MySize.shoes: Individual Fitting for (Virtual) Footwear Retailing

Building a link from 3D CAD to Industrial Made to Measure

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***Abstract*—This paper introduces a new approach for Virtual Fitting and Virtual Try On of shoes in Footwear Retailing, named "Individual Fitting" – the future, developed by the Italian company ELSE Corp, in collaboration with its strategic business and technology partners, ShoeMaster International and ATOM Group. The virtual footwear fitting method described, is integrated into the else.shoes™ platform and is currently in experimental development with a dozen footwear brands and manufacturers of Made in Italy products. This approach mixes industrial knowledge about the footwear process, CAD Design data, machine learning and human interaction, to identify the ideal shoe last for each customer. A customer can be matched with a pair of shoes, by first identifying the best shoe last that is best suited for their feet – from made-to-stock, made-to-order or made-to-measure shoes.**

Keywords—virtual fitting; footwear; mass customization; retail

I. INTRODUCTION

Currently known approaches to gathering customer measurement data via 3D foot scanning technologies employ statistical analysis, biometric analysis, or 3D reconstruction using photogrammetry. These approaches are advanced enough to represent a human's feet accurately as a 3D model as well as providing relatively precise (depending on method) meta data and the measurements, relevant to produce made to measure footwear. But, they fall short as they do not consider the unique properties of the shoe product itself and how they react with the nuances of each individual foot.

To go from a 3D scan of a foot to the selection of a suitable shoe, or the adjustment of a 3D CAD pattern of a customized pair of shoes, to eventually manufacturing that pair of shoes; other supporting methods need to be employed to attain the result of a truly well-fitted pair of shoes for a specific customer. ELSE Corp is currently working on an Individual Fitting method commercially known as MySize.shoes, that in addition to using the currently diffused approaches, also employs individual Customer Feedback and connects an algorithmic simulation with the real-life experiences.

II. BACKGROUND

Simplified approaches to Sizing and Fitting not only cost the fashion industry a lot in monetary terms, but also have a negative impact on the environment as they lead to immense amounts of waste, by producing far more shoes, than the market is able to digest. Furthermore, each manufacturer has their own sizing charts with information interpreted according to their own production and economic values and constraints. A wider array of brand-specific fit and sizing, leaves individuals unable to find clothing which meets their needs [1]. Returns are a huge expense for retailers, costing a total of £20 billion a year [2]. Lack of accuracy in fit reduces customer satisfaction and in turn, the potential lifetime value of the consumer. Fit is more than a matter of linear measurement: a 3D profiling of body shape reveals large differences across similar measurements [1]. The demand for customized products is on the rise. The World Economic Forum predicts that by 2026, consumers will have access to a seemingly unlimited choice of products, price transparency, bespoke experiences and convenient fulfilment options (WEF, 2016). The customized clothing market is expected to be worth €34 billion by 2020.

To this end, since 2014, ELSE Corp has been building B2B frameworks, platforms and services around their core concept 'Virtual Retail' (www.virtual-retail.org), that facilitates the demand for mass customized, made to measure products that can be manufactured on demand on the industrial scale and with industrial process scalability logic. It also enhances a brand's physical experiences with virtual tools. The company is focussed on using new technologies, such as Cloud computing, 3D CAD, machine learning and AI to enhance the physical shopping experience of customized products. While delivering these services, the company is focussed on providing brand's customers with products that 'fit individually', both in terms of size as well as aesthetics. With the Individual Fitting method, each customer will own unique products that fit them perfectly and will basically have their own individual "Fitting Profile" (which is much different from Sizing calculation, adapted by hundreds of online fitting service providers).

As seen in Fig.1. below, the Individual Fitting method for footwear retail is set to combine the known Virtual Fitting methods with a Real Fitting/Try-On with feed-back incorporated; which together result in a unique algorithm generated for each customer – the more trials registered by a customer, the more precise the algorithm becomes.

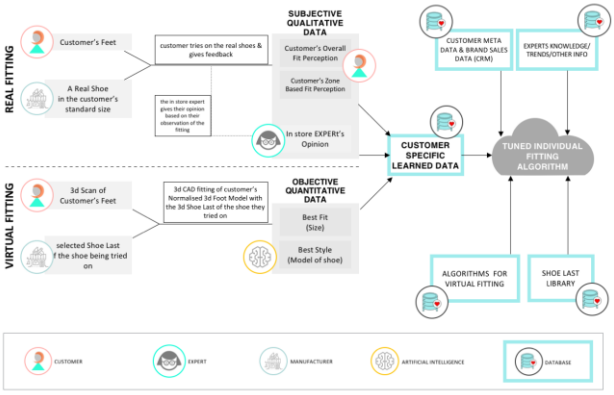

Fig. 1. Individual Fitting for Footwear Retail

Currently, the Virtual Fitting feature – a mathematical method, is setup and integrated in the else.shoes™ platform; while the Real Fitting module MySize.shoes, which uses data science and feedback, is still in development and will be presented to the market in Q2 2018. This paper will elaborate on ELSE Corp's in-development Individual Fitting method that incorporates both Virtual Fitting and Real Fitting data.

III. ELSE.SHOES™ VIRTUAL RETAIL PLATFORM

The company's else.shoes™ platform was launched on the market in September 2017. With it, companies can easily transition to a Virtual Retail or 'No Stock Retail' model. It is an end-to-end industry solution for the footwear sector, based on the E.L.S.E. core framework for Mass Product Customization and the ELSE-ware manufacturing 4.0 middleware framework; enabling mass customisation, industrial made to measure and on demand production. It is present in the product and customer lifecycle, intervening in Design & Prototyping, Mass Customization of the products in Retail, CRM, Custom Order generation (optionally Made to Order) and the Hybrid Cloud Manufacturing of the customized products.

The following points are key for the else.shoes platform:

A. *The brand's shoelasts*

As each brand has their own sizing charts, toe allowance and other unique factors to consider during the manufacture of their footwear, the else.shoes platform needs to have the accurate 3D models and metrics of the shoelasts being used by the brand for production.

Once a brand has decided to sell their customizable products through the platform, 3D CAD models of their products will be input into the configurator along with all their customization options and their corresponding shoelasts for each product – for each standard size offered by the brand for that product.

The accurate 3D representations and metrics of all the shoelasts are vital for the Virtual Fitting module as they are used to compare with the 3D models of a customer's 3D foot scans and metrics.

For the Individual Fitting method, it is important for each shoelast to be classified and registered (as meta data only) in a database of shoelasts with the following information stored about it:

- Metrics: measurements and dimensions
- Related models, based on these shoe lasts
- "Similar" shoelasts from different models or collections
- Product Part identification, coming from CAD 3D and shoe modelling (based on an x,y,z axis)
- Feet zone identification for feed-back registration and generation of industrial MTM extension of shoe last (based on an x,y,z axis)
- Recommended feet types
- Any other meta- data, to be taken into account by Machine Learning

B. *Virtual Retail Corner: physical space for a new customer experience*

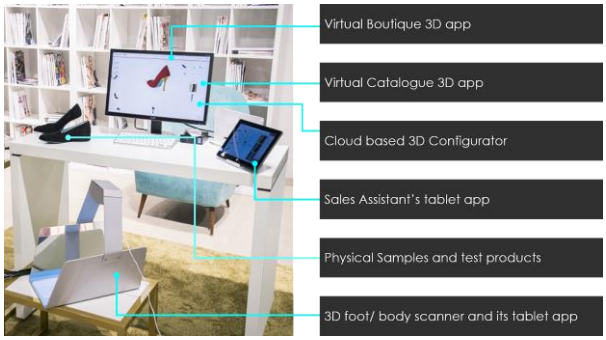

Fig. 2. Example of a Virtual Retail Corner

Customers can engage with the platform physically at 'Virtual Retail Corners', or virtually through augmented, mixed and virtual reality devices.

- Virtual Boutique 3D app: the first point of contact with the platform - a digital representation of the brand's retail space, navigable via embedded hotspots
- Virtual Catalogue 3D app: a navigable catalogue of all the brand's shoppable virtual products
- Cloud based 3D Configurator: customers can view and select configuration options for a selected 3d product
- Sales Assistant's tablet app: a remote device to navigate through the options and make selections
- Physical Samples and test products: physical samples of products materials and accessories serve as tangible

aids to assist the customer to better imagine how their final product will be. Test products serve for physical Try-On and the results from the trials get registered in the individual customer's profile

- 3D foot scanner & its tablet app: to gather the customer's measurements

C. The Virtual Shopping Experience

In a physical space, the flow of the experience would be as follows:

- Register/Login: A customer would first register themselves on the platform or login to their existing customer profile
- Scan Feet: Through integrated 3D scanners, present in the brand's Virtual Retail Corner, the customer would have their feet scanned. This 3D Foot data is gathered from the customer and gets stored in the brand's cloud CRM extension for 3D body information management. It matches this data with the product CAD and metadata and matches the feet shape and particularities with product data and provides sophisticated analysis for style suggestions and product analytics.
- Select a product: Then, either autonomously or with the help of a sales assistant, they would navigate through the Virtual Boutique and the 3D catalogue of virtual customizable products and would select a product to customize.
- Customize the product: Through the 3D configurator a customer would customize the product – selecting product parts, colours, materials, accessories etc.
- Virtual Fitting: Through the Virtual Fitting feature, the customer will be able to see how the different sizes of the brand would fit them best.
- Try On registration: The customer tries on the physical shoes and the results of the try on get stored in the database of records, related to the real experience of existing shoes, with all the relevant feed-back (overall and zone based), which gets used for elaboration of the Individual Fitting setup

D. Modules

The else.shoes platform is made up of three modules. Each of these modules is still in progress. This paper will focus on the MySize.shoes™ module and will elaborate on the progress made and the plans for it.

1) *MySize.shoes™ Fitting module*

SaaS Cloud services tackle the sizing problem through a Virtual Individual Fitting module called MySize.shoes™ (henceforth referred to as MySize). MySize.shoes™, is an AI-powered virtual sizing and industrial made-to-measure production optimization service related to footwear manufacturing, that integrates CAD models and 3D frameworks. It is comprised of a set of algorithms – internal and from partners of ELSE, that optimize the customer experience related to detection of their unique fit.

This module can exist also as a separate independent cloud service and can be integrated directly by a brand into their e-commerce systems.

2) *MyStyle Customization module*

MyStyle is a product style customization module powered by E.L.S.E., currently found in the else.shoes platform. The MyStyle SDK for product configuration is built on the Azure cloud.

3) *DIY&AI Artificial Intelligence based style & size recommendation module*

DIY&AI™ is a set of Machine Learning based individual style and individual size recommendation services, extending the functionality of MySize and MyStyle modules.

As the focus of this paper is on Individual Fitting, the following sections will elaborate in detail on the MySize.shoes™ fitting service and the individual fitting method.

IV. Customer Fit Solutions: A Four Level Approach

As mentioned by McDonald and Golub, at present, the designing and production of personalized shoe lasts is one of the more relevant challenges that mass customization processes are facing—lasts need to be designed and produced in a very short time, a flexible way, and at a very cheap cost because they may only be used once [3]. In their paper, they mention the possible approaches to customer fit solutions for which we are developing technologies. Of the four levels to approach customer fit solutions, Level Zero and Level One do not modify how lasts are fabricated and do not change current production methods. In contrast, Level Two and Level Three require a method of temporary lasts and the Individual Fitting method mentioned in this paper will be used primarily in the second and third level approaches, as explained below.

A. *Level Zero: "Sizing"*

This is the most basic approach. Each brand's shoelasts are designed with a certain size grading and shape that is unique to them. In fact, as noted previously, when shopping for shoes one of the biggest problems for customers is finding the right 'size' because each brand has their own interpretation of standard sizes. So, it is up to the customer to determine if the footwear fabricated from these lasts will fit them or not. Usually the best way of doing this is by trying on the shoe created based on the specific sized shoelast and judging it on a set of criteria to determine shoe comfort and fit.

As mentioned in an article by Runner's World, the following are a list to check for fit [4]:

1) Heel should fit snug, but not tight.

2) A shoe's upper should feel snug and secure around the instep.

3) Foot should be able to move side-to-side in the shoe without crossing over the edge of the insole. Should be able to

pinch a quarter inch (6 mm) of upper material along the widest part of the foot.

4) A thumb's width of space between the longest toe and the end of the shoe. The toes should also wiggle freely up and down.

5) The shoe should bend and crease along the same line the foot flexes.

6) Pinpoint shoes that match the foot's contours and movements.

B. Level One: the "Best Fit Approach"

In this approach, through the Virtual Fitting module, a shoelast with at least an 85% fitting factor (see Fig. 3.) is identified. It considers the stored data of the shoelast being viewed and the individual customer's related data stored in the database, such as:

- Shoelasts related to their previously purchased shoes
- Shoelasts that the customer has tried on and that have fitted them well
- Zone-based feedback and general feedback on tried shoelasts

The Best Fit approach is useful for the mass and fashion market and will work in most situations, suiting most retailers and brands, but naturally, not all customers.

Currently, this is the approach that is implemented and active in the Virtual Fitting module on the else.shoes platform.

C. Level Two: "Industrial Made to Measure Approach"

In the traditional footwear manufacturing industry, this is a method that is usually carried out manually on a shoelast where pieces of cork are manually shaped and applied to a standard size shoelast, to make it a made to measure shoelast, as seen in Fig. 4. This is a labor-intensive method that requires different machinery, tools and human resource.

Fig. 3. Traditional Shoelast patching method

In the "Industrial Made to Measure Approach" that we propose, a shoelast is modified with individual 3d patches that are 3D printed and then temporarily applied to it to create aa 'custom last' that resembles the customer's foot. As this is a made to measure approach and not a bespoke approach, only pre-defined 'MTM Zones' are modifiable on the shoelast, which makes the whole process compatible with the industrial Product Design and Manufacturing techniques.

1) Selection of shoelast

Through the virtual fitting module first a suitable standard shoelast is identified. The selected shoelast should be smaller than the customer's size and so will have an inferior fitting factor (under 85%). It needs to be smaller than the size determined through the Virtual Fitting module since patches will be added to it.

2) Identification of the 'MTM Zones' to be modified

The shoelast and the normalized 3d foot scan of the customer are compared and the parts that correspond with the pre-defined 'MTM Zones' are identified. Based on the predefined MTM Zones of the shoelast, the corresponding zones of the foot that differ from the last are visualized in 3D as 'patches' and are converted into separate files suitable for 3D printing. An example idea for the industrialized process of this can be seen in Fig. 5 below.

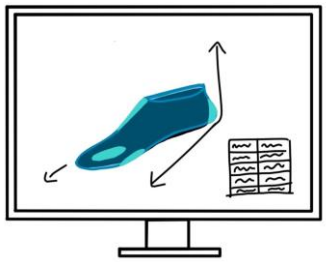

Fig. 4. The difference of the shoelast and 3d foot scan

3) 3D Printed and temporarily applied to shoelast

The patches are then 3D printed and applied to the physical shoelast. The shoelast is then ready to be used for MTM production of the customized shoe, while the shoelast remains a standard size shoe last, and it can be used any time (without individual patches applied) for standard size production, and also serve as a source for "temporary individual last" for different customers, with different MTM enhancements requested

ELSE Corp has developed a method for this process and an idea for a new hardware for direct 3D printing on the shoelast.

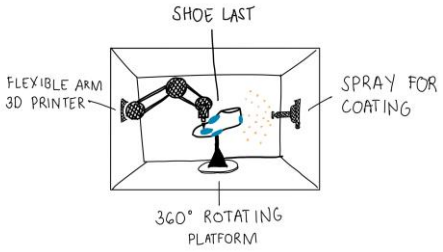

Fig. 5. An idea of an industrialized method of temporary application of the 3D patches

D. Level Three: "Totally Custom/ Bespoke Shoelast"

In this approach, a true custom/bespoke shoelast is created for the customer. It is designed in CAD 3D visually or through

a semi-automated procedure and can be either created with traditional last production methods or 3D printed. As the shoelast is created from scratch, there is an extra cost that needs to be covered by either the customer or the brand.

With the rapid development and progress in 3D printing tools and materials, it is predicted that the cost of 3D printing a shoelast will soon be the same as making it through traditional last making machines.

Fig. 6. An example of a 3D Printed Shoelast printed in two pieces [5]

V. Current Progress on Virtual Fitting

With 'Level One' already integrated into the else.shoes™ platform, called "Best Fit", at the moment the virtual fitting feature on else.shoes™, shows the customer which standard-size shoelast of the shoe model that they have selected would fit them best. The approach, already experimented by different shoemakers, of having different types of shoe lasts for the same shoe model (narrow, normal and wide), gives a huge level of flexibility to the "Best Fit" approach. In the case of purchasing a standard-size product, the system identifies the best standard-fit, and in the case of a made to measure product, it will identify the closest shoelast for the manufacturer to be used and adjusted to fit the customer's individual fit data best. Current virtual fitting methods are based mainly on mathematical conclusions.

The features currently incorporated can be seen on the interface shown here below in Fig. 7.

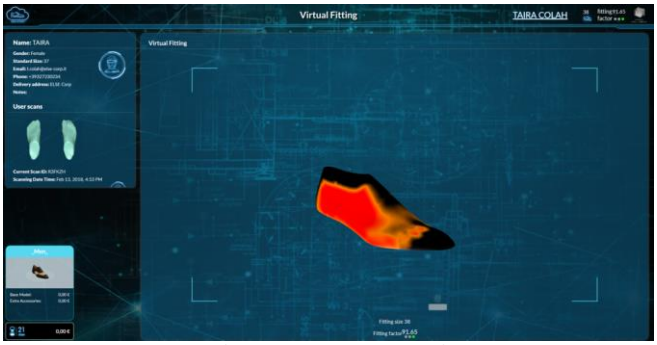

Fig. 7. Virtual Fitting interface on else.shoes™ platform

Each customer has their own profile which they log into when using the platform. A customer profile contains their customer related data. We see their personal data, their scan data, a summary of the product they are customizing and the virtual fitting information.

On the rest of the screen we see the Virtual Fitting result. A visualization of a shoelast – shows the heat mapping indicating the tightness or looseness of the 'fit' compared to the customer's foot. We also see a 'Fitting Factor' and 'Fitting Size', elaborated below:

A. *Fitting Factor*

The fitting factor is a value that is generated based on the metrics of the customer's measurements confronted with those of a virtual shoe last. It considers the geometry of the 3d models of their feet and the 3d model of the shoe last. In the MySize module, the user will see a visualization of a shoe last with heat mapping on it. It indicates the tightness or looseness of a size shoe for the specific user.

- Fitting factor above 95% indicates and ideal fit
- Fitting factor of 85 and to 95: Indicates a good fit
- Fitting factor from 85 to 75: Indicates an average fit
- Fitting factor from 75 and below: Indicates a bad fit

It needs to be understood that in this context the "fit" considers different possible recommended sizes (smaller and bigger than an ideal), as it elaborates many different parameters of "fit", not only volume and measurements

B. *Recommended Size*

The Recommended Size or 'Fitting Size' indicates the size that in the end is best suited for the customer. Each brand has its own sizing table and references which are digitalized. Each shoelast corresponds to a standard-size. Based on the customer's 3d scan data, certain metrics are compared to the standard sizes and the closest match is selected and displayed on the screen. This approach goes much further than the already highly adapted simplified approaches of measurement-based sizing correspondence.

VI. Implementation of Virtual Fitting for Manufacturing 4.0

One of the most pivotal cases in which the else.shoes™ platform has been integrated is a joint project between ELSE Corp and its partners ATOM Lab and Shoemaster. The project represents a fundamental step towards the 360° integration of all the processes involved in the manufacturing of personalized and on demand footwear. As mentioned, ELSE Corp offers technological solutions for Virtual Retail and Cloud Manufacturing to fashion brands, retailers, manufacturers and designers. ATOMLab, the research laboratory of ATOM, develops innovative technologies and projects for new methods of production. The third partner in this project, Shoemaster® is a part of the ATOM Group, offering innovative CAD/CAM systems for the realization of footwear models in 2d and 3d. The 'RoboShop' was the store-factory of the future where a customer's personalization and purchasing experiences were merged with the live experience of the manufacturing of their own shoes, called 'RoboShoes', in a perfect digital fabrication scenario.

The project demonstrated a streamlined vision for the future of the footwear industry based on ELSE Corp's 'Virtual Retail' business model. By incorporating Virtual Retail into

Industry 4.0, the project integrated industrial 3D CAD into the mass customised footwear manufacturing process.

A. *The project*

Shown in February 2018 at the SIMAC fair, RoboShop, demonstrated an "assemble-to-order" process for ultra-rapid footwear manufacturing in the store-factory of the future where a customer's personalization and purchasing experiences merged with the live experience of the manufacturing of their own shoes, in a perfect digital fabrication scenario. The setting was completely digital, starting from the first phase of 3D CAD modelling of the RoboShoe collection by Shoemaster, to their customization, best-fit matching and order processing in ELSE Corp's else.shoes™ platform and to the robotic production by ATOMLab.

With ELSE Corp's else.shoes™ platform's MySize SDK for 3D Foot Scanning and Virtual Fitting; the 'RoboShop' was able to recommend to a customer their 'Best-Fit' in terms of size and style.

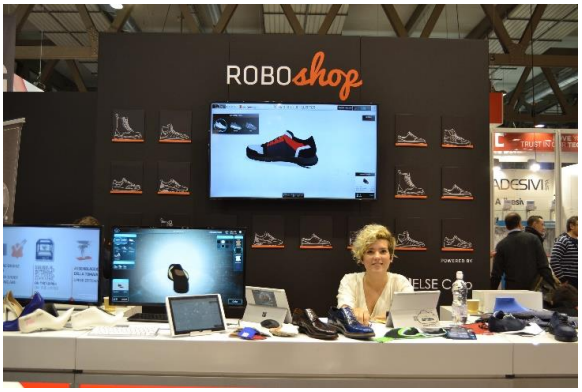

Fig. 8. The starting point of the Innovation Arena in 2018 called RoboShop

B. *The process*

The project demonstrated the ultra-rapid manufacturing of "assembled to order" shoes through the onsite manufacturing of the RoboShoes carried out in four stages. Here below in Fig. 9 is a 'map' of the Innovation Arena:

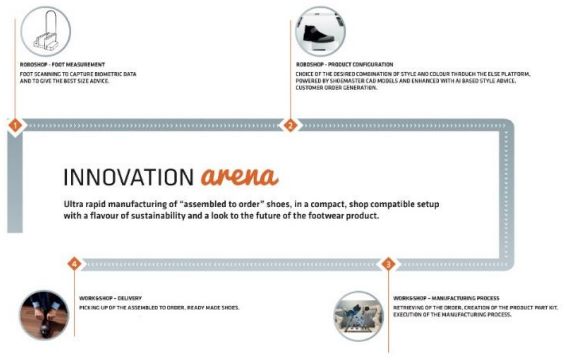

Fig. 9. The Four-step Innovation Arena

1) Scanning: The customer began their journey in the RoboShop where they had their feet scanned.

2) Virtual Fitting: They were then recommended the 'Best-fit' style and size through ELSE Corp's Virtual Fitting feature.

3) Customization: After which, they would customize their selected model of shoes by selecting the combination of upper and outsole.

4) Order Generation & Assembly: Once completed, an order would be generated with the size of shoelast, upper and outsole to be combined and then sent to the 'Work & Shop' via the ELSE-ware middle ware. The customer would retrieve their order here and begin the manufacturing process. Once fully assembled to order, the customer could leave the area with their newly manufactured pair of shoes.

This project showcased the value of the Virtual Fitting feature applied to mass customization and cloud manufacturing scenarios. A project with a sustainable footprint, it looks towards the future of footwear, implementing the concept of Mass Customization, now also in the footwear sector.

With Virtual Fitting implemented, the company is now working on including the Real Fitting data to arrive at the Level two and three fitting approaches and the Individual Fitting algorithms.

VII. Real Fitting

Still in its early stages, the individual fitting service has further developments planned to make it a more efficient and reliable footwear fitting service for the Virtual Retail context. As mentioned, the Level Two and Three fitting approaches incorporate both the Virtual Fitting and the Real Fitting. A fundamental addition to the fitting service is the inclusion of customer feedback during these real physical fittings. A layer of data science considers general and comfort zone-based feedback of customers from physical fittings.

When in a store (or retail space), the feedback will be recorded by a store assistant (expert) and supported by an application on a tablet that is easy for the customer to use to indicate their general and zone-based feedback.

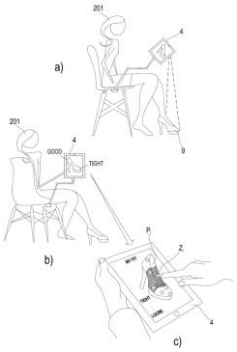

Fig. 10. Gathering feedback through a tablet device

VIII. TYPES OF FEEDBACK

A. General Feedback

In the real fitting method, first, a customer tries on the shoes from the brand's collection in 3 sizes for each foot separately

- a size closest to their own standard size
- one/half size smaller
- one/half size bigger

After walking around in each of these sizes, they would give general feedback about their perception of the fit of the shoes they are trying on. This feedback would be about the overall perception of the fit of the shoes, for example, size 39 is too tight, or is fits well only for the left foot, while not really well for the right foot - this may lead to the on demand production of different customized shoes in the future, as it is known that half-size differences between the left and the right feet is quite common in the market, if not to say the rule.

The customer would give feedback for the overall fit based on a five-level scale, as follows:

a) Very comfortable (ideal fit)

b) Comfortable enough (acceptable fit)

c) Uncomfortable, but… (bad fit but with further reasoning)

d) Not comfortable (wrong fit)

e) Very uncomfortable (very bad fit)

B. Comfort Zone-based Feedback

Each type of shoe, depending on its structure and parts, has different criteria to be considered when identifying the zones for feedback.

1) General parts of footwear to consider for zone classification

In general, the following general parts common to most types of footwear can be considered:

a) Shoe last

Standard last designs are defined mainly by heel height and shoe style. These lasts have an acceptable fit, which has been market tried and tested, and remain invariant for years. This means that all commercially available shoes offer practically the same fit. A number of brands, however, have developed wide sizes in order to increase the number of users who perceive a positive fit sensation when wearing these wider-fit shoes. In view of this, three categories of last fit can be defined: wide, standard and tight.

b) Toe cup

The main style-related changes that affect last design are mostly related to toe shape. This is a relevant factor as it affects the perception of fit in the toe area. Accordingly, we defined three types of toe shapes: squared, rounded and pointed.

c) Upper flexibility

The upper rigidity of a shoe is the main factor that influences how a shoe adapts to foot shape. Correspondingly, we defined three levels of rigidity: low, medium and high. Level of rigidity was assigned accordingly to a data base of characterized materials and takes into account kind and quality of material and thickness of the upper.

d) Fastener adjustments

The level of adjustment provided by the shoe fastener is also an important variable in shoe fit. A fastener with a high adjustment level accommodates a greater variety of foot shapes and gives the sensation of a more comfortable fit in the instep area. We defined four levels of fastener adjustment: low (elastic fastener), medium (strap and belt), high (laces), and an additional level for bumps without an upper covering the instep area.

e) Sole

Sole design is an important variable in considering dynamic fit as high sole rigidity may reduce the capacity of a shoe to adapt to foot shape. Three levels of sole rigidity consider the combination between the material and the geometry of the sole.

2) Comfort Zones

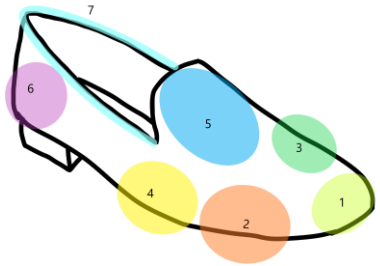

Fig. 11. Comfort Zones for Feedback

The seven comfort zones marked in Fig.11. here above are as follows:

a) Toe Box

b) 5th metatarsal joint

c) 1st metatarsal joint

d) Outer arch - proximal end of 5th metatarsal

e) Instep

f) Heel / Rearfoot

g) Collar / Ankle

3) Comfort zone based feedback scale

For the comfort-zone based feedback a five-level symmetric scale can be used, as follows:

a) Too tight

b) Tight

c) OK

d) Wide

e) Too wide

IX. Fitting Service Architecture

Below is provided a high-level description of the MySize.shoes Fitting Service Architecture.

A. *Fitting Service Architecture*

1) *Fitting Service Characteristics*

- Data collection and analysis of customer's biometric data.
- Metric data collection of shoes available in the virtual stores
- Aggregation of orders & end user relations metadata (previous purchases and how they fit the user etc.)
- Fitting metrics calculation to provide wide range of valuable information to the end user (advice about fitting & comfort of selected product to end user based on Machine Learning and calculations)

2) *Fitting Service Technical Parts*

- Web services, which provide access to service actions and data by network requests. Web services are used by other services of E.L.S.E frameworks and provide APIs for data integration with customers (stores & productions).
- Web interfaces, which provide administrative access for customers (stores & production) to their products data.
- Data storage, which is used to collect and analyze all service data (end customer's metadata, biometrics data, metric products data, orders history and user feedback, etc.)
- Calculation modules, which are used for fitting metrics calculations and data analysis
- Data security modules, which provide security for external data transport and external APIs security.

3) *Fitting Service Infrastructure*

The Fitting Service is a cloud-based solution, available through web services.

4) *In terms of data and business/ functional logic, ELSE Fitting Service architecture is organized as follows:*

a) Data Storage Cloud

Data Storage Cloud based on distributed data model is powered by OrientDB (Multi-Model NoSQL Database with a Graph Database Engine).

It is built on several data stores by Multi-Master Replication model, delivering greatly improved performance on high volume real-time external requests, using a cluster sharing schema to provide quick access to data that greatly optimizes storage use.

b) Data Structures

Data used by ELSE Fitting Service is organized within two main clusters:

- End User related data: referring to the data related to the person using the virtual fitting service
- Customer related data: referring to the data related to the brand or company who's shoes are being sold

The following diagram presents the main ELSE Fitting Service Data Structure entities:

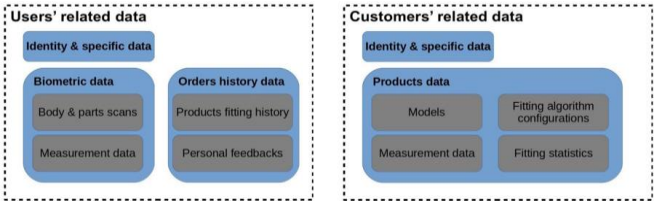

Fig. 12. Fitting Service Data Structure Entities

c) Multi-Model data organization

Multi-Model data organization (Graph + Document engines) provides:

- high level of data integrity & safety
- flexible storage for abstract data with hard to predictable structure
- powerful functionality for logical linking and data processing
- high level of classical algorithm support because of graph engine
- flexible ways for data access and analysis

d) Data Processing & Learning modules

Data Processing & Learning modules are based on python modules and IBM Watson machine learning modules. They are used to collect and build structural metric data for biometric computations and analysis.

e) Calculation modules

Calculation modules are based on python modules for high-level data processing and computation modules based on Fortran OpenMP for parallel computing.

f) Data Security module

Data Security module provides overall data security for external access (authentication & authorization control and data encryption)

g) Web services & Web interfaces

Web services & Web interfaces provide external APIs access for all parts of E.L.S.E Virtual Retail framework and customers (stores & productions).

Web services built on Python Flask - to keep the consistency of internal data structure processing and support of WSGI for productive interaction with hosting web server and python modules.

Call processing RESTful API Web services and JSON serialization. Docker containers technology is also used for easy horizontal scaling and delivery to any platform. For some specific APIs, binary protocols with encryptions used as well.

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