems. The system learns progressively about the users' preferences based on their evaluation of expert-approved styles and updates the recommendations in line with the user's tastes.

LITERATURE REVIEW

Research studies have been conducted for fashion styling recommendation, and a range of commercial systems for fashion recommendation have been implemented on various scales and for various purposes. The styling and/or fashion recommender systems in the market can be categorized considering several parameters, such as recommendation agents, system types, data collection and application types [5].

Systems such as Outfittery.com and Wishe.me gather information about the customer's style, size and price preferences, and personal style services recommend items of clothing based on these needs. In these systems, the stylist can choose from a range of brands. Some other systems that use recommendations provided by online stylists are Glamour Ask a Stylist, Nordstrom Stylist Services and The Chapar [5]. Some of these platforms are web-based, others are mobile applications.

Stitch Fix.com is one particular example of an online personal styling service that uses recommendation algorithms to make recommendations based on size, budget and style [6]. Styling recommendations evolve with greater information on the customer's taste, needs and lifestyle; the system uses personal stylists to uncover pieces that suit to personal taste, size and price range [7]. Trufit.com is one well-known example offering a personalized platform focusing on fit in addition to style. The system finds the best size and then recommends styling from among the garments provided by the brands covered by the platform.

Intelistyle.com provides personalized styling with the use of machine learning by analysing the latest catwalk photography and social media. Dressipi.com is a similar technology support for retailers providing personalized shopping experiences. Nosto.com and Stylebookapp.com provide personalized recommendations based on machine agents. Amazon.com uses an automatic system as a recommendation agent [5], providing personalized recommendations of items based on user history data [8]. Additionally, Amazon launched a camera-based personal fashion style assistant device called "Echo Look" in 2017, giving fashion styling advice on fit, colour and current trends using a combination of machine learning algorithms and fashion specialists' advice [9], however, Amazon withdrew this system shortly after its launch. These platforms offer a customization experience in terms of various parameters such as body type, occasion, colour code, etc. StyleUp.clothing has another unique approach, allowing a personal avatar to be created by entering body measurements into the system. The system can calculate the body type and recommends styling options for specific body shapes. Asos.com offers a visual search technology called "Style Match" as a mobile application. When the user uploads an image, the system searches their brand database for the most similar products [10].

A survey of such existing fashion recommendation platforms reveals that some online recommendation systems are start-ups, which turn into big businesses, while others fade away or switch to another retail strategy. Despite various possibilities for fashion styling recommendations from the consumer and retail perspective, such systems are not widely applied. About the 'perceived ease of use' and 'perceived usefulness', consumers' acceptance of information technology is strongly correlated with perceived usefulness, and the prominence of usefulness is over ease of use [11]. All other factors being equal, users are more likely to adopt a user-friendly technology. Adopting the Theory of Planned Behaviour [12], Innovation Diffusion Theory [13], and Technology Acceptance Model [11], a new model is developed and tested to evaluate the effects of mobile recommendation agents [14]. According to these results, product purchases increase with the perceived usefulness of the mobile recommender agent, additionally, recommender agents help to predict usage intentions and influence consumer shopping preferences. New retail business models should meet both the information and communication demands of customers.

Recommender agents are useful tools from the customer perspective for decision-making, and have some obvious advantages, such as enormous data processing capacity and almost unlimited memory, allowing for smarter and more interesting results with less effort, powerful search engines [15], and the ability to create an enjoyable experience, especially for the customers who seek comfort [6]; however, major obstacles of these systems are the unnatural processes, the lack of emotional and social intelligence, and the practical difficulties in applications.

Consumer participation is a factor to increase satisfaction and create a joyful experience in online product recommendation services, while decreasing perceived ease of use, especially for purchases with high financial risk [16]. The recommender systems currently take time to use, so improving the simplicity with which customers can express their preferences will pave the way for more widespread use of these systems [15].

Based on the survey of current fashion recommendation platforms and within the theoretical framework given above, an innovative approach in this field is the integration of an interactive customer interface with an automatic system styling providing recommendations in a user-friendly and pleasurable way. The creative merging of the customer's taste with the expert's opinion, and developing these styling options further with the machine learning capabilities

is an underexplored area and our contribution to this gap in the field. Another difficulty in current online garment sales is achieving a good fit due to the challenges of dealing with personalized data such as body shapes [2], therefore, we considered applying fashion styling recommendations for female body shapes.

OBJECTIVES

With this context, this research aims to integrate RS for fashion styling, which recommends expert-approved items in line with user preferences. The specific objectives are as follows:

1. To develop a personalized interactive web platform for fashion styling recommendations based on female body shapes and with the use of intelligent decision-making systems.
2. To develop a novel methodology and framework to merge expert and user aspects in recommended items.
3. To show that Interactive GA can be used as the RS's central instrument to provide the critical capabilities of incremental learning, adaptation and creativity in fashion recommendation solutions.

METHODOLOGY/APPROACH

Development of the database for the web-based platform

In this research, to create personalized fashion styling suggestions, a female body shape classification was devised based on the proportions of the front view silhouette, identified and coded using figures based on letter shapes [17]. Styling recommendations were provided for the following body shapes: V (inverted triangular), A (triangular), H (rectangular) and O (oval)-shapes. To create an aesthetic relationship between the shape of the body and the garment for fashion styling, we assembled combinations of top and bottom garment pieces or dresses with several attribute categories. The attribute categories included garment details such as waistline, hem and flare for pants and skirts; collar type, sleeve length and garment length for tops; and colour and pattern design for all garment types.

A knowledge base is built consisting of fashion styling recommendations for these four female body shapes. The design recommendation system was achieved through a garment design archive consisting of 2310 2-dimensional technical drawings. Additionally, styling suggestions for each specific body shape were generated by three experts in fashion design. One expert has 21 years, the other has 35 years of experience in the field of clothing production and fashion design. The third expert is a PhD candidate in fashion design.

Initially, 700 styling suggestions were provided across all four body shapes. Basic principles of design, such as contrast, balance, emphasis, proportion, hierarchy, repetition, rhythm, pattern, movement, variety and unity were considered for creating an aesthetic relationship between a specific body type and the styling suggestion. Balancing a specific part of the body by drawing attention to the contrary; playing with proportions to elongate the body; repeating of body shape on the garment silhouette; and emphasizing parts of the body with colours and patterns are some examples of applying design principles for styling suggestions.

Development of the algorithm

The proposed algorithm assumes that the expert has more mechanic-like and static principles so that the expert opinion can be modelled by formal methods for automation, whereas the user's taste is based on human subjectivity which will be inferred by interacting with the user. The expert opinion is modelled by a formal fitness function such that given the attributes of an item, it returns a numerical value indicating the level of approval of the expert. To construct such a fitness function, one can apply any artificial intelligence techniques or ontology-based approaches; or construct a decision tree with fitness outputs, depending on the application domain. The steps of the two-stage methodology are listed below and sketched as a diagram in figure 1.

The first stage is called the expert stage, where the candidate items that the expert approves are generated. The second stage is called the true personalization stage, where the idea is to use human evaluation as the fitness function, the so-called Interactive Genetic Algorithm [18]. In the proposed methodology, the sequential nature of the steps guarantees that the user evaluates only the expert-approved items, as in Steps 2-3-4. Also, the expert opinion has priority over the user's taste in fashion since the expert is the first to evaluate and generate candidate solutions. Thus, the proposed methodology permits searching for solutions that reflect the user's taste in the expert-approved space of solutions. In Step 5, the user's opinion is embedded into the fitness values of the top-N items as the weighted average. Next, in Step 6, GA operators run on this new list to fuse the user's taste into the population. This newly created population is then used as the new initial population in the second round of Step 2, where the newly constructed population will now breed. As this sequence is repeated, the system continually recommends expert-approved items and adapts to the user's taste. So, it is expected that the task of recommending expert-approved and personalized items could be accomplished.

RESULTS AND DISCUSSION

Website design

Considering the difficulties associated with the applications of recommender agents, it is important to improve the interactivity and usability of RSs [15]. Based on the suggested algorithm, the expected major outcome of this research was the development of an apparel recommendation system featuring a web-based platform with a contemporary, easy-to-use, and interactive interface. A detailed visual brand

Stage 1: The Expert Stage

0. Construct a fitness function that imitates the expert.
1. Randomly generate initial chromosomes each corresponding to an item/solution.
2. Apply GA to create a pool of creative items/solutions by iterating enough (m_i) steps using the fitness function of expert from Step 0. m_i can be customized in each i^{th} iteration, since every iteration is an optimization problem of its own.

Stage 2: The True Personalization Stage

3. Offer the user the top-N (e.g. top-20) elite creative solutions/items from the pool, which reflects the expert opinion.
4. Let the user evaluate the top-N items as such giving numerical values, for instance ranking over 5, or binary 0-1 etc.
5. Update the fitness values of top-N as the weighted average of the artificial expert's and user's evaluations.
6. Combine the list of top-N and other chromosomes (i.e. binary coded items), then apply GA operators such as mutation and cross-over to the combined list for one iteration and generate a new population.
7. Using the generated new population in Step 6 as the initial population, repeat steps 2-6 for the next sessions.

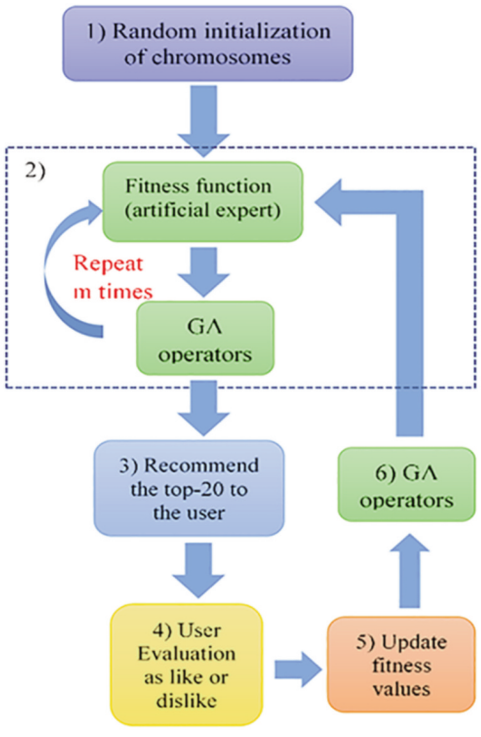

Fig. 1. Proposed recommendation methodology for suggesting expert-approved items that the user is likely to prefer

identity was created for the development of the website. Figures 2 and 3 illustrate some screenshots from the website. Initially, the platform shows some introductory photos, drawings, and videos, and explains the body shape terminology used in the platform. For the suggested flow, the user needs to log in to the system. The system gives three options for identifying the body shape: (1) by entering body dimensions from the front view (the platform provides detailed photos and instructions for measurement taking), (2) by allowing the user herself to select the shape (providing detailed visual and written information introducing the body shapes), and (3) by allowing the user to upload a front view photo (figure 2, *c*).

Based on the identified body shape, 700 styling suggestions were provided by fashion experts, however, the intelligent system provides unlimited suggestions. The user interacts with the system, making choices from alternatives, such as a combination of pants/skirts and tops, or dresses as a single look (figure 3, *a*). When making choices, the user selects from a moving card system showing styling suggestions, based on complete visuals, which provides users with both an expert-informed and a trend-informed experience; thus, this solution contributes to improving the ease of use of the proposed system. To test the platform, three imaginary brands were created and real garment photos were uploaded to the system. As a final step, the system suggests a selected garment from one of these brands and shows an image of it (figure 3, *b*).

Taking an interdisciplinary approach, the development of the platform involved integrating design and engineering perspectives to offer customers an extended service with options. Therefore, the uniqueness of this suggested platform, in contrast to competitors such as StyleUp, StitchFix, and Truefit, is the integration of a machine agent for styling recommendations providing unexpected and more creative styling options, in a continual development based on the customer's taste and expert's opinion.

Stereotype modelling: artificial users

Customer choices depend on rational factors and those that are irrational, arising from human subjectivity, and thus impossible to exactly replicate through computer simulations. Nevertheless, it is possible to create artificial stereotype users who prefer certain features in recommended garments, and this system can be tested, at least for the rational aspects. The idea of stereotyping relies on the presumption that user interests are reflected in the attributes of the preferred items, and are also influenced by attributes of the visual components of the recommended styles [19]. Thus, for a more precise quantitative evaluation of the proposed methodology, before testing with real users, we carry out mass experiments on 20 different artificial stereotype user models and plot the average performance of the implemented methodology to provide insights on its effectiveness (figure 4, *a*). In the Stage-1 of figure 4, *a*, the artificial expert alone is used as the fitness, and at , a local optimum of average fitness chromosomes (around 0.86) is reached. As can be seen, at the user's first evaluation of the top-20 chromosomes, the average fitness values of the population decrease due to the cold start problem. However, as the new sessions are attained, the average fitness values begin to increase, which indicates

Fig. 2. Sample cut-out screenshots from the online fashion styling platform where information is provided regarding the system: *a* – About ShopShape; *b* – Initial styling combinations in the system provided by experts; *c* – What's my body shape

Fig. 3. Photos of: *a* – styling suggestions and user interaction in the web platform; *b* – suggested garment belonging to one of the brands in the platform

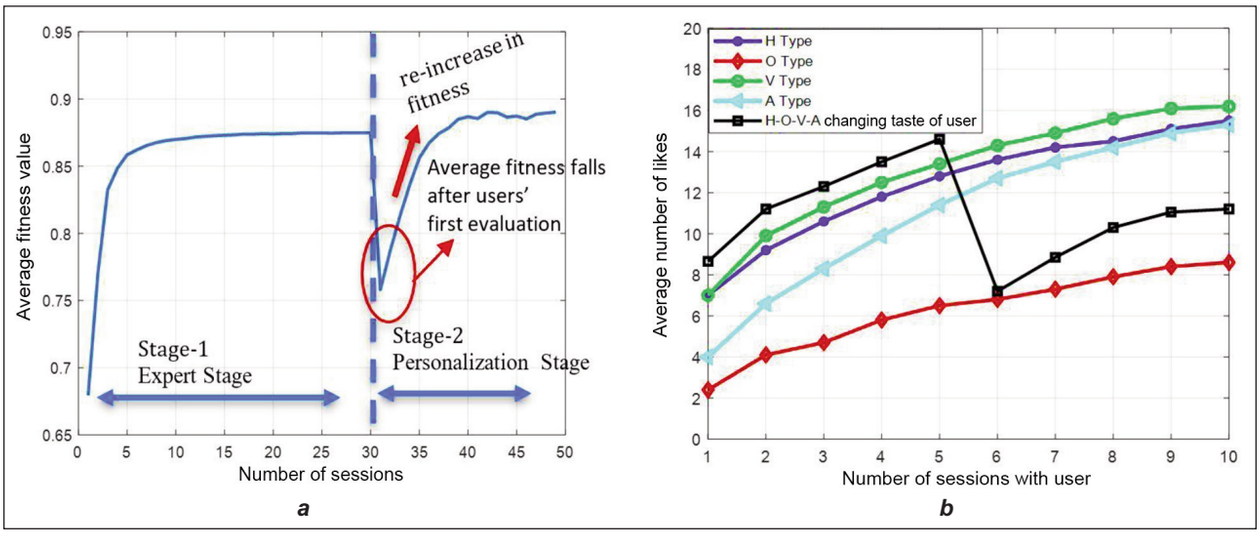

Fig. 4. Graphs of: *a* – fitness values of the candidate solutions in the population-averaged over 20 stereotypes; *b* – for each body shape category the average number of likes in each session, found by averaging over 10 different artificial experts over 20 stereotype users. The black line with square symbols: average number of likes through sessions 1 to 10 in case of change in user's taste

greater satisfaction for both the user and the artificial expert.

We propose two criteria for the success of the algorithm: 1) the more the user interacts with the algorithm, the number of likes in each session should increase correspondingly (the running of the algorithm from steps 2 to 6 is considered as one session); 2) this rising trend should be independent of the artificial expert, stereotype or body shape category. Figure 4, *b* shows an increasing trend for each body shape category in an average number of likes per artificial expert, per stereotype number with an increasing number of sessions. Thus, the results indicate that the algorithm is effective, on average, for all body shape categories (figure 4, *b*), and, on average, for the stereotype users (figure 4, *a*).

Adaptation of the proposed system to the changing taste of artificial users

To test our system's performance in matching the changing tastes of users, we implemented the following test: we defined 5 stereotypes with changing tastes, each defined by two constituent stereotype models symbolized by stereotype-i-j, where the user with stereotype-i-j behaves as stereotype-i in the first 5 sessions, and as stereotype-j in the last 5 in a 10-session experiment. We experimented on arbitrarily chosen models of stereotype 1-5, stereotype 2-19, stereotype 8-13, stereotype 9-14, and stereotype10-15 for each body shape category. The line with square symbols in figure 4, *b* summarizes the number of likes for changing stereotypes. A fall in the average number of liked items is seen in the 6th session due to changing taste, however, increases again after this session through the 10th session. Such adaptation is a manifestation of incremental learning capability.

Results with real users

For experimenting with real users, the web-based platform allowed the evaluation via a simple button click to indicate whether the recommended style is liked or disliked. The system was tested with 50 women participants. Participants indicated their positive remarks for the recommendations provided by the intelligent fashion styling platform. Unlike the synthetic users' results, which can only be interpreted based on the number of likes, the real users' results can be interpreted with additional data from their perceptual impressions obtained using a questionnaire. This impression of the system was positive (about 4 over 5).

CONCLUSIONS

The new approach in our research to online shopping supports the tendency towards increasingly personalized services for online users. This paper contributes to the literature in four main respects: 1) by introducing the proposed intelligent system to enable fashion styling for diverse female body shapes; 2) by developing an automatic adaptive web-based apparel design and recommendation platform for online use; 3) by incrementally enhancing the performance of the proposed intelligent system based on the user interaction, thus obtaining a person-specific design recommendation system; 4) creating a digital dataset for fashion styling considering female body shapes, initially constructed by human experts, and developed in line with the user's taste.

The evaluation of the fashion items reflects the way that the user evaluates a photo on social media, suggesting that the algorithm is compatible with social media, one of the most effective communication methods in fashion [20]. In this very competitive market, it is important to differentiate the service add value to consumers' shopping experience and bring a

competitive advantage. This can be done with small changes, such as integration with social media embedding an expert view, and providing an easy-to-use interactive interface with many visuals rather than text. In addition to the possibilities in current platforms existing in the market, this new approach allows the integration of machine agents complementing the styling recommendations from experts and underlines the simplicity for the customers via providing a sample platform designed for the implementation of the suggested algorithm. In parallel to the theory for a new retail model to meet customers' demands for both information and communication [14], our system offers such an interactive online retail model with a personalised shopping experience, which could add value to online shopping, in the face of the major challenges caused by a lack of real touch and fit issues.

The proposed online platform is shown to be appropriate for use in e-commerce for fashion styling and can be adapted to various other fields. Its two main advantages are the simple, customizable web-based platform, and the convenience of the recommendation algorithm, which simply involves a yes (like) or no (dislike) button. However, in real-world cases, the satisfaction of a given user depends on many factors, including irrational ones. When features above and beyond the body types are involved, the problem becomes more complex, requiring more powerful methods for expert modelling. Recently, deep convolutional neural networks have gained attention due to their success in learning in complex situations [21]. The large databases required by such studies can be obtained by implementing recommendation systems such as those developed in this paper. Such studies will allow the full assessment of the accuracy of the algorithm, and discuss its various impacts.

As further work, 3D visuals and virtual fit opportunities will be integrated as complementary functions. These steps will be conducted in collaboration with a company, and include a wide range of product categories. Such a shopping experience could inform developments in omnichannel marketing, which is a contemporary retailing setting. Such a channel leads to personalization, and also to a more environmentally friendly approach by decreasing product returns and increasing digital communications.

The use of intelligent systems in the fields of fashion and apparel design, in which creativity is a key concept, is an innovative and challenging area. In a field in which practical and commercial applications are currently rare, the encouraging results of these preliminary experiments demonstrate the feasibility of applying intelligent systems to fashion styling. This application, which integrates intelligent systems into design fields, may become an inspiration for similar platforms in other areas of design.

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REFERENCES

[1] Goncalves, D., Liu, L., Sá, J., Otto, T., Magalhães, A., Brochado, P., *The importance of brand affinity in luxury fashion recommendations,* In: Recommender systems in fashion and retail. Lecture notes in electrical engineering, 2021, 734, 3–19, N. Dokoohaki, S. Jaradat, Corona Pampín H.J. & R. Shirvany (Eds). Springer: Cham., https://doi.org/10.1007/978-3-030-66103-8_1

[2] Zhang, J., Liu, K., Dong, M., Yuan, H., Zhu, C., Zeng, X., *An intelligent garment recommendation system based on fuzzy techniques,* In: The Journal of the Textile Institute, 2019, 111, 9, 1324–1330, https://doi.org/10.1080/00405000.2019.1694351

[3] Shim, S., Kwon, W., Chattaraman, V., Gilbert, J., *Virtual sales associates for mature consumers: Technical and social support in e-retail service interactions,* In: Clothing and Textiles Research Journal, 2012, 30, 3, 232–248, https://doi.org/10.1177/0887302X12456903

[4] Liang, Y., Lee, S.-H., Workman, J.E., *Implementation of artificial intelligence in fashion: Are consumers ready?,* In: Clothing and Textiles Research Journal, 2020, 38, 1, 3–18, https://doi.org/10.1177/0887302X19873437

[5] Guan, C., Qin, S., Ling, W., Ding, G. *Apparel recommendation system evolution: An empirical review,* In: International Journal of Clothing Science and Technology, 2016, 28, 6, 854-879, https://doi.org/10.1108/IJCST-09-2015-0100

[6] Kim, J., Kang, S., Bae, J., *The effects of customer consumption goals on artificial intelligence driven recommendation agents: Evidence from StitchFix,* In: International Journal of Advertising, 2022, 41, 6, 997–1016, https://doi.org/10.1080/02650487.2021.1963098

[7] Stitch Fix, *What we do at Stitch Fix*, Available at: https://support.stitchfix.com/hc/en-us/articles/203317264-What-we-do-at-Stitch-Fix [Accessed on February 2023]

[8] Linden, G., Smith, B., York, J., *Amazon.com recommendation: Item to item collaborative filtering*, In: IEEE Internet Computing, 2003, 7, 1, 76–80, https://doi.org/10.1109/MIC.2003.1167344

[9] Guan, C., Qin, S., Long, Y., *Apparel-based deep learning system design for apparel style recommendation.* In: International Journal of Clothing Science and Technology, 2019, 31, 3, 376–389, https://doi.org/10.1108/ijcst-02-2018-0019

[10] ASOS, *The ASOS experience*, Available at: https://www.asos.com/about/asos-experience/?ctaref=aboutus|asosexperience [Accessed on February 2023]

[11] Davis, F., *Perceived usefulness, perceived ease of use, and user acceptance of information technology,* In: MIS Quarterly, 1989, 13, 3, 319–340, https://doi.org/10.2307/249008

[12] Ajzen, I., *The theory of planned behavior*, In: Organizational behavior and human decision processes, 1991, 50, 179–211, https://doi.org/10.1016/0749-5978(91)90020-T

[13] Rogers, E. M., *Diffusion of innovations (5th ed.),* New York: Free Press, 2003

[14] Kowatsch, T., Maass, W., *In-store consumer behavior: How mobile recommendation agents influence usage intentions, product purchases, and store preferences,* In: Computers in Human Behavior, 2010, 26, 697–704, https://doi.org/10.1016/j.chb.2010.01.006

[15] Murray, K.B., Häubl, G., *Personalization without interrogation: Towards more effective interactions between consumers and feature-based recommendation agents,* In: Journal of Interactive Marketing, 2009, 23, 2, 138–146, https://doi.org/10.1016/j.intmar.2009.02.009

[16] Sheng, X., Zolfagharian M., *Consumer participation in online product recommendation services: Augmenting the technology acceptance model,* In: Journal of Services Marketing, 2014, 28, 6, 460–470, https://doi.org/10.1108/JSM-04-2013-0098

[17] Vuruskan, A., Bulgun, E., *Identification of female body shapes based on numerical evaluations,* In: International Journal of Clothing Science and Technology, 2011, 23, 1, 46–60, https://doi.org/10.1108/09556221111096732

[18] Takagi, H., *Interactive evolutionary computation: Fusion of the capabilities of EC optimisation and human evaluation*, In: Proceedings of the IEEE, 2001, 89, 9, 1275–1296

[19] Rich, E., *User modeling via stereotypes*, In: Cognitive Science, 1979, 3, 4, 329–354

[20] Loureiro, S.M., Serra, J., Guerreiro, J., *How Fashion Brands Engage on Social Media: A Netnography Approach,* In: Journal of Promotion Management, 2019, 25, 3, 367–378

[21] Lee, G.H., Kim, S., Park, C.K., *Development of fashion recommendation system using collaborative deep learning*, In: International Journal of Clothing Science and Technology, 2022, 34, 5, 732–744, https://doi.org/10.1108/IJCST-11-2021-0172

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