POLITECNICO
MILANO 1863

HIGH TECHNOLOGY PROCESS INNOVATION IN FOOTWEAR DESIGN

Irene

Andrey

Alina

Javier

Agostina

Juan

Betina

Adriano

Antonio

Mirei

Sample of feet from a variety of users, courtesy of ELSE Corp

Catalina

Matteo

Andrey G

Clara

Eleonora

Francesca

Mirko

Mertcan

To all those who has inspired me and will never read this

To Else Corp that has supported me during the process

To Polifactory that believed in this project from the first day

To my family and friends

POLITECNICO
MILANO 1863

DIGITAL CITIZENS

HIGH TECHNOLOGY PROCESS INNOVATION IN FOOTWEAR DESIGN

AGOSTINA ISSOLIO

Master's Degree in Design for the Fashion System
A.A 2017/ 2018
School of Design

POLITECNICO DI MILANO

Tutors:

Prof. Alba Cappelieri
Prof. Viola Vecchi

Developed in Collaboration with Polifactory

DIGITAL
CITIZENS

Abstract *11*

INTRODUCTION . Fashion Design through a fourth Industrial Revolution *13*

RESEARCH

1
MASS CUSTOMIZATION AND FOOTWEAR

Introduction *16*

1.1 Style Customization *18*
1.2 Best – Match fit *20*
1.3 Custom fit *22*

2
COMPUTER AIDED DESIGN

Introduction *27*

2.1 From traditional to virtual shoe making process. Case study: Shoe Master UK *28*
2.2 Virtual Retail. *34*
2.3 Digital Boutique *36*

3
COMPUTER AIDED MANUFACTURING

Introduction *41*

3.1 Fuse deposition modeling *43*
3.2 Selected Laser Sintering *51*
3.3 Generative Design *55*

4
FOOTWEAR AND COMFORT

Introduction *65*

4.1 Foot Anatomy and bio- mechanics *66*
4.1.1 Foot Pathologies *68*
4.1.2 Orthotic and Design *69*
4.1.3 Plantar Pressure Analysis during the gait cycle *70*
4.1.4 Case Study. Fit Station *72*

CONCLUSION. Designer Future Challenges *77*

PROJECT

1
DESIGN PROCESS

1.1 Design Concept *80*
1.2 Sketches *82*
1.3 Exploring in 3D *85*
1.4 Designing through making *87*
1.4.1 Processes and materials *89*
1.4.2 Modules & Textil Interaction *91*

2
FINAL PROPOSAL

2.1 Generation of modules *95*
2.2 Foot anatomy regions and plantar pressure *97*
2.3 3D Design *99*
2.4 Final Model *101*
2.5 3D Printing *103*
2.6 Collection. Digital Citizens *104*
2.6.1 Models *106*
2.6.2 Variants *109*
2.7 Retail and Merchandising *115*

3
FURTHER DEVELOPMENTS

Designer Future Challenges *116*

BIBLIOGRAPHY *118*

ABSTRACT

KEYWORDS: MADE TO MEASURE, 3D PRINTING, 3D SCANNING, 3D FOOTWEAR DESIGN

This project starts with a research on the latest technology trends in the footwear industry. It addresses the pioneers that are guiding the future of this field by taking the advantages and accepting the changes in the fourth industrial revolution.

The proposed collection of made to measure footwear leaves behind shoe lasts and standard sizes, defining instead the individual foot as the white canvas in which the design is born. The starting point is then the foot scan of each individual, and the CAD systems has been used in order to generate the geometry to perfect fit the anatomical shape.

In order to achieve this proposal, a deep experimental phase was needed, working mainly in 3d but testing the parts psychically by using 3d printing technology. The result are only two separated and exchangeable pieces that are needed to build up the product, avoiding any kind of glue or stitches between parts. The collection presents a sole that works both as insole and out-sole, using the latest technology and materials. The upper part is a sock that is presented in a variation of materials and styles allowing the user to change it according to the daily outfit.

"A leaf is beautiful not because it is stylish but because it is natural, created in its exact form by ts exact function. A designer tries to make an object as natural as a tree puts forth a leaf. He does not smother his object with his own personal taste but tries to be objective. He helps the object, if I may so put it, to make itself by its own proper means, so that a ventilator comes to have just the shape of a ventilator and a fiasco for wine has the shape that blown glass gives it.

Each object takes on its own form. But of course this will not be fixed and final because techniques change, new materials are discovered, and with every innovation the problem arises again and the form of the object may change¨

Bruno Munari, Design as Art

INTRODUCTION. Fashion Design through a fourth Industrial Revolution

Fashion industry is one of the largest, continuously changing and evolving industries of the world. Unfortunately, its business model is currently based on providing more and more clothes, faster and faster, for less and less money. These reparative steps are a nuisance to the economics of most fashion companies. But you can only drive a broken engine so far before it starts to self-destruct. A system that places profits before the human and environmental resources creating them is fundamentally unsustainable.

Global Leaders around the world are talking of a Fourth Industrial Revolution. A revolution that is building on the third, digital revolution – in information technology and data analysis- that has been occurring since the middle of the last century and gave rise to the fast fashion giants.

´´ The Fourth Industrial revolution is a technological revolution that will fundamentally alter the way we live, work and relate to one another. In its scale, scope and complexity. The transformation unlike anything humankind has experience before ´´

World Economic Forum, 2016

From music to news, the growth of digital media has fundamentally reconfigured the way content is created and consumed, ending the monopoly once enjoyed by large record companies and publishers and giving rise to a wider chorus of voices. Now, new digital fabrication technologies are set to drive a similar revolution in physical manufacturing, making the tools of factory production available at the click of a mouse, with no penalty for short production runs.

This revolution is transforming the fashion product itself through new technologies that are blurring the line between physical, virtual and biological spheres. Technology is becoming one of the most important areas that global leaders are getting involved into and understanding its importance is a key for keeping companies a step forward, affecting also directly the role of designers.

One of the main trends in this new era and the focus of this project is the brake and transformation of the mass consumption system into a mass customization one. This project analyses the many different approaches that luxury companies are taking, the latest trends, start-ups and technology services that work together in the fashion system in order to define the future of footwear.

1 MASS CUSTOMIZATION AND FOOTWEAR

I think in order for mass customization on-demand to work, there are three key pillars that have to exist and have to be executed well. That's the technology, the manufacturing, and the marketing. I personally believe the reason that on-demand hasn't ever worked before is because manufacturing just simply doesn't do on-demand on scale – which is why we built our own factory.

Jodie Fox, Shoes of Prey Co-Founder and Chief Creative Officer

INTRODUCTION

Empowered by social networks and their digital devices, consumers around the globe are increasingly dictating what they want, when and where they want it. They have become both critics and creators, demanding a more personalized service and expecting to be given the opportunity to shape the products and services they consume.

In the future, businesses that do not incorporate an element of personalization into their offering risk losing revenue and customer loyalty
Mass personalization is finally becoming a reality. Businesses have not only developed the capabilities to measure specifically what each individual consumer wants, they are now also in a position to link their processes and resources to provide it.

This has been possible by advances in manufacturing and distribution technologies. For example flexible manufacturing and 3D printing enable mass personalization at lower costs and allow manufacturers to rethink their supply chains radically. Businesses are now postponing production until the latest possible point to allow individual customization.

Beyond the ability to provide more customized products, postponing production in this way can help reduce inventory levels and ultimately increase plant efficiency.
Delivering personalized products and experiences can provide benefits for both the business and the consumer.

Offering mass personalization gives businesses the opportunity to demonstrate the value consumers get from their personal data being used. At the same time businesses gain deeper insight into consumer behavior. It also allows businesses to simplify their product and service range that means lower marketing and production costs while creating more predictable demand.

In addition it makes it easier for consumers to understand the offer while getting better value for money.
Offering personalization might require a rethink of business operations including adapting strategy and operating models and changing core processes such as manufacturing, distribution, marketing and customer service

Customization is basically involving the customer in the value chain of the shoe. There are different ways of integrating the consumer in the value chain of the product, each one having a specific relation with the way the product is then developed, manufactured and sold. In traditional mass production systems, end users are not involved at all; the whole business is about manufacturing and then selling standardized products to customers who remain rigorously anonymous, goods are made to stock. Some “flavors” of customization can, to a minimal extent, be present also in mass produced shoes, but they all tend to satisfy classes or categories of consumers rather than individuals.

We can have a soft customization when the consumer interaction point is in sales or retail, but hard customization digs more deeply into the company structure and organization. The implications (constraints) on design deriving from involving the consumer in the sale-design-manufacture-distribution loop depend very much on the degree of customization adopted.
Shoe customization is possible at 3 main levels; each specific level has a well-defined impact on the design, manufacturing and sale of the shoe:

1. Style Customization - based on standard lasts and sizes consumers can choose style options such as colours, fabrics, leather, and accessories set by the manufacturer.

2. Best-Matched Fit - the feet of each customer are examined using foot scanners and matched to an existing library of lasts, insoles and soles with a much higher granularity than in today's mass production systems.

3. Custom Fit - the feet of each custome r are examined and his or her specific habits are analysed and used to make an individual last, insole and sole.

The higher the level of customization the company aims at the more complex and high technology demanding the sales outlet becomes; on the design side new functions and operations become necessary, while on the manufacturing side it will be a real challenge and a quest for the utmost flexibility to handle a virtually "infinite" range of products and to keep manufacturing costs of unitary lots at a level appropriate to the amount of money the consumer is ready to pay (more) for the customized shoes.

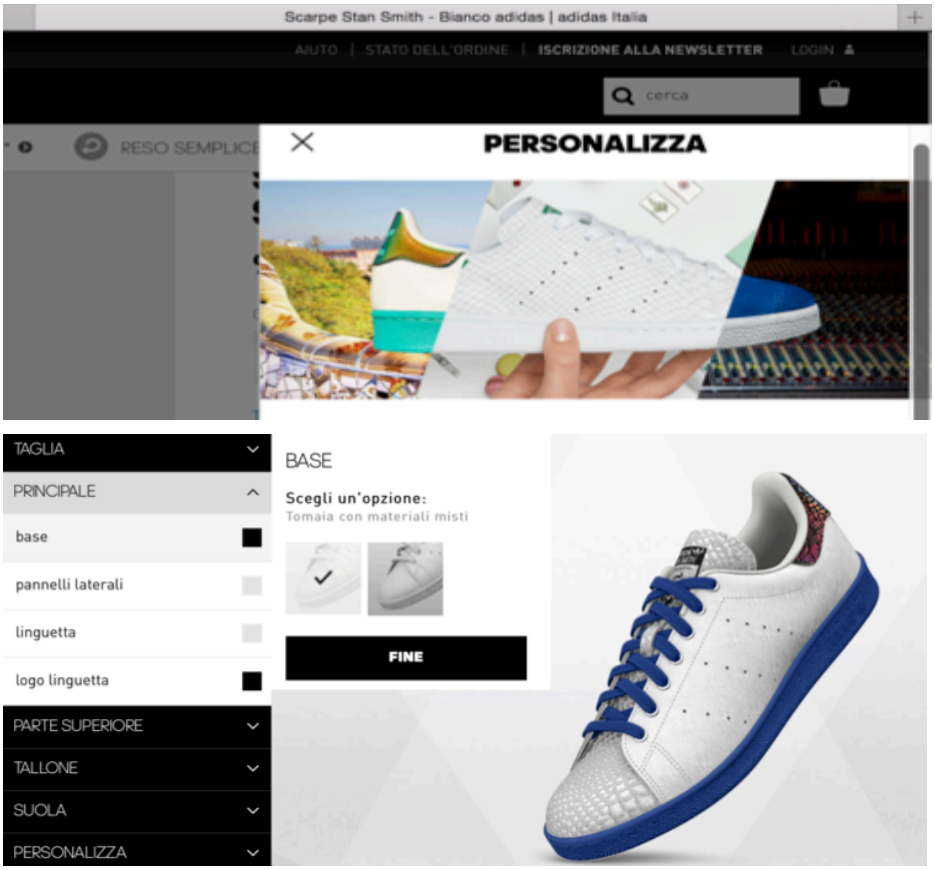
To go from a 3D scan of a foot to the selection of a suitable shoe, or the adjustment of a 3D CAD pattern of a customized pair of shoes, to eventually manufacturing that pair of shoes; other supporting methods need to be employed to attain the result of a truly well-fitted pair of shoes for a specific customer.

On the first levels of customization the focus and most of the effors is in sizing, starting with standarized metrics that helps clients to find the best size, to the use of foot scanners and apps that suggest directly to the clients the best- match shoe last fot his/her feet. On a second level, 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

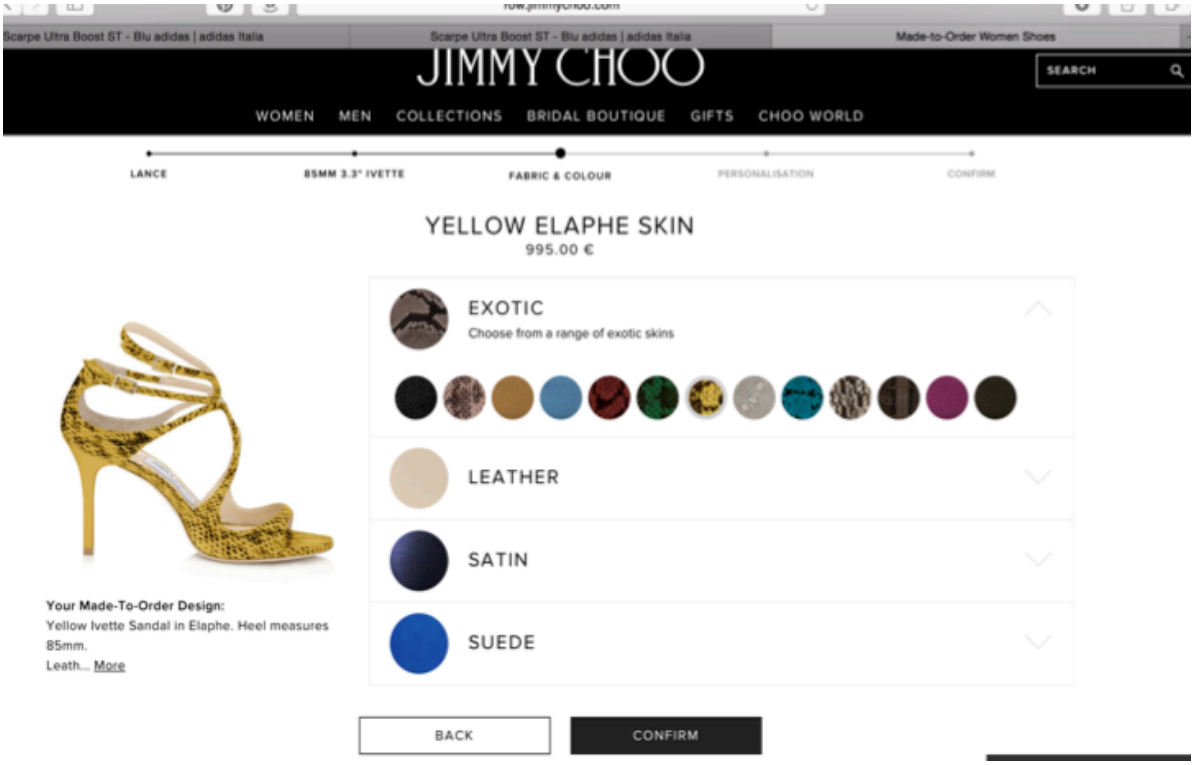
1.1 STYLE CUSTOMIZATION

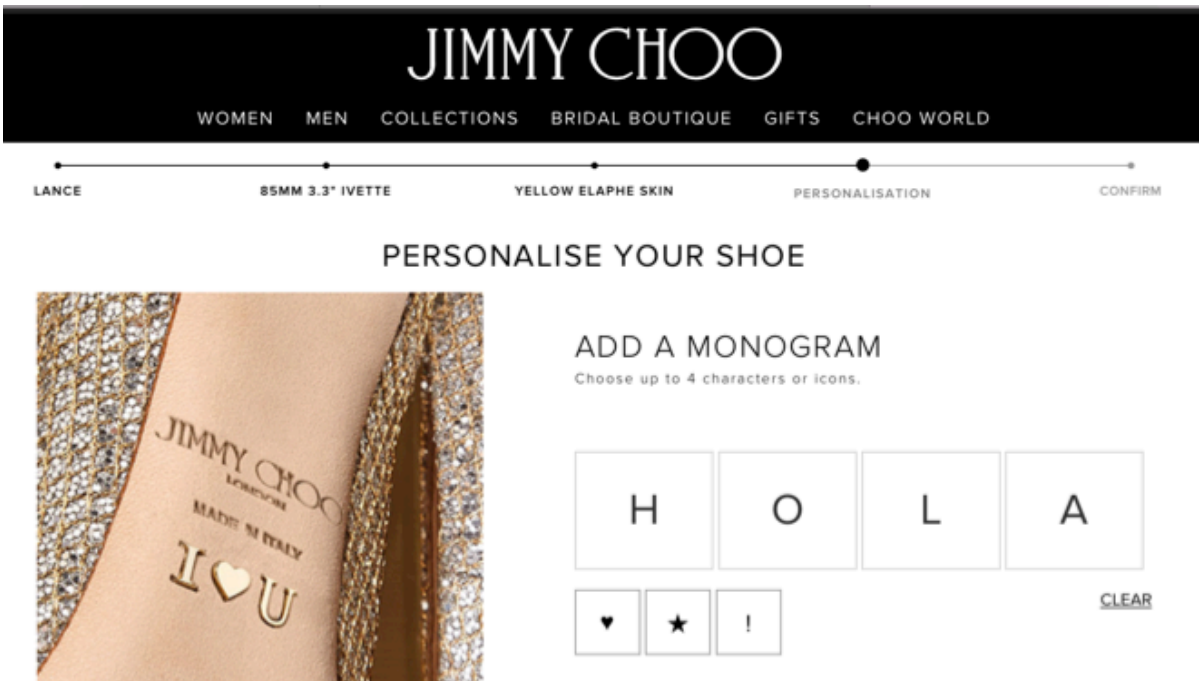
This is the most common case of customization offered by the footwear brands, satisfying consumers demands in terms of aesthetics, making sure that a shoe in the desired materials, colors and with the desired components can always be made for the consumer. The consumer receives a shoe that fits perfectly his or her aesthetic preferences and is guaranteed that the shoes will be available (since they are made to order) in the size specified. There is no risk that the shoes that are chosen from the aesthetic point of view are not available in the desired size; yet the consumers still has to know his or her size.
He or she can check a a size chart conversion in relation to foot length (CM) and international size methods.
Products are mass produced
but the consumer is offered some limited options to customize their products .The items offered for the customization services are mainly the iconic products of the brand.

It is normal that this service is offered only in specific geographical locations; most of the brands have this service available only for United States and Europe. We can assume that the customers of premium and luxury brands in US and Europe are more mature to invest additionally in the personalized goods, while those in the developing countries can still be satisfied with the standard premium goods.



Adidas originals offers the possibility to choose material and color of almost each component that build the shoe





Jimmy Choo offers a section of ¨made to order¨ shoes in which customer can choose between eight shoe models: Pearl, Anouk, Lance, Platforms, Lottie, Romy, Luna and Ren, giving its clients the possibility to select not only the material and color but also the height of the heels. In addition, the client can add his/her initials or a numerical plaque like that from a special date. The final price depends on the shoe style and on the type of the material chosen.

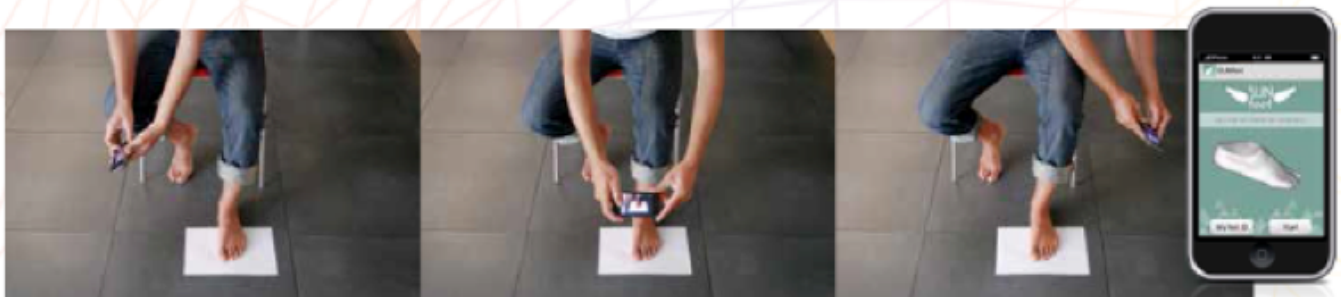
1.2 BEST -MATCHED FIT

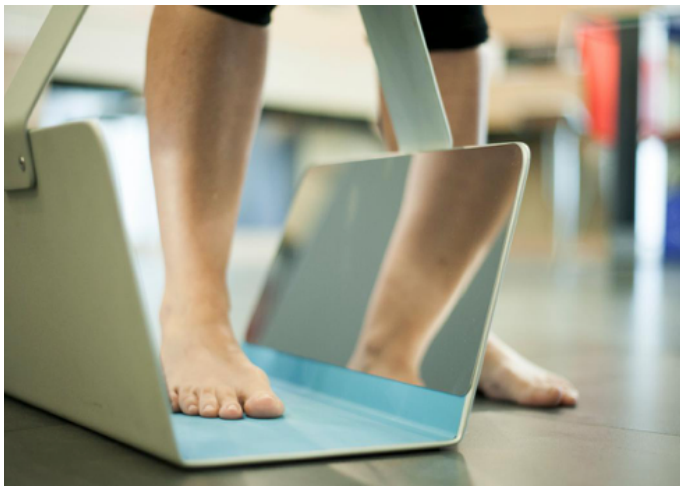
This level of customization aims at privileging comfort
together with aesthetics. The consumer is not supposed to know what size his or her feet are, but identifying the right size and choosing the most appropriate last is the task of the producer. To make the process simpler the last is not really tailor made, but selected (matched) from a library of sizes as the closest one to the dimensions of the consumer; shoes are made to order with the selected aesthetic configuration and in the size calculated after the measurement of the feet. This step produces a remarkable increase in the level of individual satisfaction of the consumer. This approach requires the customer´s foot to be analyzed, there are two methods that are being used in order to do this:

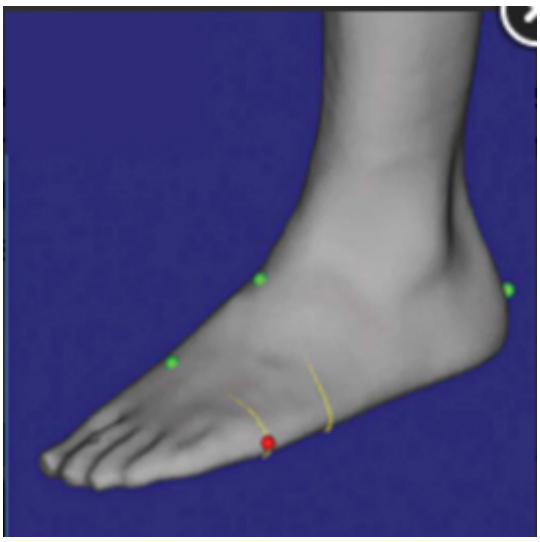
1 through a cellphone app : The user takes pictures and the app will reconstruct the mesh, extracting the measurements

2 using foot scanners : There are two main technologies that are used ,traditional laser scanning or mesh reconstruction using photos of the foot . Laser scanning for foot has been used for many years on the orthopedic industry, instead the mesh reconstruction is a solution to make the process less laborious. This method is not yet working for orthopedic shoes.

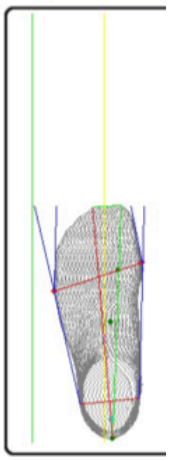
Foot measures has been traditionally taken bin shops using a foot guage, but this would include only the very the basic data of feet – foot length and width- and are easily done in shops or even at home by the clients. Instead, foot scanners can give a much more detailed database that is archived for each individual such as position and angle of toes and ball, heel width, navicular position, etc.

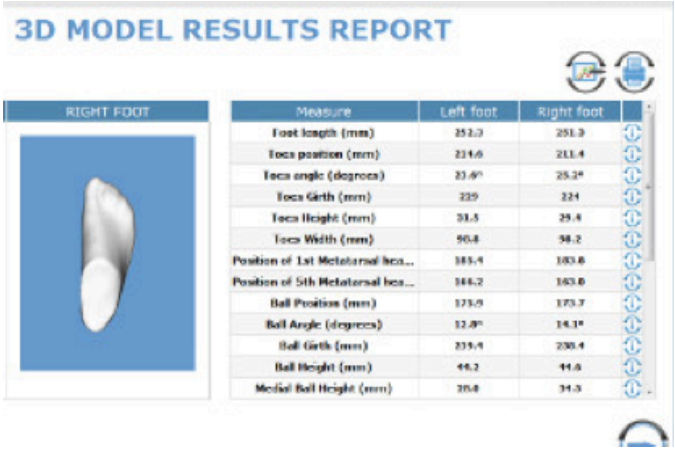






Dimension	Left	Right
Foot length	242.2 mm	244.9 mm
Ball Girth circumference	237.6 mm	240.0 mm
Foot breadth	97.3 mm	98.6 mm
Instep circumference	232.7 mm	233.2 mm
Heel breadth	62.5 mm	65.0 mm
Foot size	4.5	5





Laser Scanners. Left: ***In-Foot,*** *Rigth:* ***IBV.*** *Opposite:* ***IBV app***

1.3 CUSSTOM- FIT

Is the ultimate comfort experience with the entire shoe -the last and all the components of the shoe- tailored on the morphometric data of the consumer.
Truly tailor made shoes in which an individual last is elaborated specifically on the foot morphology of the individual consumer; hence all the shoe components are also tailor made. At the borderline of the mass customization paradigm, typically adopted by craftsmen. It also implies accurate foot measurements and aesthetic customization. Shoes are of course made to order with very long waiting time.

The orthopedic sector is the classical example of how the design of the shoe must incorporate a thorough understanding of the static and dynamic effects of the footwear on the human body. The notion of dynamic effect is also associated with the notion of customization, each pair of orthopedic shoe being strictly tailor made for each individual patient. However, in the orthopedic sector, the customer is welling to pay the cost of the fabrication of a pair of last made for him/her. In the fashion industry, we must consider that this approach would not be suitable since the cost of each product might be too high.

In order to achieve this level of customization in traditional shoe- making process, there are companies doing modifications on last by attaching cork fitting pieces to the standard last to achieve the perfect (bespoke) fit. This adjustments they store and every ongoing pair has the same fit. Advanced customers have their own personal lasts in our workshop. But this process become very laborious and close to orthopedics shoe processes. The most suitable approach could be thinking of a solution to make this patches temporary or exchangeable. There is some research going towards this direction, but it is still not common method.

Another trend in this field is the 3d printing of shoe lasts based on the data of the costumer, but this approach has not have much success since the materials used for 3d printing can still not reach the properties that are required for a last to resist many process , tooling and temperatures that are common in a traditional shoe making process. Of course the use would not be industrial, so it could probably work for some shoe types. The material should be though properly tested for the desired process

The ultimate approach is to work directly with foot scans, making customized digital lasts, or even using the mesh as a starting point in order to generate the pair of shoes. Even if this seems an appropriate direction , passing from a 3d mesh of the foot to a workable format to start designing the shoe, is not an easy process

Saint Crispin's cork fitting pieces, ShoeKit 3D printed lasts Earl Stewart *designed with* the 3d scan mesh is the base for the construction of the model

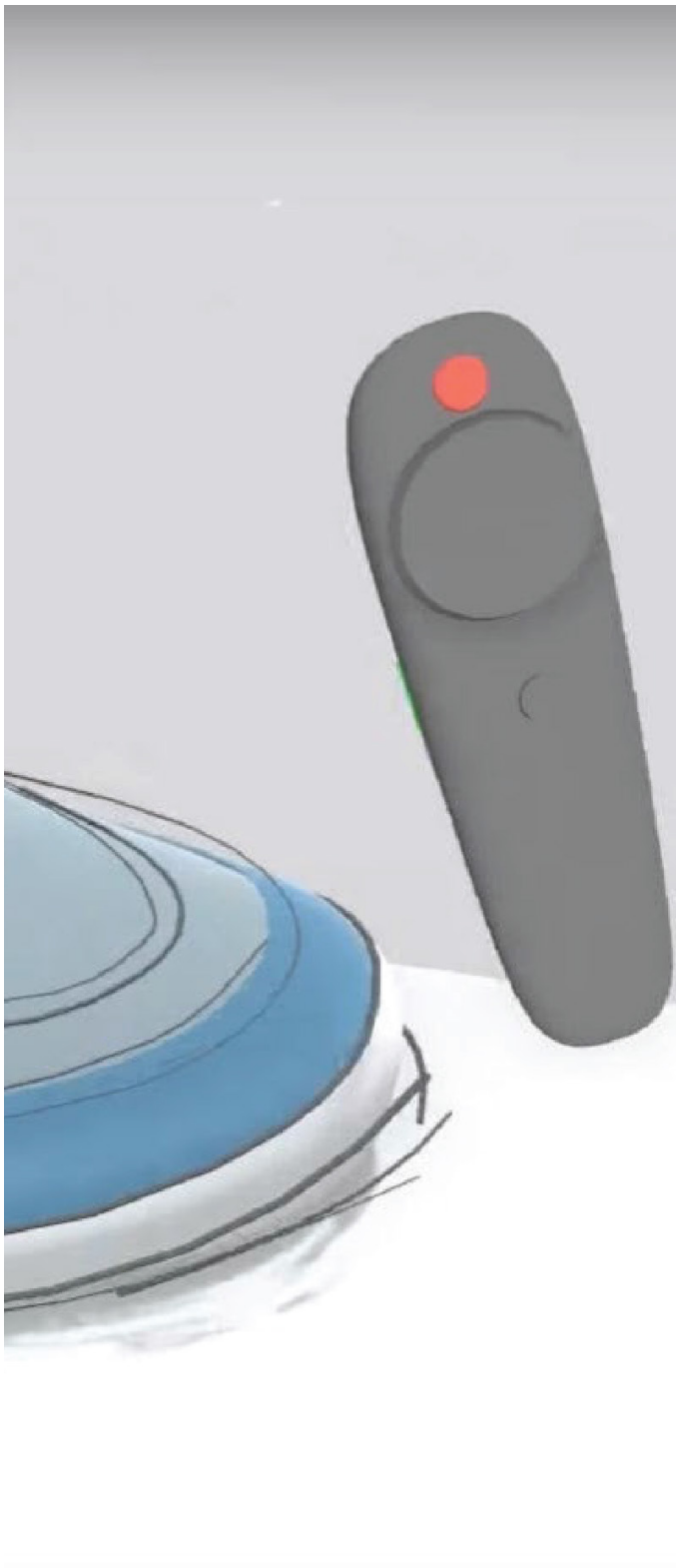
2 COMPUTER AIDED DESIGN

I don't want technologies that integrate with my body, I want clothing and accessories that make my body do things and feel things I have never thought I was capable of. We learn the most from contradiction. The greatest moments in the history of fashion have been fueled by conflict…
Designers need to stop thinking about how the future is going to save us. Let us see what our new capacities will be for better or worse. Technology expands what we can do and what we can make, if we want to keep evolving I hope we will use these technologies to produce more contrast and continue to show us the unseen.

Francis Bitonti

Shoe Design using Gravity Sketch VR 1.0. ***Source:*** *cgrecord.net/*

INTRODUCTION



The digital design is the multilevel activity of designing product and manufacturing processes with new systems (CAD,CAM, ICT), it influences the whole manufacturing system in many aspects:

- It raises productivity in every process of the production chain, reducing time and cost of product development

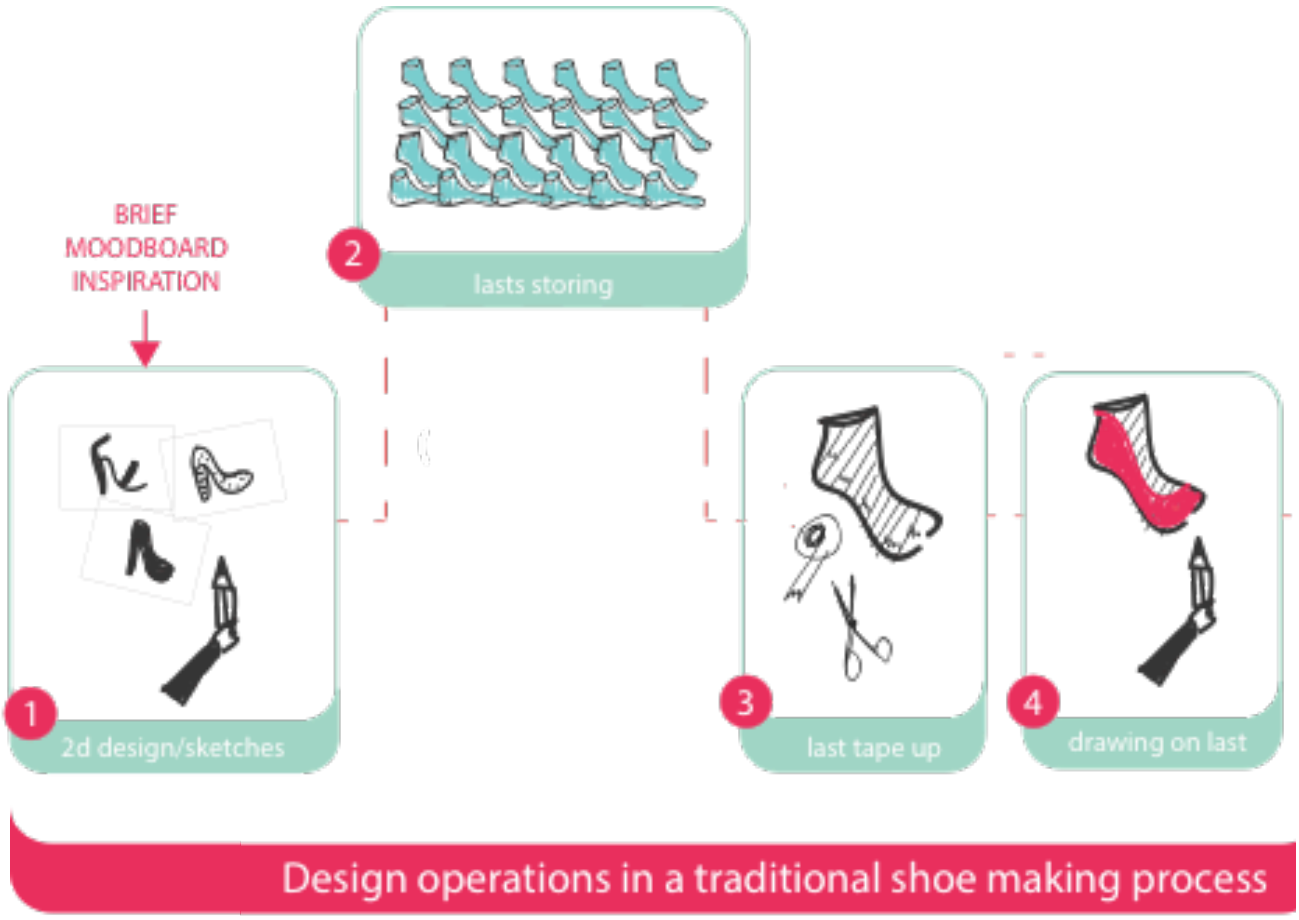
- It eases the teamwork between all members

- It improves the quality of operations

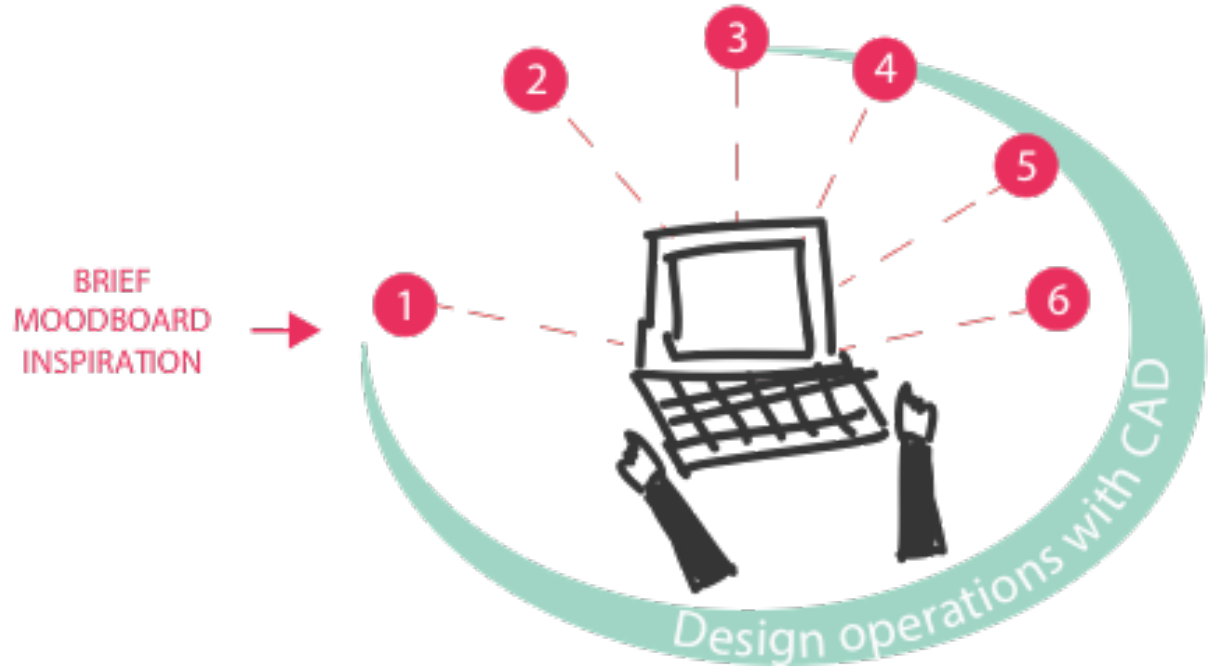
The efficiency of this process lays on the harmony in which the many different operations are developed; there is a clear and more direct relation between each operation and its required techniques and technologies. The physical spaces needed for each operation is reduced and the communication between them is much easier -cloud data-base-, reducing the time of transporting materials, prototypes and components, also less group meetings are needed.

The possibility to organize and share specific information makes it easier for the creation of mock-ups and prototypes lowing the costs up to 80%. The better use of time make it possible to realize the orders before the dead lines, overcoming the customer expectations and guaranteeing his/ her satisfaction.

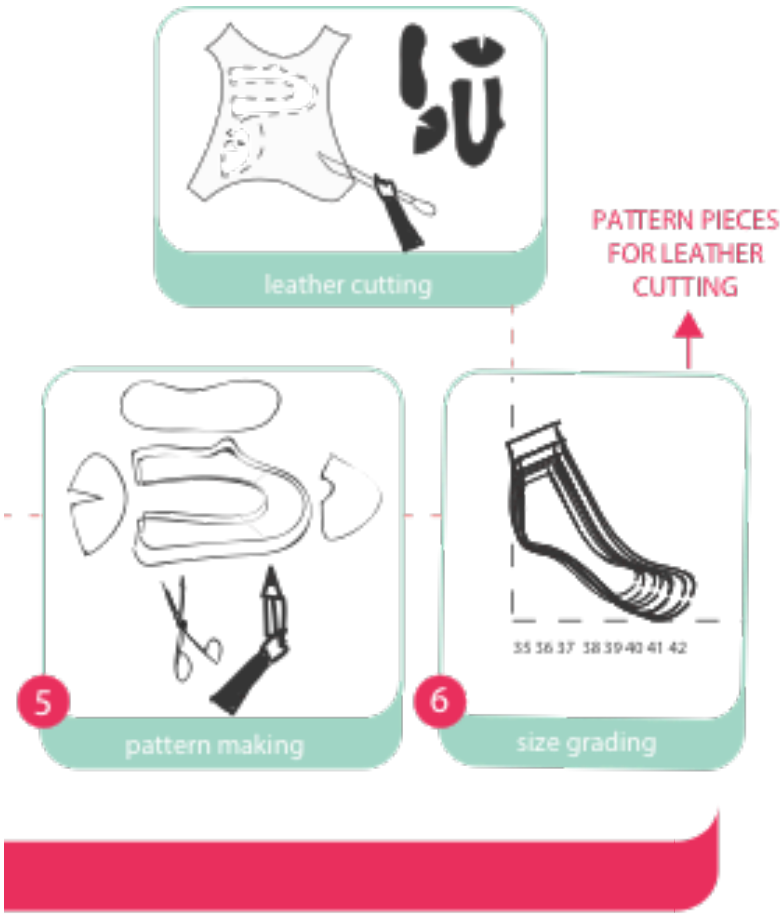
The work-flow is more flexible, all members of the team can check processes simultaneously, the development is more integrated and the work is interdisciplinary. The creative team keeps and checks the coherence in every step, decreasing the mistakes and the necessity to redo tasks.



Design operations in a traditional shoe making process



2.1 FROM A TRADITIONAL TO A VIRTUAL SHOE DESIGN PROCESS



The evolution of computer aided design software has made possible to replace much of the traditionally hand made or semi industrial processes, avoiding the need of the physical space and time

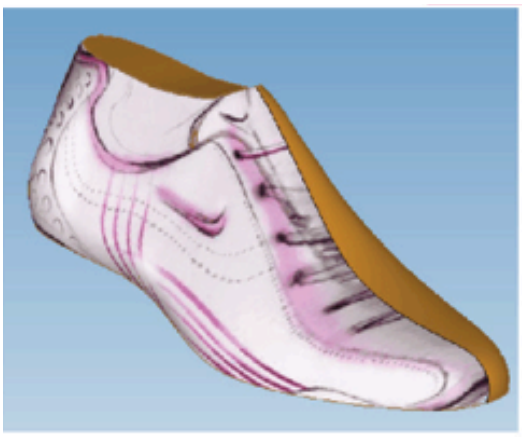
Within the fashion industry, many relevant CAD programs have been developed over the past decades. Art- based packages such as Adobe Illustrator, Photoshop, InDesign and SketchbookPro are invaluable, along with 3D programs developed specifically for shoe design and manufacturing such as Shoe Master CAD design, ICad3D and Romans CAD. These original 3D programs for shoe manufacturing taught designers to work from 3D lasts digitized onto the screen that were transformable into 2d flat patterns for sample making and manufacturing. This gave designers a unique insight into the shape and form of new designs instantly. Alternating between the 2D and 3D form gave the ability to instantly alter design details and solve problems that may previously have reminded undiscovered until sample making. It also gave pattern cutters the ability to manipulate and re-cut patterns with speed, saving time and cost.

The use of automated processes affectsthe whole manufacturing process in the footwear industry; the previous scheme aims to represent the most relevant changes in the designer role, in traditional shoe- making process compared with the computer assisted design method.

The starting point is the brand collection brief and inspiration that the stylist or designer would receive to start working, the activities to follow go until the development of shoe models patterns – normally done by a pattern maker- that would be used in a traditional shoe making process to proceed with leather cutting. The following is the comparison of the most relevant activities within the shoe making process, focused on the role of the designer.

SKETCH ON LAST

The CAD systems allow the use of digital sketching tools, previous drawing can be use as reference for the new design by projecting them on the last; It can be also linked to Adobe Photoshop to work in parallel. The lasts database is available in the digital library and the designer will choose the most adequate model from the very first beginning.



LAST STORING

A shoe last is a block that represents the shape, heel height and fit of a finished shoe. It is the starting place and key part of shoe design/manufacturing. In traditional design processes the collection is designed in 2d by stylists who must consider the availability of shoe lasts that the company can provide; otherwise the designs must be later adapted to the shapes of the lasts.

Lasts are designed and produced by skilled last makers and can be made from plastic materials or wood. Traditionally they would have been handcrafted but are now likely to be created digitally and milled on CNC machinery. Physical lasts can be purchased from the last maker or alternatively be bought the in a digital form, called an e-last, which can then be opened within CAD.

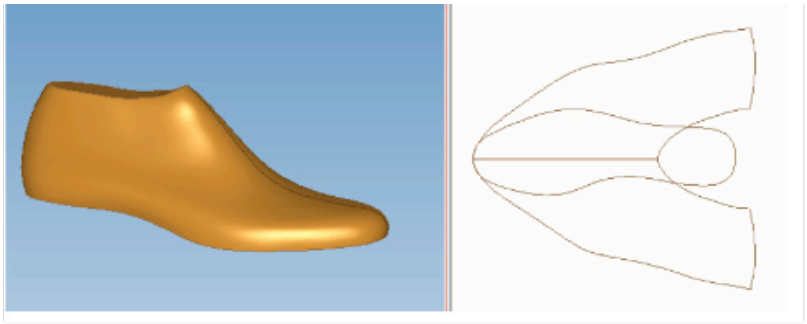
If the brand has only physical lasts there a couple of different options in order to use them within CAD. The simplest option is to contact last maker and ask them if they are able to provide the CAD data, which will either be in e-last format or in a format that can be converted.

Another option is to have the last scanned and then converted into an e-last format

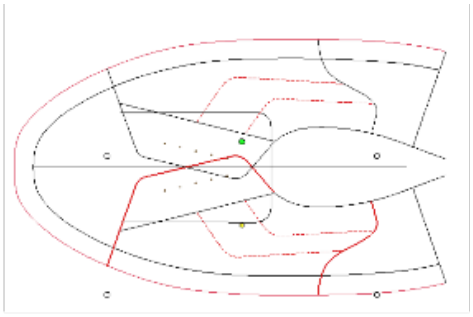
PATTERN MAKING AND SIZE GRADING

In a traditional shoe making process, after the collection has been designed by the stylist or designer, the sketches must be passed from 2d to 3d on to the shoe last. The last ´´tape-up´´ is a traditional technique that is used to achieve this process. The pattern makers would draw the model lines on the taped-up last, that will be then flatten and transformed into patterns to build up the shoe model. These patterns are normally stored by the industries in a material like cardboard or metal, which would allow a long term conservation.

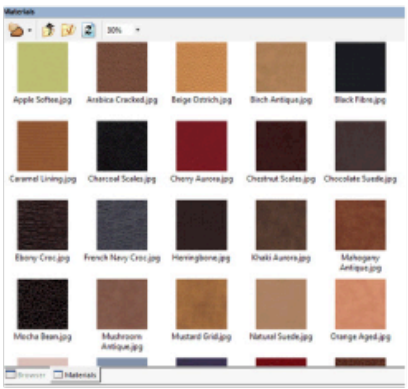
The pass from the designer sketches -2d -to the shoe last -3d - and then to the construction of patterns- back to 2d- is a complex process that can be automatically done by the CAD software. The patterns will be easily scale by the software, there is no need to work on more than one shoe size.

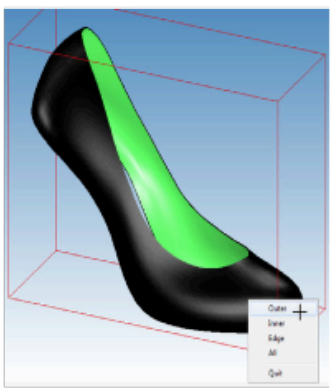


Default flattening



Pattern edition in 2d





From style lines to materialization

2.2 VIRTUAL RETAIL

Technology driven innovation, the overarching socio-economic trends and the shifts in consumer behavior are pushing brands to leverage and create more appealing retail experiences for their customers. There is a new innovative concept for the Fashion Retail industry: Virtual Retail or 'No Stock Retail' that essentially means three things:

-Industrial made to measure: product with a perfect fit, main competitive advantage for quality manufacturing
-Mass customized: customizable products are the biggest luxury consumer retail trend for the future of fashion retail
-Made to order: a unique product, a new operational model for the whole retail chain

This concept is a reboot to physical retail stores and is mainly based on the following market changing principles:
-Shoppers are seeing less value in the physical retail experiences; they want products to be available when they want
-In the physical stores they find some difficulties such as comparing and locating products, they frequently face queues at checkouts.
- The discount or promotions are not personalized.
-The existing trend of personalization of products and the predisposition of customer to spend more money and wait more time to add this value.

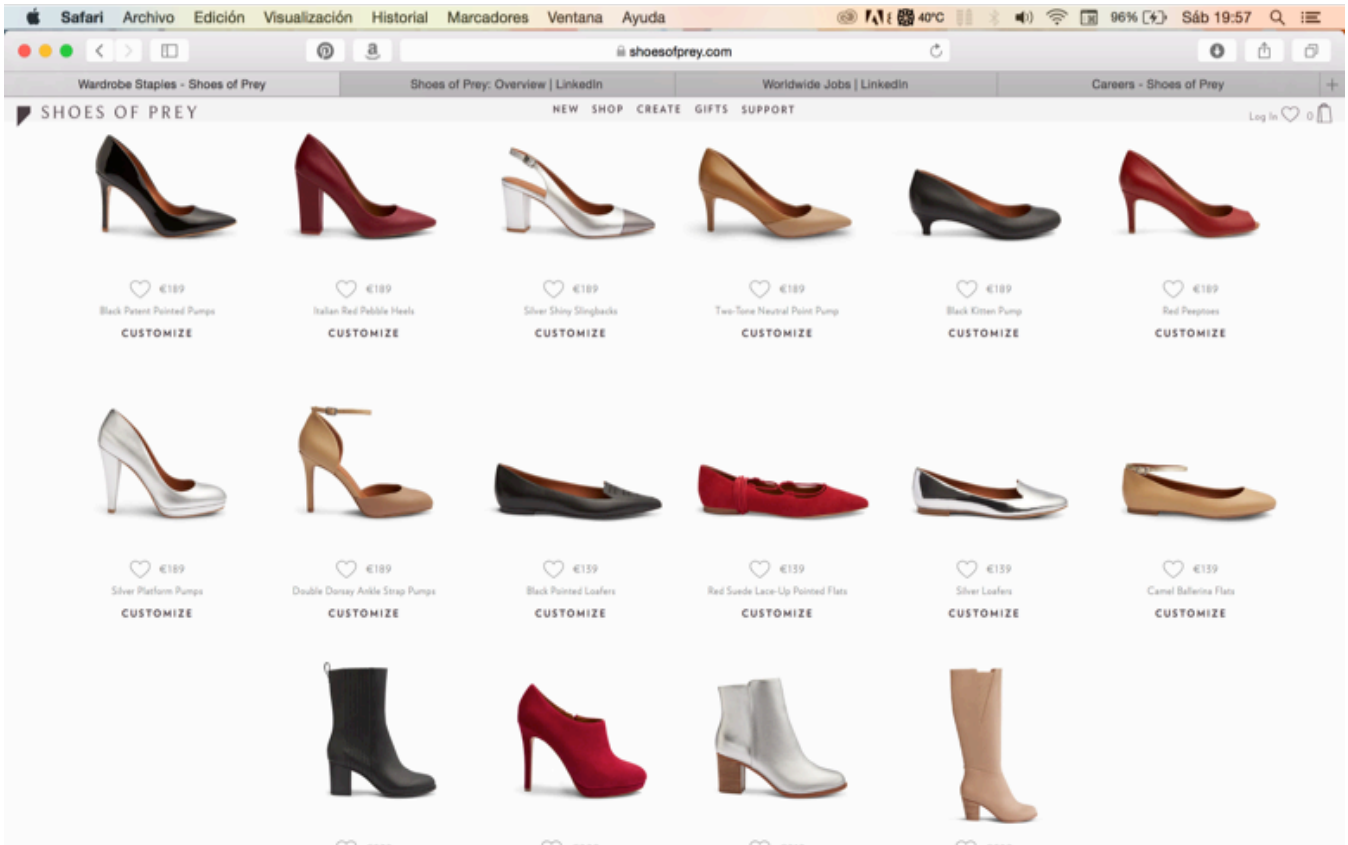
The virtual retail would fade the barrier between the digital and physical world, using technology as an experience enhancer for products and services. Luxury brands are already acknowledging the role that social media and advanced sensory led technologies play in consumers 'everyday lives, and they are adopting them to their own purposes with a smart upscale twist; applying new technologies into traditional scheme, trying to insert Limited edition Collections. In this scenario, the role of the digital designer is not limited to design for production considering manufacturing processes but also to design for sale, considering the virtual interface of the product with the consumer. The products need to be ´virtually manufactured´ even before any manufacturing decision is made. The shoppers will want to see many options of model and sizes, variations, materials, accessories, and more.


Basic Product Customization Logic: FOOTWEAR
3D Base Model
Configurable Elements
Virtual Collection Designs
Brand Communication Materials
Catalogue
UniCredit Start Lab
© 2017 ELSE Corp S.r.l.
5

2.3 DIGITAL BOUTIQUE

Opposite to a standard boutique, the digital boutique does not need any manufactured or available product in order to sale. The complete models or variation of these can be digitally exposed to on- line customer. Web sites or mobile App. are the channels making the contact between brands and customers. CAD designers and web developers are a main key for highly customizable product brands.

Back in 2009, the Australian entrepreneur Jodie Fox started out on the Shoes of Prey journey, a global retail brand, both online and offline that allows women to design their perfect shoes, which they custom make and deliver worldwide. Nowadays, the company has one of the biggest digital shops of the footwear industry. Most of the products are interactive CAD models that customers can personalize.

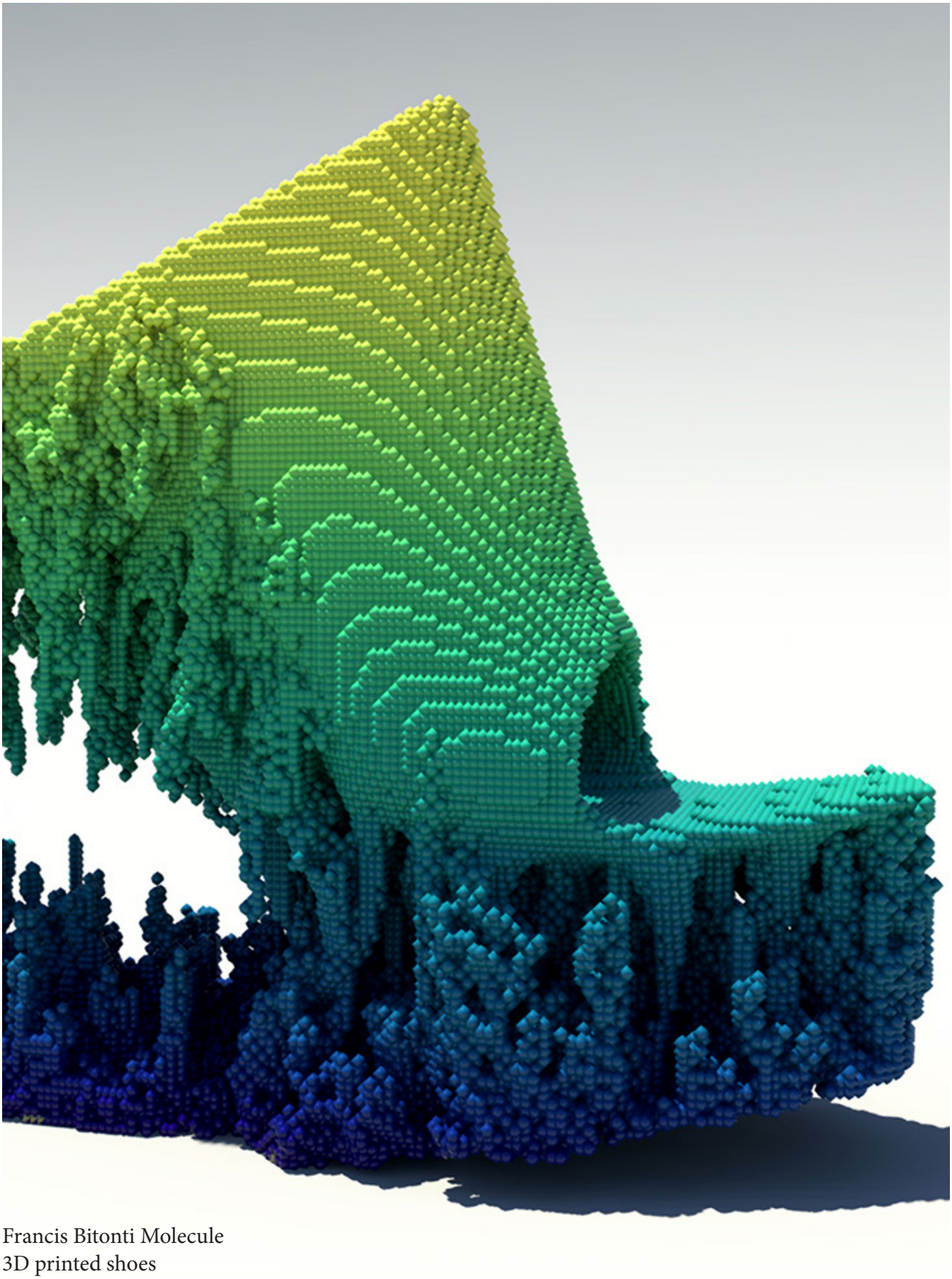


Selection of heel at the digital boutique of Shoes of Pray. Opposite: ELSE- Corp digital boutique through HoloLens

3 COMPUTER AIDED MANUFACTURING

We live in a time of language; I am not interested in anything that cannot be codified in some linguistic fashion. This is why I work with 3D printing, we have g-code: a codified language for material production. The Internet was a revolution because under it all was a codified linguistic method of creation and reproduction.

Francis Bitonti



Francis Bitonti Molecule
3D printed shoes

INTRODUCTION

When physical products move from the analogue world to the digital realm, they usually acquire a new descriptive term. Songs that one-generation ago were referred to as vinyl tracks are now known as MP3s, while photos have quickly become known as JPG. This new words do not actually describe the original item, but a computer based digital representation. In computer aided manufacturing, we are still at that fluid stage where the new term for this data objects has not yet been decided. It might be an .stl, perhaps a CAD file, or perhaps the new term ´physible´will quickly catch on. Whatever we end up calling them, they are going to become immensely important in the near future. Just as Gutenberg´s printing press gave rise to bookshops and libraries, the computer aided manufacture will see the growth of enormous online resources full of 3d representations of all our real world objects.

Sustainability must also be better integrated into the evolution of the technology. 3D printing enables substantial savings in materials and can radically reduce carbon, by making freight transport obsolete because objects can be created on site. But, on the other hand, there are issues with the recycling of unused powder and more research is required on the use of very high temperatures in the solidification process of materials.

The actual concept of 3D printing technologies involves different methods, which use either a heating source to fuse, sinter or melt thin slices of materials to create an object layer by layer from the button up. The whole process can take from a couple of minutes to several days, depending on the complexity of the printed object. Since its creation around 1980's, 3D printing technologies – or Additive Manufacturing- had been mainly used for rapid prototyping within different industries, but in recent years this technology has really started to shake up the fashion world.
One of the most prominent advantages of 3D printing technology is that it allows for rapid prototyping. You can test out any number of ideas, and have physical models of these ideas 3D printed within hours also allows for the creation of shapes and forms that would be entirely impossible to produce through any other means of fabrication.'
The emerging technology leaves behind virtually no waste. Its localized production and one-size-fits-all approach also racks up markedly fewer travel miles, requires less labor, and compresses fabrication time to a matter of hours, rather than weeks or months. Using 3D printing in manufacturing will not mean only zero wasted materials, but also products could also be potentially recycled at home.

3.1 FUSED DEPOSITION MODELLING (FDM)

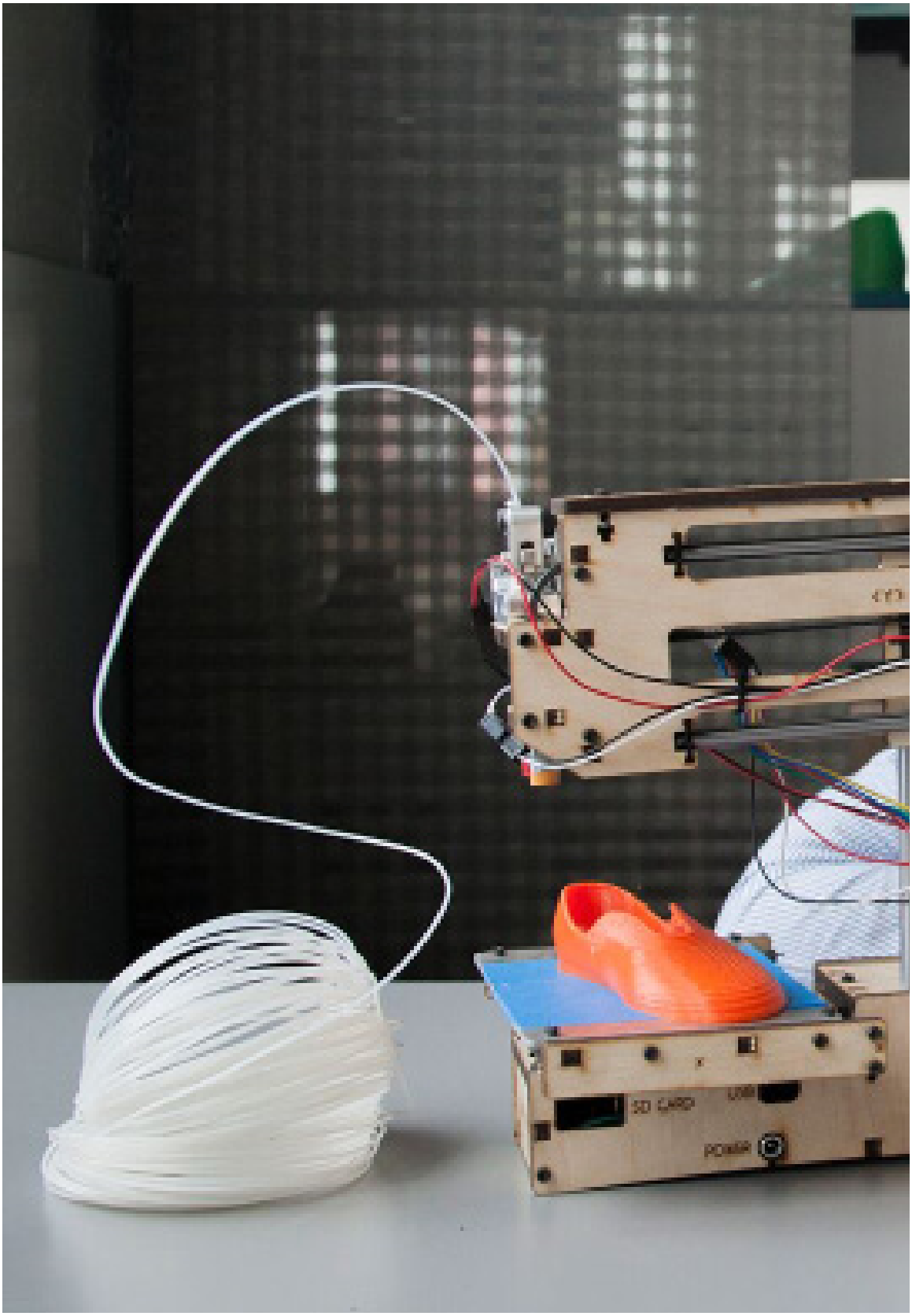
Stratasys founder Scott Crump invented FDM Technology more than 20 years ago, and Stratasys has continued to lead the 3D printing revolution ever since, developing a range of systems that appeal to large manufacturers, designers, engineers, educators and other professionals.

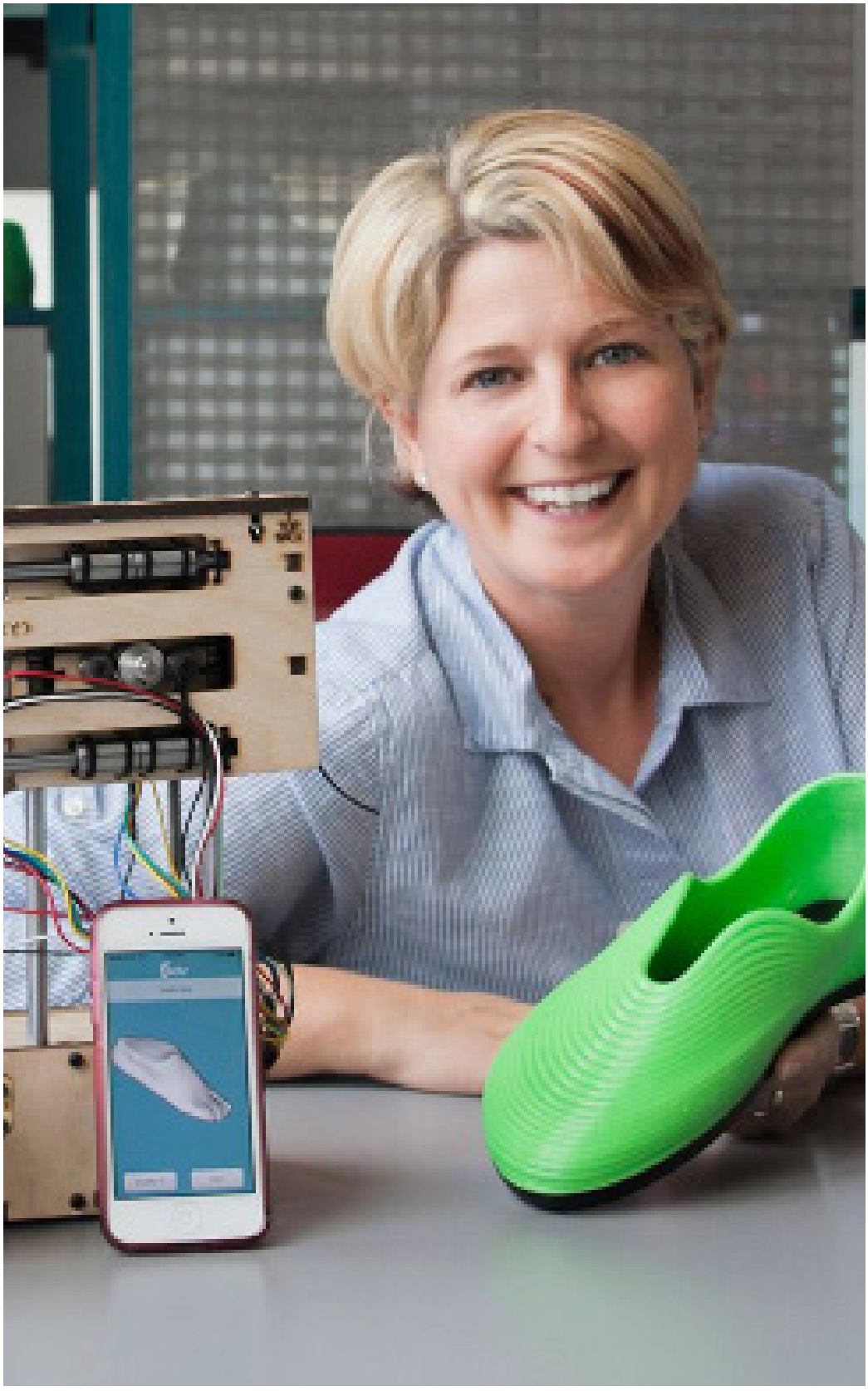
3D printers that run on FDM Technology build parts layer-by-layer from the bottom up by heating and extruding thermoplastic filament. The software that comes with this technology automatically generates support structures if required. The term fused deposition modelling and Stratasys Inc trademarks its abbreviation to FDM. The members of the RepRap project to give a phrase that would be legally unconstrained in its use coined the exactly equivalent term, Fused Filament Fabrication (FFF).

The FDM technology works using a plastic filament or metal wire which is unwound from a coil and supplying material to an extrusion nozzle which can turn the flow on and off. The nozzle is heated to melt the material and can be moved in both horizontal and vertical directions by a numerically controlled mechanism, directly controlled by a computer-aided manufacturing (CAM) software package. Extruding melted material to form layers as the material hardens immediately after extrusion from the nozzle produces the object. This technology is most widely used with two plastic filament material types: ABS (Acrylonitrile Butadiene Styrene) and PLA (Polylactic acid). Though many other materials are available ranging in properties from wood fill to flexible and even conductive materials.

This technique is becoming part of creators´ domestic tools, everyone can buy or build their a 3d printer at home. The open sources CAD libraries continue to expand, and designers are sharing their 3d models for free. 3D printing undoubtedly puts more power in the hands of consumers, who can play a bigger role in the design and realization of their products. But up to what point? To make one's own objects is cool and 3D printing is a highly significant innovation for the maker movement. But in fashion and luxury, this has its limits while it is easy to print a basic resin bracelet, it is much more complex to create a sophisticated luxury product. But it's not impossible to imagine brands offering their clients the option of making simple products within certain parameters.

Indeed, perhaps most of all, 3D printing will facilitate differentiation and customization, enriching the dialogue between the consumer and the designer and giving rise to a wider range of goods than ever before.


SD CARD
USB
POWER



We want to reach a point where whether you want heels, flat or glittery shoes to wear to a party, we have a design that we can print and have to your door in seven days

Lucy Beard

Tennessee-based hi-tech manufacturing start-up, which has created an app and manufacturing concept that allow shoppers to buy shoes that are unique to them using 3D printing technology.

Lucy Beard first had the idea for the business after se struggled to find shoes to fit her size. Company stated that 30 per cent of the people that signed up they do not have particularly large or small feet or précised requirements, but they only want bespoke shoes. They called themselves ´´the digital cobblers´´, claiming to combine the benefits of custom-made footwear, such as those hand made by shoemakers, and the custom style offerings currently available from brands like Nike, which allow customers to change elements of their footwear, such as colour. Some of the recognized benefits to have ´´digitally manufactured customization´´ are: for a pair of shoes you can pay between $150 and $250 that comparing to traditional made to measure shoes is not a high Price. The company also expect to offer lower prices as the technology become more accessible. The time that it takes for a pair of shoe to be done is around 24 hours, with a projection to become one hour in 5 years. Sustainability is also a point in favour to Feetz, since traditional shoe making process contain too many materials and glues for this to be cost effective, ending up to landfill. The 3d printed shoes offer a recycling service and the simplicity of the process and materials allow them to be fully recyclable. The new pair of shoes includes a return label so one can send back the first pair to be recycled.

The company has developed an app, which builds a virtual image of the user's feet, in order to create the bespoke shoes. The app does not require any fancy scanning system; It allows everyone with a Smartphone to use their feet pictures to generate a 3d model. The data of feet shape, height of arch and body weight is fed into Feetz´s back end, which is powered by the Autodesk platform in order to choose the right material for shoes. The lines of code generated by the design are then fed into the 3d printers to create the finished product.
The shoes are currently manufactured by Feetz but the company is hoping that within five years, its designs will be printed on any 3D printer that is local to the buyer, which will eradicate shipping costs.
This will require the printers to be stocked with materials developed by Feetz, including anti-microbial and cooling qualities for inside the shoe.

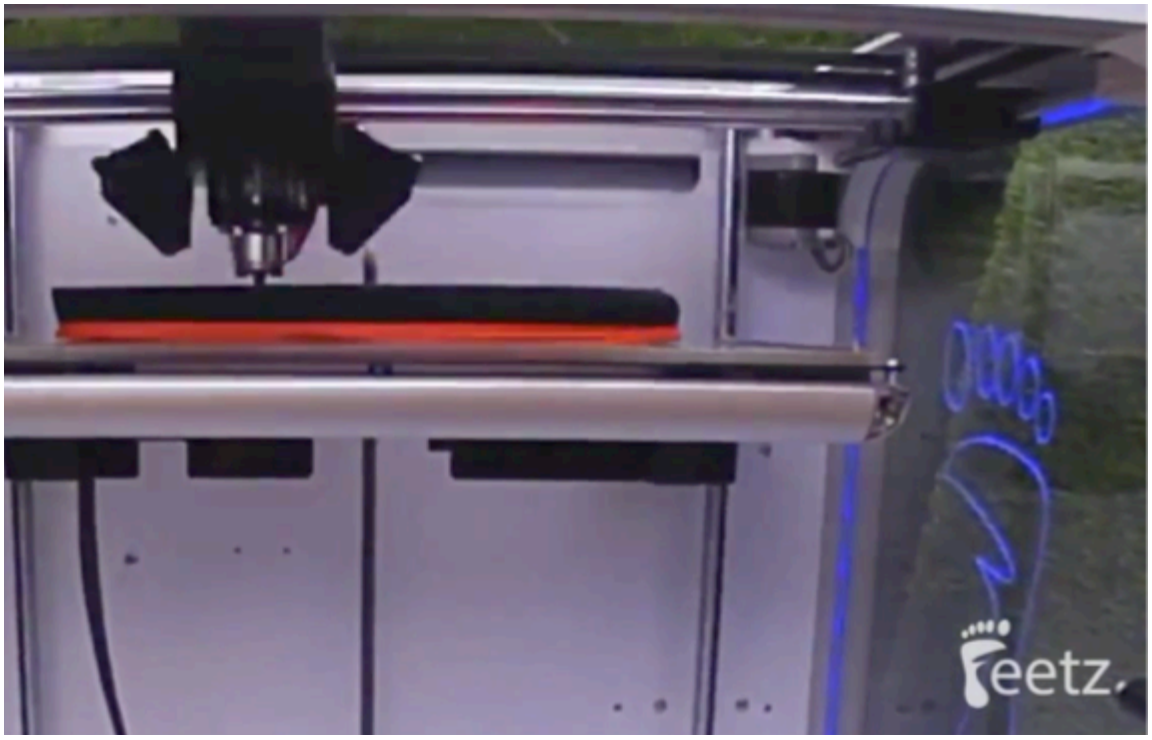
Feetz mass customization production in progress

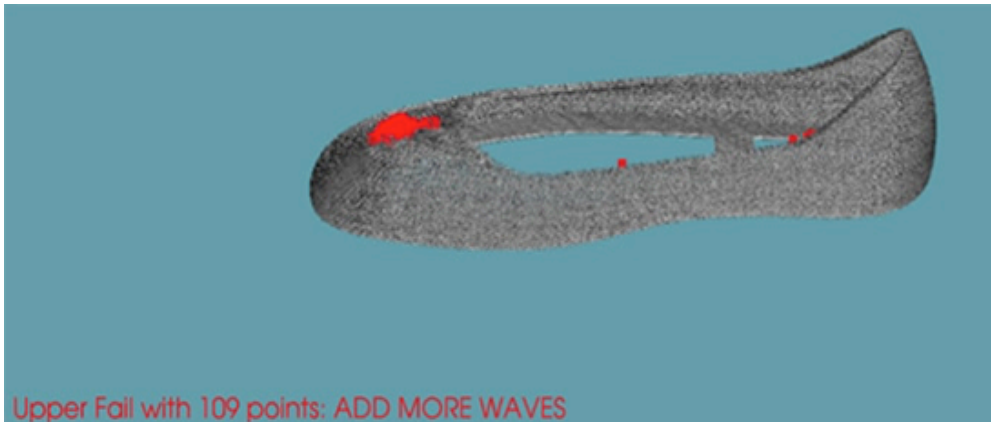
3D KNITTING WITH FLEK NIT

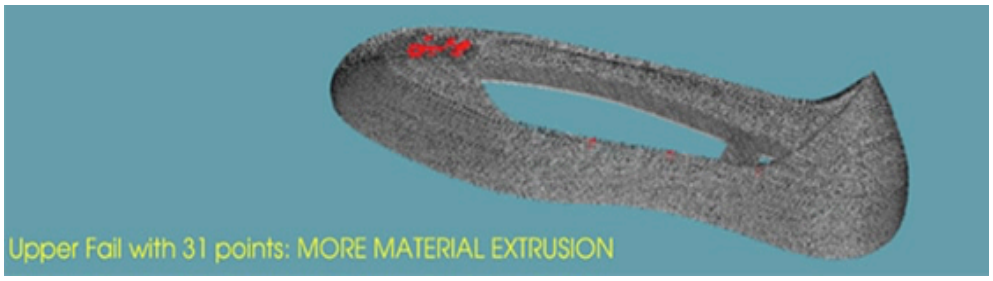
Feetz is one of the few companies that achieved to make footwear that can reach a massive market. A particularity of the Brand is the aesthetic they approach, which is far away from ´´futuristic´ ´but It looks more like traditional shoes. Some of the secret to the *"wait, this is 3D printed?"* aspect lies in the FlexKnit material on the top of the shoe, a patent design structure utilizing knitted textures in 3d printing format that forms to the person wearing it .It has helped the shoes come a long way in no longer 'looking 3D printed.' As Beard explains:

"FlexKnit is a totally unique way to mimic knitting but without all the current waste in traditional shoe manufacturing – there is no shoe last and no excess material cut away or wasted."

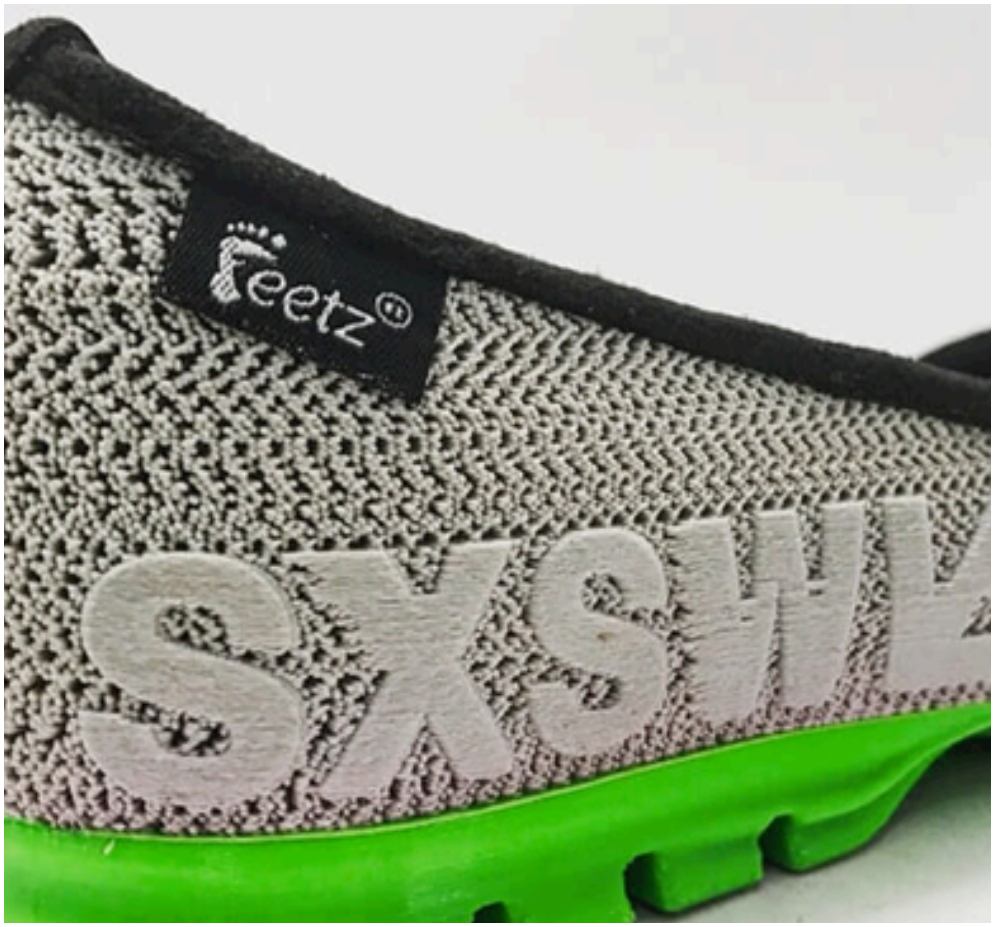
Working process: the printer works both on the sole as a flexible solid, and also the upper as knitwear



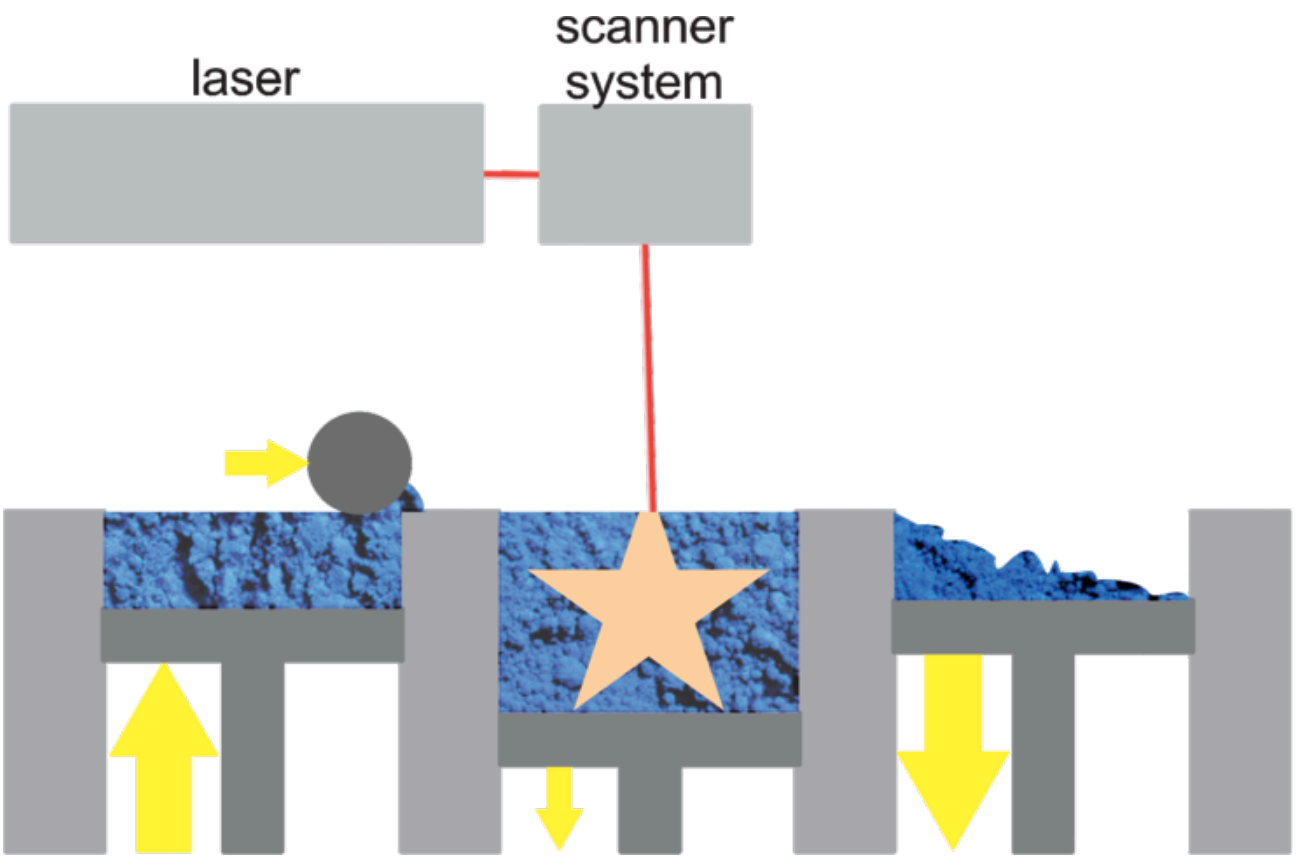




Patented system for optimizing waste and production yield for a 3D printed part - with automatic fixes applied to identified issues



Texturizer: Patented customization engine spanning typography, logos, patterns across targeted areas of an object from a 2D file converted to 3D printable object


laser
scanner
system

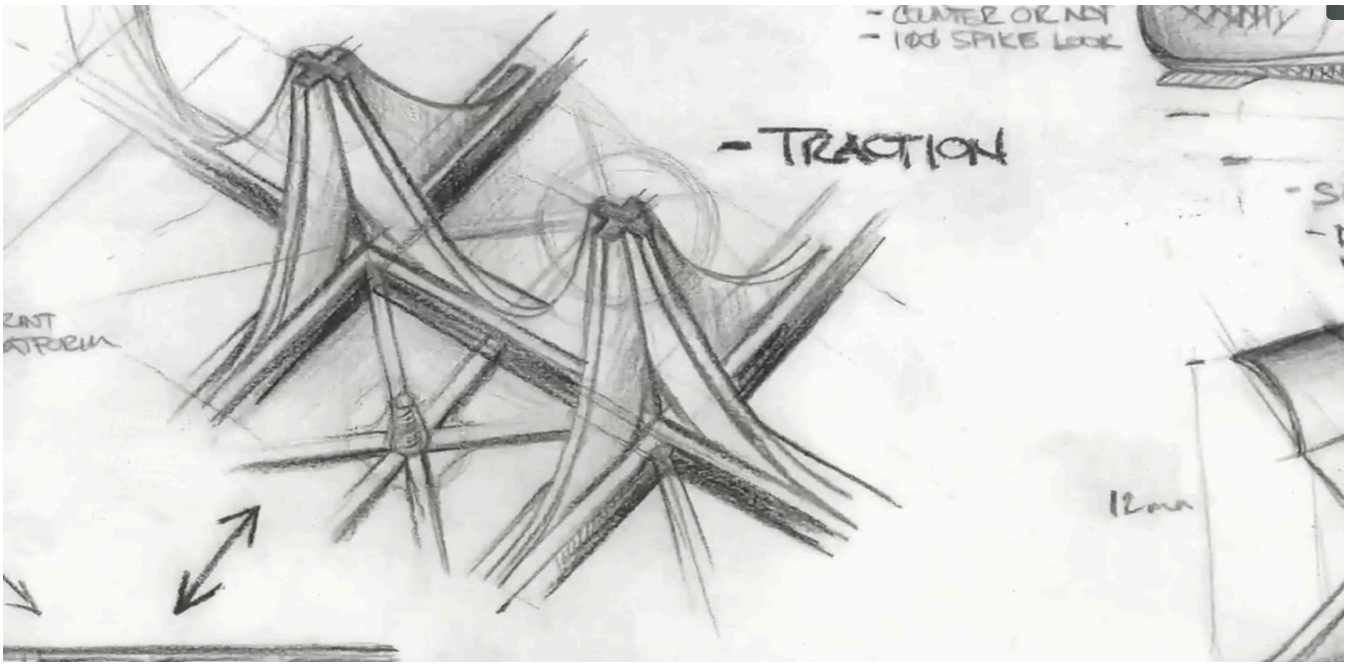
3.2 SELECTED LASER SINTERING

SLS uses a CO2 laser to sinter powder (50 µm particles size) based materials together, lay-er-by-layer, to form a solid model
the ‘part’ chamber consists of a ‘build’ platform, powder cartridge, and leveling roller
a thin layer of ‘build’ material is spread across the platform
the laser traces a two-dimensional cross section of the part, sintering the material together
the platform descends a layer thickness and the leveling roller pushes material from the pow-der cartridge across the build platform, where the next cross section is sintered to the previous
the process continues until the part is completed

Among the 3D printing technologies is the one called Selective Laser Sintering (SLS), that consists in tiny particles of plastic, ceramic or glass are fused togeth- er by heat from a high-power laser to form a solid, three- dimensional object. The laser sintering is an “evolution” of the regular sintering, that is the process of creating objects from powders using atomic diffu-sion to create a three di- mensional object. Sintering has been used for thousands of years to create ev- eryday objects like bricks, porcelain and jewelry.
Like all methods of 3D printing, the object needs to starts as a computer-aided design (CAD) file, that is converted to .STL format, which can be understood by a 3D printing apparatus.

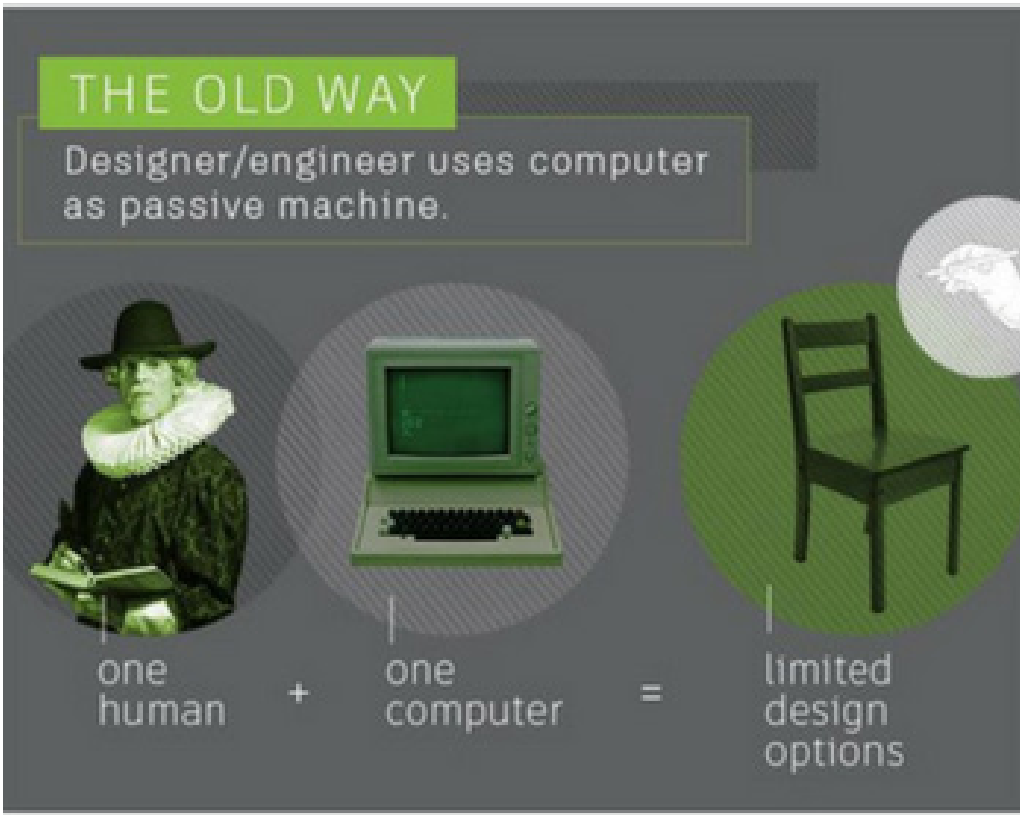
The laser heats the powder either to just below its boiling point (sintering) or above its boiling point (melting), which fuses the particles in the powder together into a solid form.
Once the initial layer is formed, the platform of the SLS machine drops, usually by less than 0.1mm, exposing a new layer of powder for the laser to trace and fuse to- gether. This process continues again and again until the entire object has been printed. When the object is fully formed, it is left to cool in the machine before being re- moved.
Unlike other methods of 3D printing, SLS requires very little additional tooling once an object is printed, mean- ing that objects don’t usually have to be sanded or other- wise altered once they come out of the SLS machine.
SLS also doesn’t require the use of additional supports to hold an object together while it is being printed. Such supports are often necessary with other 3D printing methods, such as stereolithography or fused deposition modeling, making these methods more time-consuming than SLS.
SLS machines can print objects in a variety of materials, such as plastics, glass, ceramics and even metal (which is a related process known as direct metal laser sintering). This makes it a popular process for creating both proto- types as well as final products, and has proved to be par- ticularly useful for industries that need only a small quan- tity of objects printed in high quality materials. Using SLS, companies can create prototypes that are stored digitally as .S

TL files, which they can redesign or reprint as needed.Because SLS machines can print in a range of high-quality mate- rials, from flexible plastic to food-grade ceramic, SLS is also a pop-ular method for 3D printing customized products, such as hearing aids, dental retainers and prosthetics. And because ob- jects printed with SLS don’t rely on molds or require additional tooling, this method of manufacturing is also useful for anyone that wishes to print a highly complex or particularly delicate object.Because SLS requires the use of high-powered lasers, it is often more expensive (and potentially more dangerous) for use at home. However, there are several intrepid inventors out there who are working on their own versions of desktop SLS printers.


- TRACTION

Images from Nike site and Youtube channel

The “Nike vapor laser talon” football boot incorporates a lightweight 3D printed plate that is contoured to allow football athletes to maintain their drive position longer and efficiently. The pattern on the cleat, stud placement and overall shape of the shoe is able to increase surface traction and allows the athlete to be more aggressive while running the turf. The SLS process allows for the engineering and creation of shapes not possible with traditional manufacturing processes, as well as the ability to make design updates within hours instead of months to truly accelerate the innovation process to never seen speeds.


THE OLD WAY
Designer/engineer uses computer as passive machine.
one human
+
one computer
=
limited design options

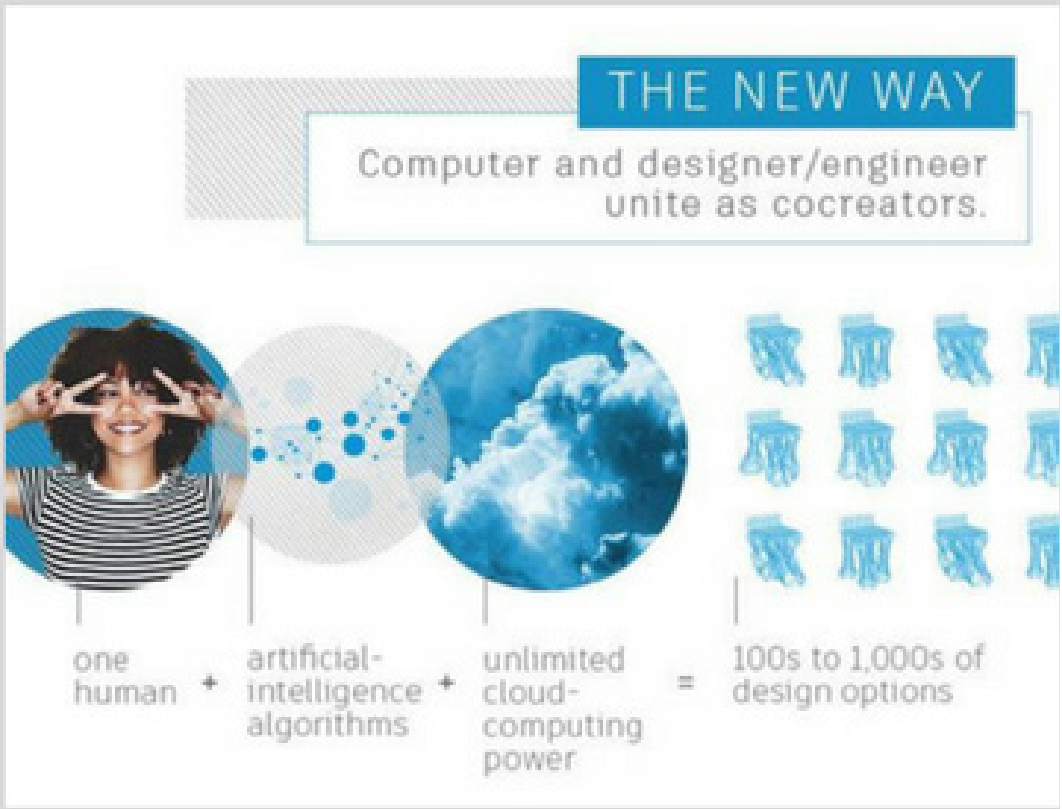
3.3 GENERATIVE DESIGN

Generative design is a form finding process that can mimic nature´s evolutionary approach to design. it can start with design goals and then explore innumerable possible permutations of a solution to find the best option. By using cloud computing, generative design can cycle through thousands- or even millions- of design choices, test configurations and learn fro each iteration what works and what doesn´t. The process can enable designers to generate brand new options, beyond what a human alone could create, to arrive at a most effective design.

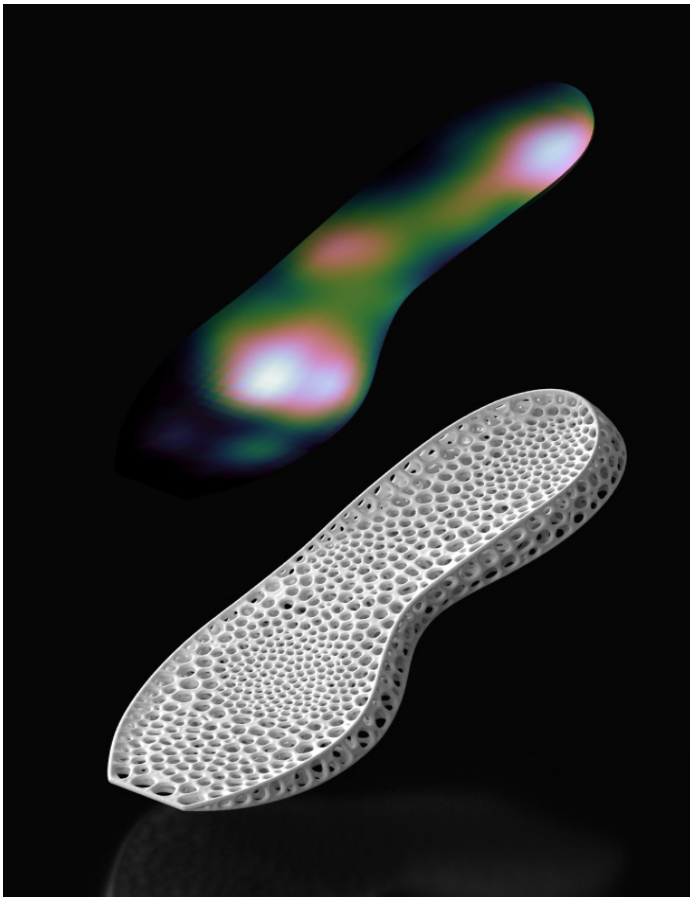
Most generative design, in which the output could be images, sounds, architectural models, animations, etc, is based on algorithm and parametric modeling. it is a fast method of exploring design possibilities that is used in various design fields such as art, architecture, communication design, and product design.

BENEFITS

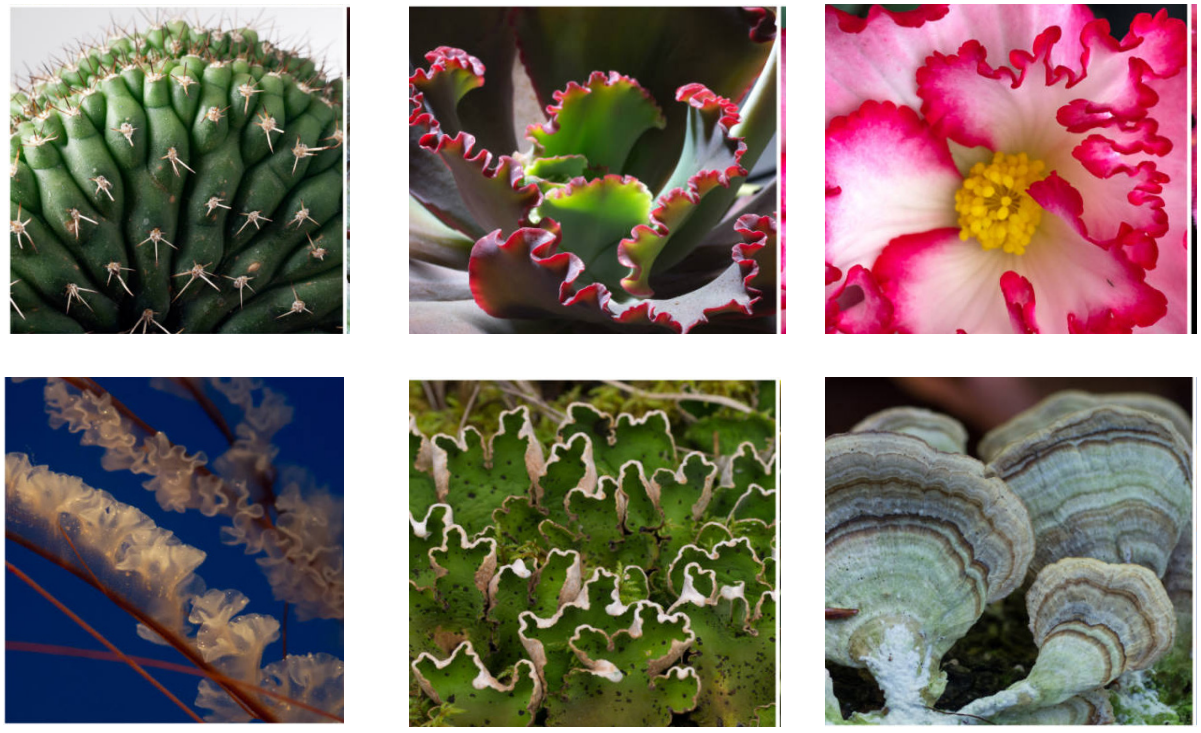
Generative design allows to explore a wider range of design options. In the time you can create an idea, a computer can generate thousands, along with the data to prove which designs perform best. It also lets you create optimized complex shapes and internal lattices. Some of these forms are impossible to make with traditional manufacturing methods. Instead, they are built using additive manufacturing methods.
Designer can set goals and parameters, and the software resolves design constraints so you can focus in innovating.



Images and text extracted from the Footwearists on- line classes



Nervous System for New Balance



Images from n-e-r-v-o-u-s.com

Nervous System finds the Inspiration in nature in order to generate the products

PARAMETRIC DESIGN

Is a process based on algorithmic thinking that enables the expression of parameters and rules that, together, define, encode and clarify the relationship between design intent and design response. Is a paradigm in design where the relationship between elements is used to manipulate and inform the design of complex geometries and structures.

The term parametric refers to the use of certain parameters or variables that can be edited to manipulate or alter the end result of an equation or system.

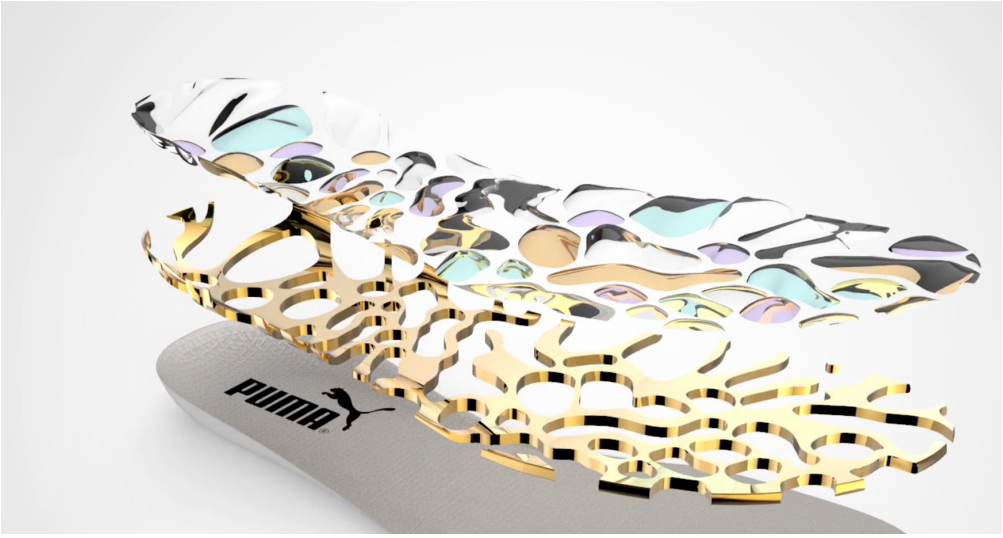
NERVOUS SYSTEM

Is a generative design studio that creates using a novel process that employs computer simulation to generate designs and digital fabrication to realize products. Drawing inspiration from natural phenomena, they write computer programs based on processes and patterns found in nature and use those programs to create unique and affordable art, jewelry, and housewares.

n the future, what we might be able to do, when it comes to optimization is to combine different types of data , not just in terms of physical properties but also including the whole life cycle of products and Its interaction with the ecosystem.

The inspiration in nature does not only happen within the aesthetics of products, many designers are exploring the natural systems in a deeper level trying to imitate the natural processes but making use of the latest technologies and developments.

The biodegradable experiments of Puma Lab , are a clear example of this approach. The brand presented a collection of biodegradable products during the last edition of Milan Design Week. The collection consisted in 3 main products related to the footwear industry, all of them include customization and generative design, re- thinking and re-proposing the meaning of each.



EXPERIMENT 1: DEEP RUNNING INSOLES

are silicone based disposable insoles that contain microbial cultures to monitor bio-mechanical vitals that change during running or workout routines.

The data captured from the insoles are used to track activity patterns and build long- term models of user activity in which the user can be informed about their fatigue before it happens.

EXPERIMENT 2: BREATHING SHOES

The upper sole of the shoe is molded with a cavity pattern in which the cavities are filled with a bacteria and gelatinous media. The organisms respond to the heat generated by the feet and proliferate by consuming the media in the cavities.
Each shoe comes in solid black or white, as media gets consumed , the surface of the shoe begins to create ventilation points allowing more air to flow through. Over time, each shoe begins to take a custom look based on the activity and profile of their users.

EXPERIMENT 3: ADAPTIVE PACKAGING

Is an inflate- on- demand flexible packaging that can be programmed to bio degrade after it use. The packaging ships flat and comes in the form of a sleeve in which products are inserted. The package is triggered to inflate by a special heating device. The air sacs begins to inflate over time and the packaging begins to take the shape of the product.
When the bacteria grows to a certain size and reaches the outer inducer, the chemical activates the genes in the organism that are the responsible for synthesizing the chemicals for elastomer degradation

CONCLUSION. Designer future challenges

Until this stage of the project, we have analyzed the different strategies that companies use in order to follow the technologies innovation that guides the footwear industry. We have seen the three main types of mass customization that are normally offered- style customization, best fit and custom fit-. We have gone through the main tools that CAD design software like Shoe Master can offer to designers and industry and how manufacture and selling process are evolving in this area.

Hand made processes and craftsmen know-how are still main keys on the Footwear industry and are always a starting point for the new technologies development in the area. New softwares, processes, materials, seem to struggle to imitate and improve the ´´traditional process´´of shoe making, but Is it the correct way to evolve? Are we using all the potentiality of technology going this way?

Even if possibilities coming from the digital world seem to provide endless tools, enough to revolutionize the way we make things, the footwear industry seems to be stuck in the traditional methods. Using technology only trying to improve the processes or selling better.

Can we re-start? Re- think? Re- propose?
Those who innovate are the pioneers of this industry, they take the risk but they also opened a complete new door of exploration and curiosity that designers must follow in order to take part of this exciting future of footwear.

4 FOOTWEAR AND COMFORT

INTRODUCTION

Consumers are in the past, buying for the only pleasure of buying, Mass customization
After going through the latest trends on footwear industry, we can affirm that the way of consuming has been dramatically changing over the last decade. The seek for personalization by the companies and the positive answer from the audience to activities that promote this trend, is affecting the way we make things.

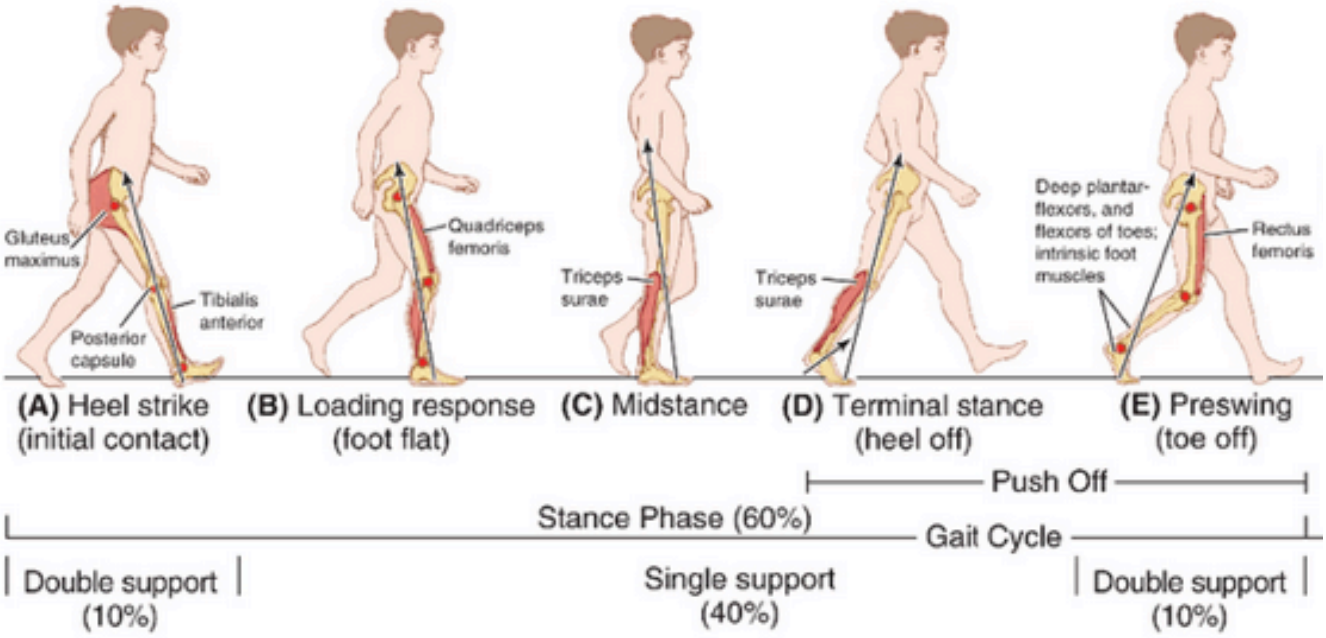
Being scanned and study makes us feel unique, and the fact that this could be the starting point of manufacturing a products makes the audience love what comes out. The use of technology devices that help us know ourselves better are becoming more and more, smart watches, training apps, personalized services, and more.

They footwear industry must wake up and experiment more on new ways to answer to these trends and leave behind the old mass-production way. The experience of artignans and the years and years of well established companies are of course of main value in order to orient the path of new designers, engineer, technician and creators. We, manufacturers influence in this process, but we are also influenced by society, we must listen and use a reciproque way of production in order to survive in the market.

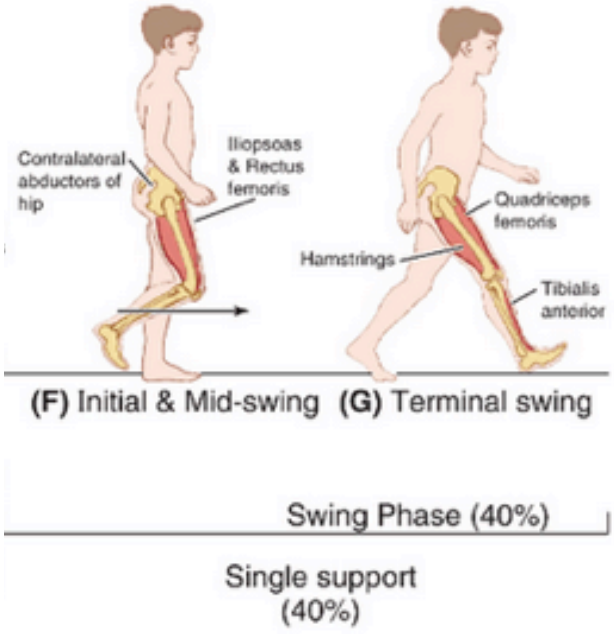
Traditional ways of doing shoes has always said ´last come first´, but it is may be time to pass this era. Last are only a standardized shape of the foot that was born for cobblers to be able to produce more in less time. At the beginning they were made by wood and even last and left where not the same for an individual. With the revolution of polymer and the leading of mass production process the ´made to measure´has been lost living space for innumerable pairs of production, fast fashion, low cost.

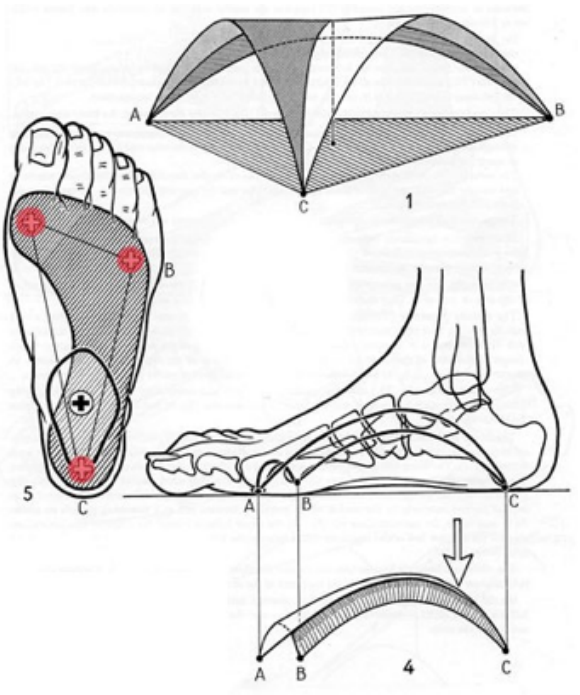
With the latest technology developments this seems a little antique. We have stayed in the past while there is a whole new way of making things to explore. This part of the project aim is

4.1 FOOT ANATOMY AND BIO-MECHANICS



The gait cycle describes the sequence of events from the point the foot comes in contact with the ground until that same foot makes contact with the ground again, producing forward propulsion of the center of gravity. Gait is one of the most frequently used forms of human movement during daily activity. As an inherently complex task, human gait requires the coordination of both neural and musculoskeletal systems to provide balance and stabilization of the body during movement. Gait is represented by out of phase leg movement, in which each leg successively shifts from one phase of the gait cycle to the next. Analysis of gait parameters plays an important role in the evaluation and characterization of able-bodied and pathological gait. The analysis of foot function in particular is essential, as the feet are the main point of support during gait, and are constantly adapting to various environments and regular exposure to large forces. The gait cycle is fundamentally divided into stance and swing phases. The stance phase accounts for 60% of the total gait cycle, during which the foot is in contact with the ground and bears the full weight of the body. The swing phase comprises the remaining 40% of the gait cycle and begins at the toe off of the foot. During this phase the foot is off the ground and swinging forward to begin the next stance, while the body weight is transferred to the other foot





Top: Illustration of the gait cycle (EpoMedicine, 2014). Bottom: Foot vault illustration from Kapanji, The physiology of the joint (Kapandji et al., 1988)

, the pressure is first applied to the calcaneus (C) then to the fifth metatarsal head (B) and finally to the first metatarsal head (A). This set of weight-bearing points can be referred to as a three pointed arch or plantar vault. The sequential pressure distribution through these set of points during the stance phase can be described as the ideal biomechanical gait. The efficiency of this movement is highly dependent on the posture of the foot during the stance phase. For example, if at heel strike the calcaneus veers too much into eversion (outward rotation), then the centre of pressure immediately shifts off course in early stance, reducing the efficiency of the weight transfer.

4.1.1 FOOT PATHOLOGIES

Because the feet are the foundation of the body´s bio-mechanical system, foot misalignment can manifest as not only foot pain, but also discomfort in the ankles, knees, hip, back, neck or head.

-80% of feet are unstable and 20% is stable
- A very small percentage f the population is born with foot problems
-An average active person takes 8000 to 13000 steps per day
- The heel hits the ground at approximately 3 to 5 times the body weight when walking and up to 10 times when running

When speaking about foot orthoses the most common term to describe an anomaly which affects around 70% of the population is supination and pronation, as illustrated in the figure :

This condition can be observed either visually or through a static pressure map of the patient in a bipedal standing position.The supinated foot has the largest contact area and exaggerated gait line due to the collapsed arch. Whilst many people notice no problem and require no treatment, some will suffer from symptoms such as swelling and back or leg pain. These conditions can benefit from a Slim insert with soft material in áreas of high pressure to relieve the sensittive áreas.

Specialists in orthotics describe a very common process in which insoles are made using different materials to vary its property, making it harder in places and softer in others. Another less common scenario is a patient with flat foot, where it is posible to increase confort by creating a low-density flat insert at points of higher pressure. The variable property requierements for an insole is crucial to its function.

4.1.2 FOOT ORTHOSES

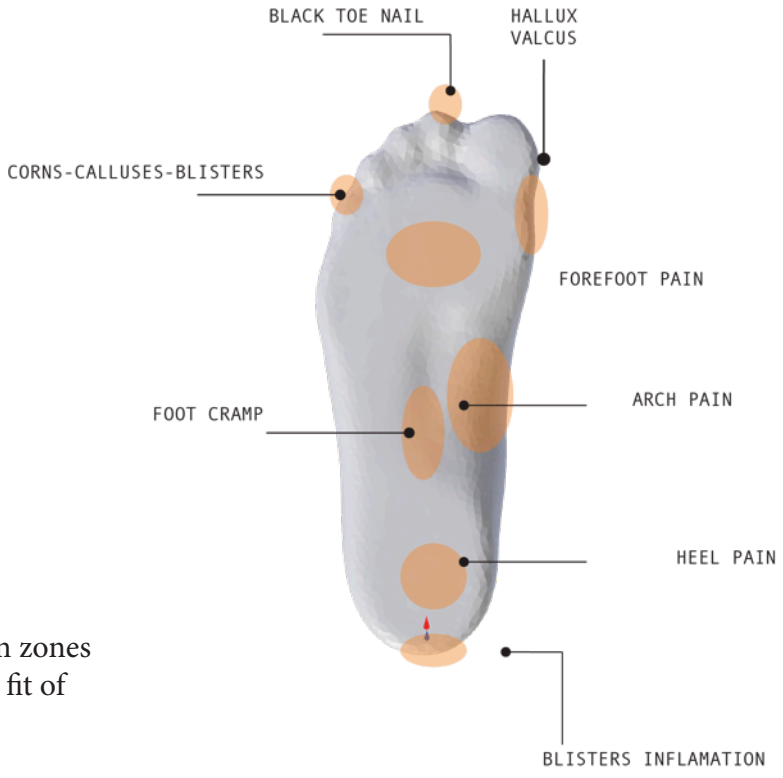
Foot orthoses are mainly used to correct the skeletal alignment and reduce forces being carried up to the upper joints. Taken from the Greek ´Ortho´, meaning straight, the purpose of a foot orthosis is to straighten the skeletal alignment of the foot. The Design process for producing optimal foot otrhoses is also very varied amongst practitioners, however there is a common consensus that orthotic devices should place the foot into a neutral subtalar joint position during the mid-stance phase of gait. By doing so the amount of pronation or supination in the foot is reduced, therefore minimizing the amount of stress transfers to the knee joint.

The main goals for foot osthoses are :

- to support the foot in the desired position and to redistribute weigh-bearing patterns for comfort and protection. Normally, the force exerted on the foot will dissipate through a variety of joint movements. When the range of motion is restricted, an external mechanism can be added to compensate the dampening of the impact. This can be achieved by providing additional cushioning.

- to provide relief in pressure sensitive plantar areas to reduce pain- . A contoured relief pad would transfer the pressure from the sensitive areas to the weight-bearing ones.

-to reduce plantar shearing forces which are important cause of blisters and calluses. Which can be reduced by selecting materials that are able to absorb these forces through internal horizontal movement.



Common pain zones related to bad fit of shoes

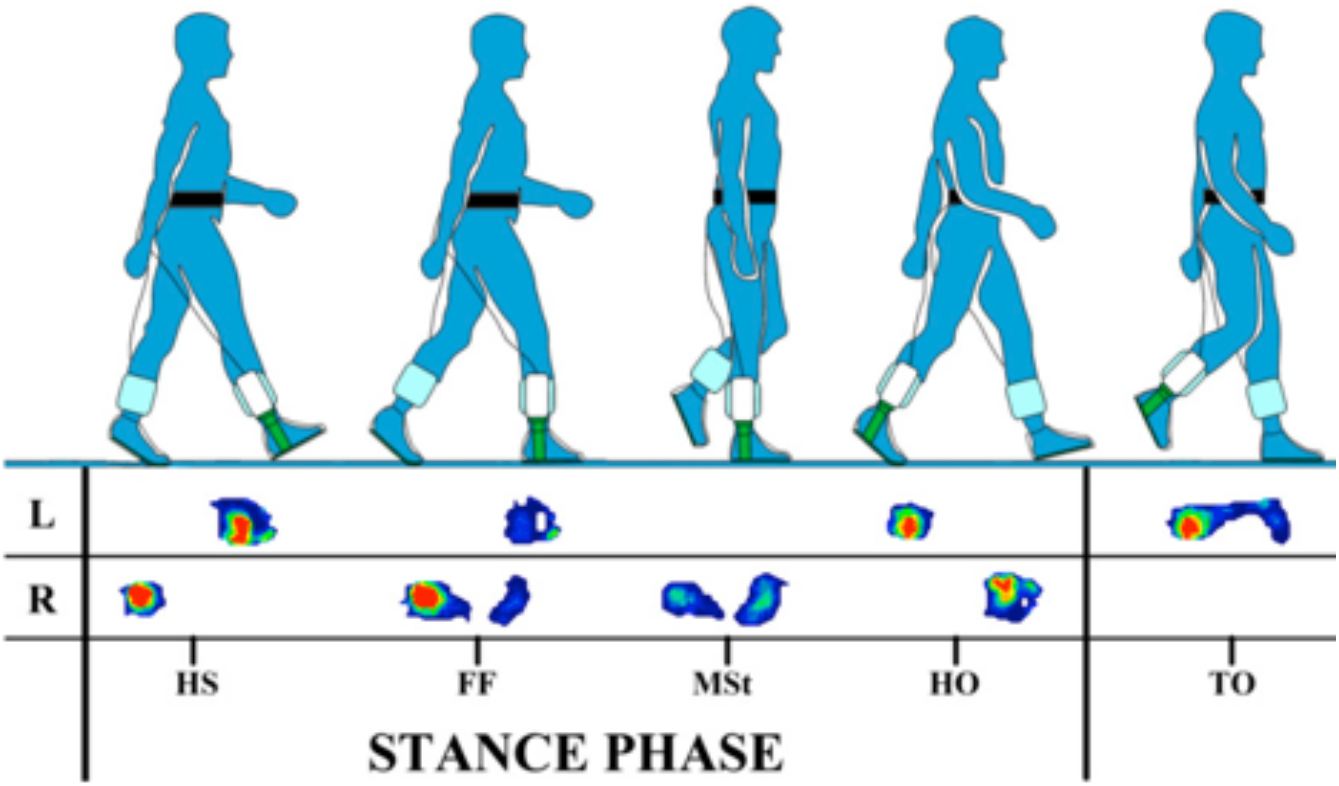
Illustration of a pronated and supinated right foot with the affected pressure map and gait line (Bunert, 2010)

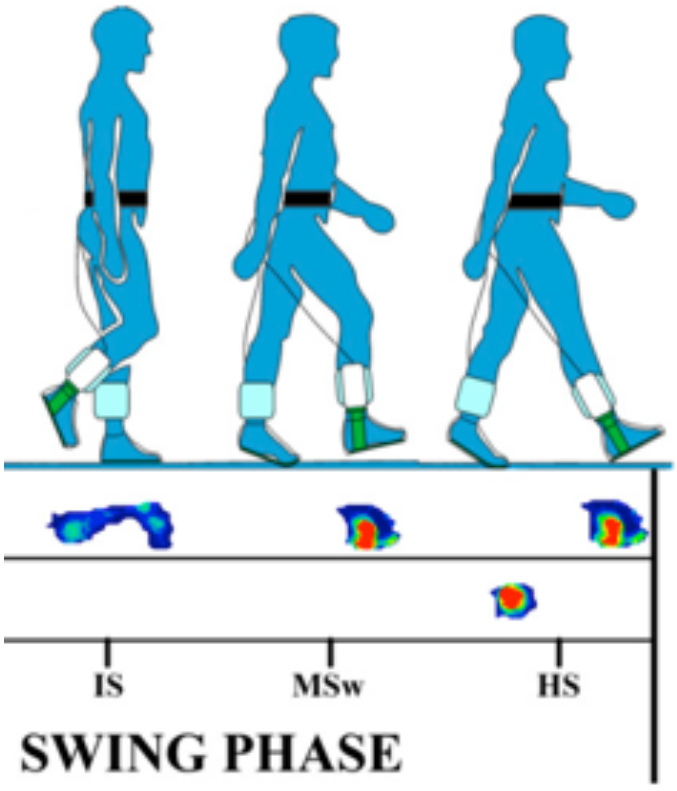
4.1.3 PLANTAR PRESSURE ANALYSIS DURING THE GAIT CYCLE

Investigations emphasize the determination and analysis of pressures or forces acting on the plantar tissue during static or dynamic conditions. Barefoot load distribution characteristic differ from person to person due to a range of factors such as the variation in the walking speed, body weight, individual age, foot geometry and stride length. However,pacing velocity and the structural variations in the foot arch can have significant influences in changing the foot load distribution among people.

It has been reported that during normal stance, each foot carries about half of the weight at the heel, forefoot, and big toe whereas lowest plantar load is located under the mid-foot.

As load distribution on the foot is affected by the foot shape, the foot can be described in three different categories by classifying the height of the foot arch: plane foot, normal, and high arch





mages come from a study of the College of Engineering and Science, Victoria University, Melbourne. Fifty one participants took part in the data collection, at a walking speed using the F-scan in-shoe pressure measurement system .

4.4.1 CASE STUDY. FIT STATION

Fit Station is aimed at disrupting the footwear retail market, forming an end-to-end solution for scanning a customer's foot, designing an insole around its unique walk and run pressures, using the data to suggest suitable off the shelf shoe types, and combining this all with a 3D printed custom insole.
The Fit Station retail scanner uses HP technologies to analyze each foot using a combination of 3D scanning and pressure plate technology to deliver a dynamic gait analysis for the individual, before the data is used to manufacture an insole using the Multi Jet Fusion 3D printer. Additionally, the data in the future could be used to transform shoe mid-soles, providing specific hardness zones and volumetric fit for PU injection molding.

"Our new solution allows us to create the most individualized shape and fit on the planet."

BROOKS RUNNING, HP AND SUPERFEET

Brooks and a partnership of SuperFeet who will make the shoes and HP which developed Fit Station demonstrated how runners feet measured in 3D along with a biometric analysis of stance/gait, all done in running stores, will in the near future see personalized shoes “made to order”in a next evolution of Brooks Run Signature program

With a singular focus on running, Brooks has a deep understanding of runners’ unique bio-mechanics and is committed to providing personalized experiences that enhance the run for every individual. Based on years of research, the company developed its Run Signature philosophy rooted in the belief that the best way to enhance comfort and improve performance is not to fix a runner’s “flaws” but to instead create running footwear that works with the runner’s natural

FitStation uses HP Multi Jet Fusion printing technology to manufacture the world’s first 3D printed insoles made using 3D scanning and dynamic gait analysis to create a one-of-a-kind digital profile of each foot.
The heart of the ME3D insole is the 3D printed Smartcap heel cup, composed of a proprietary

Based on the data a last is selected for the runner's foot shape. For each size, one of several different arch lengths could be selected. In the future the plan is to have yet more customizable lasts, potentially with modular elements snapped together like a Lego.
Later, upper and last are positioned in a molding machine. The AMP DNA material, a polyurethane instead of the usual EVA, is shot into the mold, taking the underside shape of the last- the arch length selected, with upper, midsole, and outsole all shot and bonded together in one step.

When last and personalized molding pressures (leading to personalized firmness/softness in the shoe) are combined the shoes will be able to be tuned to the runner's data for pressure patterns, heel rotation, propulsion index, and dynamic knee variations.

"FitStation by HP is changing what personalization means—from the in-store experience to the final product. In collaboration with Brooks and Superfeet, we are delivering truly made-to-measure footwear with a lot size of one,"

"Digitalization of biometric data opens an opportunity to ultimate individualization with the speed and cost efficiency of mass production. HP brings deep experience in computing, scanning and technology integration at scale to deliver a revolutionary digital manufacturing platform, creating individualized products that are available to anyone—from casual runners to elite athletes."

Ed Ponomarev, general manager of FitStation and business development HP Inc

CONCLUSION. Designer future challenges

Until this stage of the project, we have analyzed the different strategies that companies use in order to follow the technologies innovation that guides the footwear industry. We have seen the three main types of mass customization that are normally offered- style customization, best fit and custom fit-. We have gone through the main tools that CAD design software like Shoe Master can offer to designers and industry and how manufacture and selling process are evolving in this area.

Hand made processes and craftsmen know-how are still main keys on the Footwear industry and are always a starting point for the new technologies development in the area. New softwares, processes, materials, seem to struggle to imitate and improve the ´´traditional process´´of shoe making, but Is it the correct way to evolve? Are we using all the potentiality of technology going this way?

Even if possibilities coming from the digital world seem to provide endless tools, enough to revolutionize the way we make things, the footwear industry seems to be stuck in the traditional methods. Using technology only trying to improve the processes or selling better.

Can we re-start? Re- think? Re- propose?
Those who innovate are the pioneers of this industry, they take the risk but they also opened a complete new door of exploration and curiosity that designers must follow in order to take part of this exciting future of footwear.

1 DESIGN PROCESS

This projects propose to rethink the shoe, minimizing components and processes. Working with the observed and learned from the research and the experimentation phase in order to achieve a solution that uses in the most effective way the available sources and abilities of the designer and the context where this idea was borned.

1.1 DESIGN CONCEPT

1 Individual foot scan is the white canvas

2 Extraction of the plantar and upper surface of the mesh

SOLE

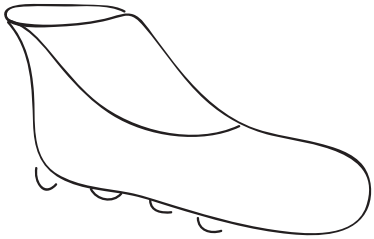
Most important aspects are ergonomy and confort, must follow the arch support

Support
Main Component

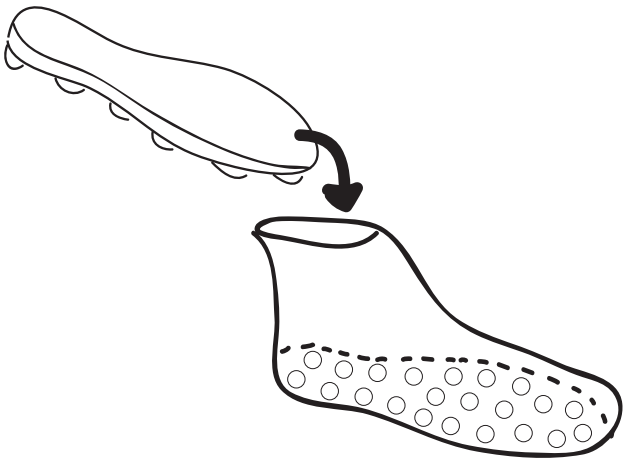
UPPER

It is also constructed by following the foot shape, the main function is to hold the feet to the sole. This part is where the style options will vary most

Exchangable
Versatil



3 The 2 surfaces are the elements that will compose the shoe



1.2 SKETCHING

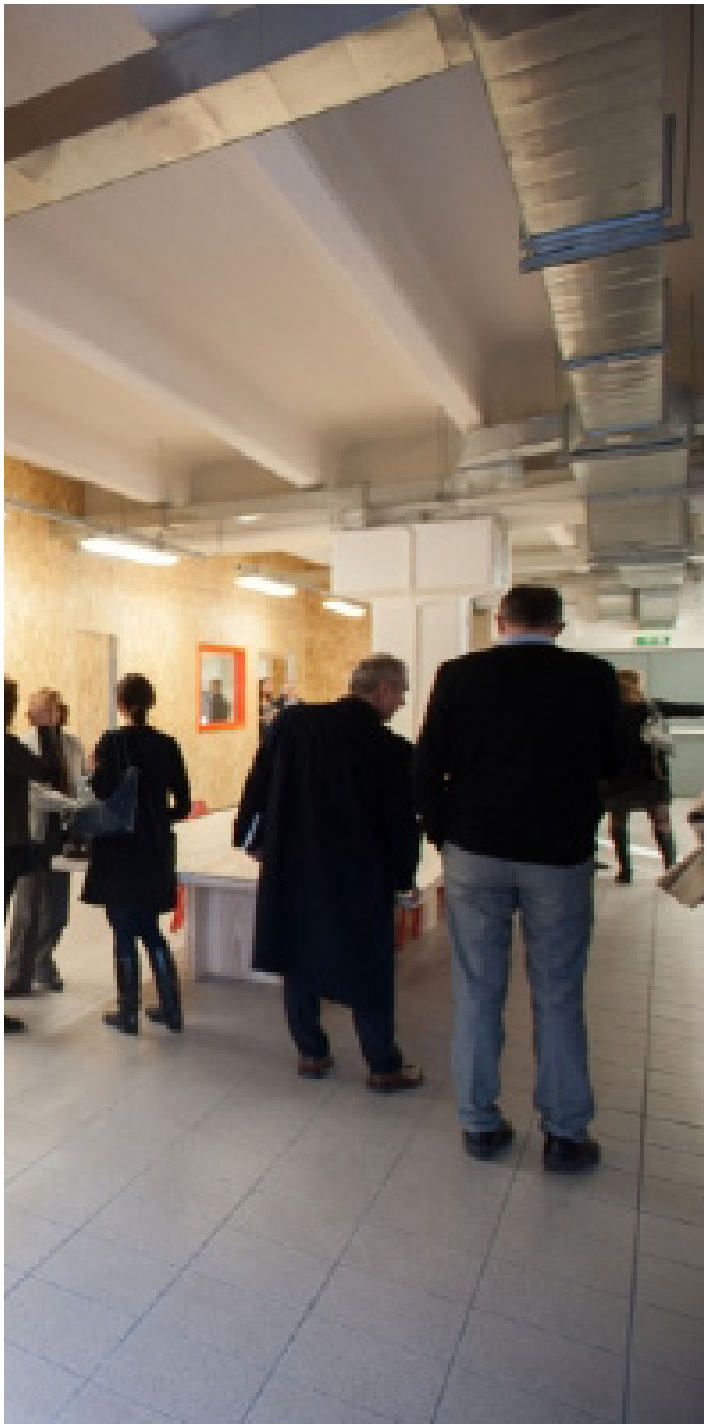
The design concept is explored in 2d, projecting the possible interaction between elements. The aesthetic is in this phase not defined, so there is a prediction by designer on how the system would through sketching.


- flexible
- barefoot
- waterproof

1.3 3D

A rough idea of the final result has already been created. The exploration of the concept is also done in a 3d level, getting to know the technic and general shapes of the foot and the most suitable CAD tools in order to achieve the desired final results.


POLITECNICO
MILANO
POLITECNICO
DI MILANO
WALL OF DONORS
POLIFACTORY
A PROJECT BY
DIPARTIMENTO DI DESIGN
DIPARTIMENTO DI ELETTRONICA,
INFORMAZIONE E BIOINGEGNERIA
DIPARTIMENTO DI MECCANICA
trotec
USM
XLAM
DOLOMITI

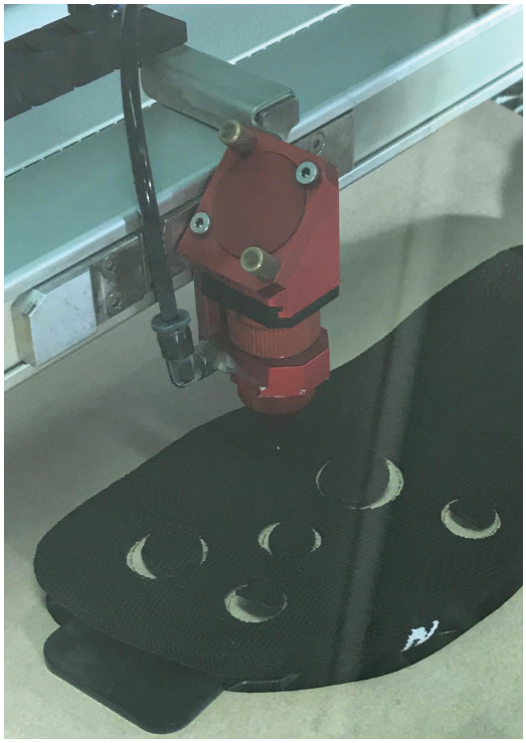


1.4 DESIGNING THROUGH MAKING

Polifactory is an interdepartmental research laboratory that explores the relationship between design and new digital manufacturing processes, promoting a new culture of making. An place where to investigate the possible future scenarios of advanced manufactory: from distributed production to open hardware up to high interactivity product-service design.
It is a container of services and activities designed to develop youngsters' multidisciplinary talent and their ability to materialize innovative solutions of product-services that integrate design and technology.
It is an avant-garde experience of the Politecnico in a matter of experimental training, research and firms consultancy.

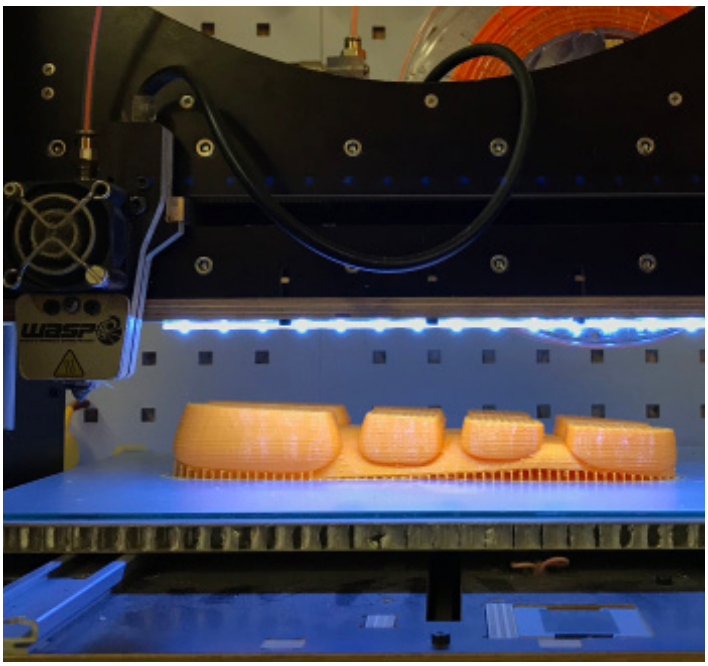
This phase of the project was done in collaboration with the space, receiving the support and guidance of the members of Polifactory. The experimentation phase is critical and the available tools, source and knowledge regarding technology defined the final results of the product.

SUBTRACTIVE

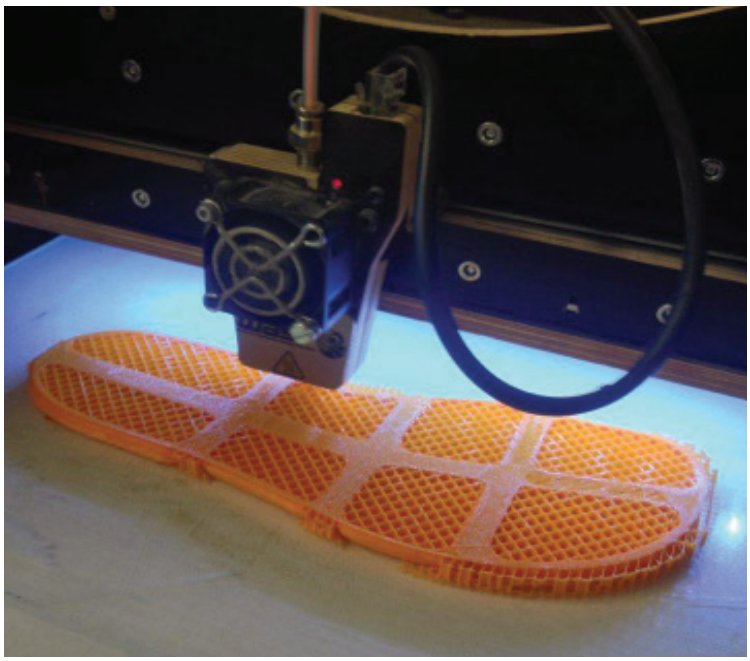


LASER CUTTER

Model: Trotec Speedy 300
Working Area: 40 X 70 cm
Workings: 2D cutting and engraving
Materials: synthetic-knitwear, neoprene

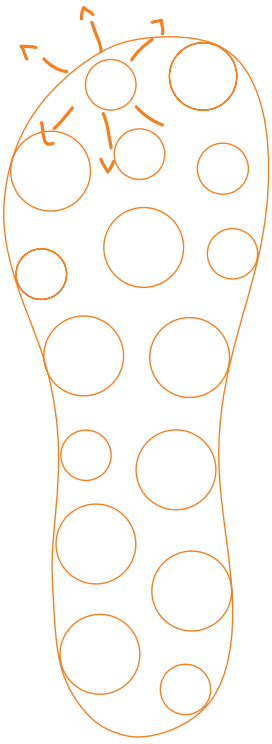


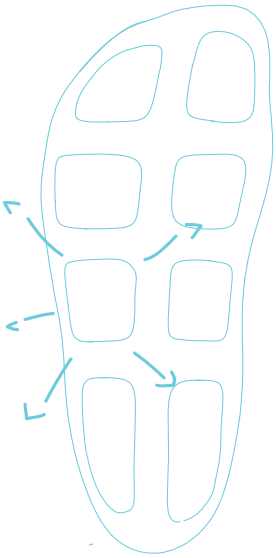
1.4.1 PROCESSES AND MATERIALS



ADDITIVE

PRINTER TYPE FDM
Build Volume: 26 x 19.5 x 19 cm
Material: PLA


circular shape
more uniform



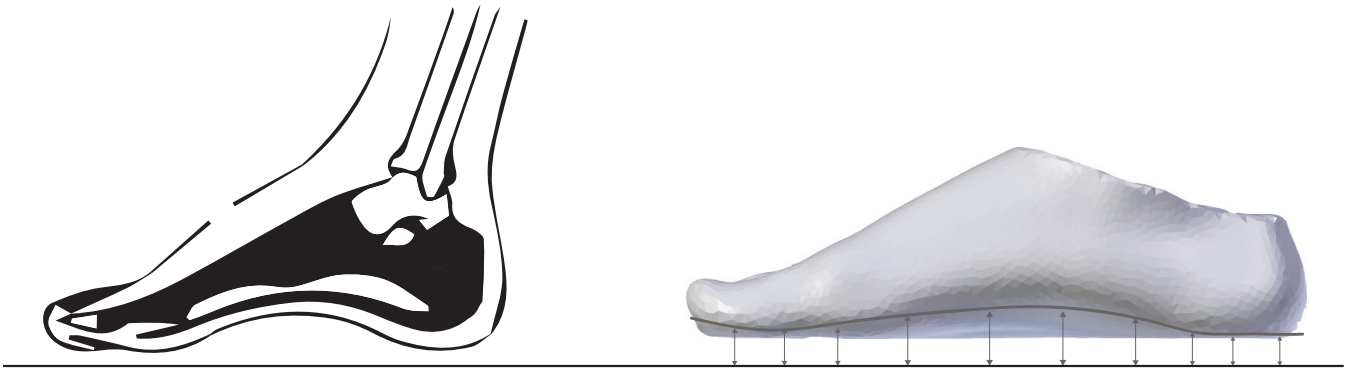
textil reaction
∴ Flexibility + shape

Two typologies of soles has been analyzed, rounded and squared-like. The idea was to analyze the response of the geometry characteristics of the sole in relation to the textile properties, to understand what is the relation that matches better between the pairs.

1.4.2 SOLE- TEXTILE INTERACTION

2 FINAL PROPOSAL

This projects propose to rethink the shoe, minimizing components and processes. Working with the observed and learned from the research and the experimentation phase in order to achieve a solution that uses in the most effective way the available sources and abilities of the designer and the context where this idea was born.



ARCH HEIGHT VARIATION

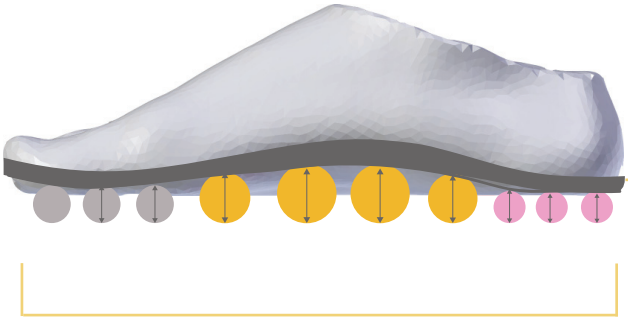
Each anatomival region of the foot varies on the distances between the floor plane and the plantar surface. This values depend on the caractheristics of each individual and the type of foot its has- plane foot- normal- high arch foot. The disposition of the arc in its natural shape helps to keep a streigth posture . The proposal in order to achieve this are two:

- to vary the diameters of the spheres to perfect match the plantar shape

-to compensate the height difference of the plantar with the insole surface and keep the diameter in one regular diameter

2.1 GENERATION OF MODULES

1



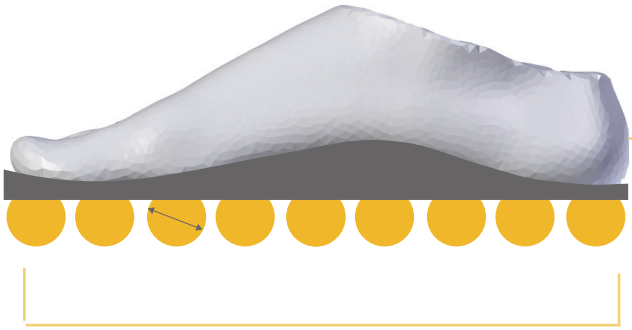
UNIFORM INSOLE

The exact copy of the plantar is given the proper thickness to act as a union element of the modules and as contact surface with foot

DIAMETER VARIATION

The modules will be distributed on the plantar surfaces, the diameter of the spheres will correspond to the height of each particular region

2

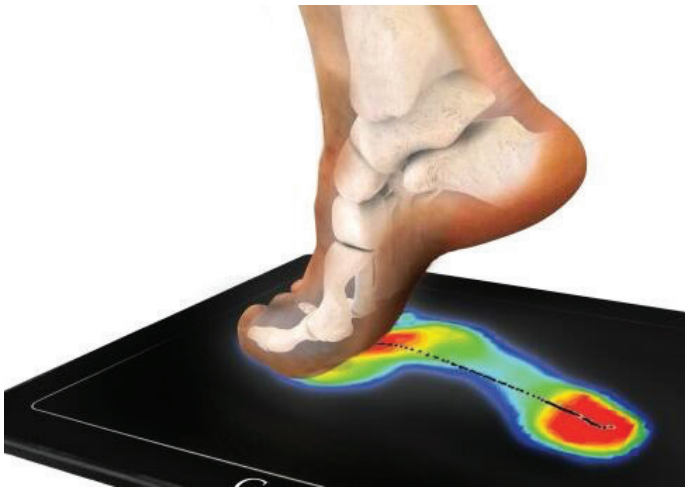


SOLE SECTION VARIATION

The exact copy of the plantar is extruded to a straight face., Compensating the difference between plantar and floor plane

UNIFORM DIAMETERS

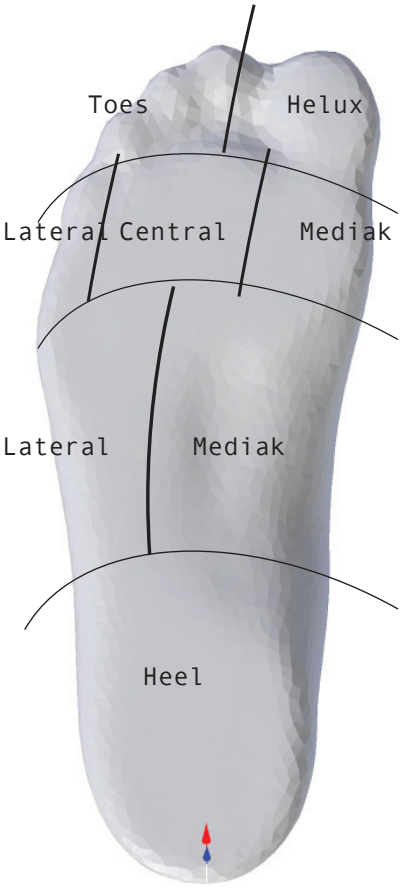
The exact copy of the plantar is extruded to a straight face., Compensating the difference between plantar and floor plane



PLANTAR LOAD DISTRIBUTION

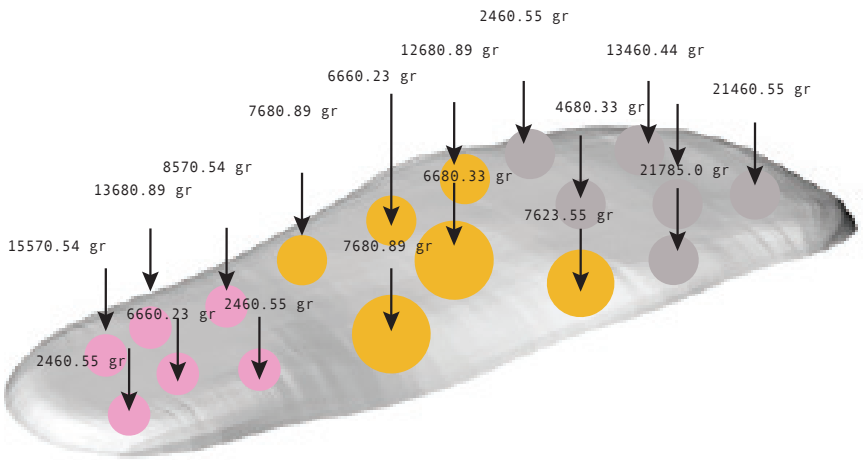
Barefoot load distribution characteristic differ from person to person due to a range of factors such as the variation in the walking speed, body weight, individual age, foot geometry and stride length. During normal stance, each foot carries about half of the weight at the heel, forefoot, and big toe whereas lowest plantar load is located under the mid-foot

FOOT ANATOMY ZONES



MAP PRESSURE LOAD

The plantar pressure analysis can provide data for the many different points of the foot that are involved in the gait cycle

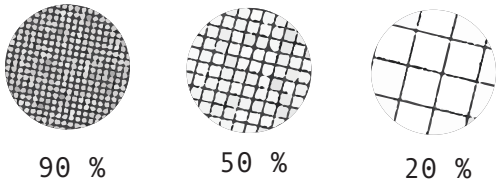


2.2 FOOT ANATOMY REGIONS AND PLANTAR PRESSURE

Opposite -top: *smart-insole-footpressuregaitanalysis.blogspot.com*

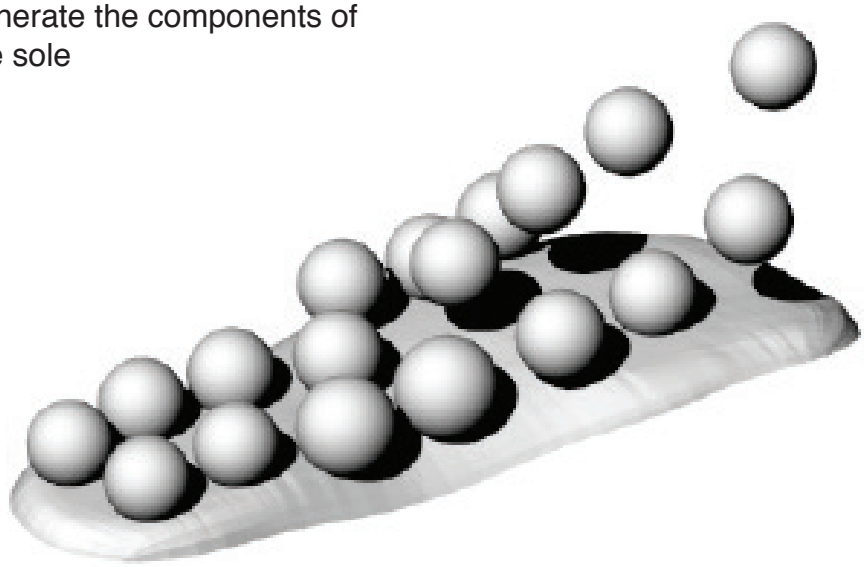
TOPOLOGICAL OPTIMIZATION
USING INFILL

The modular design allows to gain control of the pattern density on a per-region basis. Lower density will result in a lower contact area therein allowing for more horizontal movement. Using 3d printing we can manipulate the infill allowing more or less deformation to take place, making the material appear softer or harder in relation to each foot zone

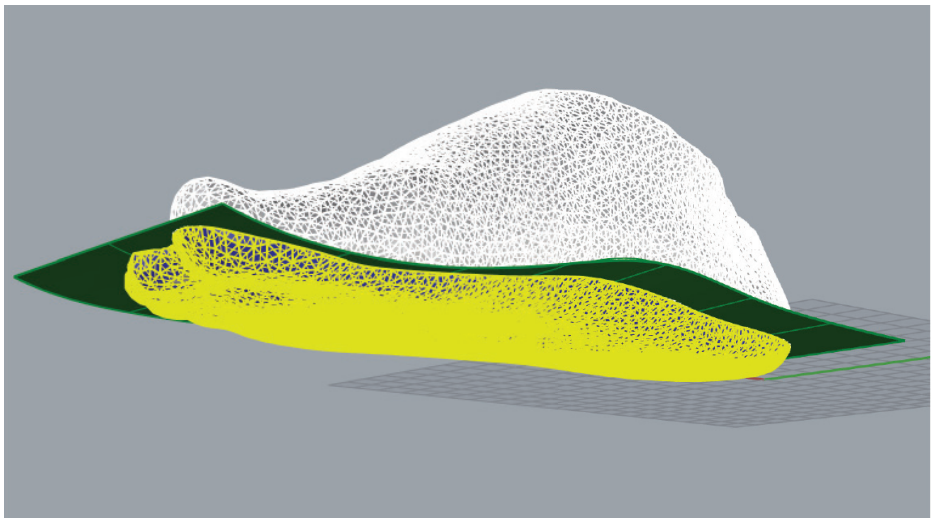


GEOMETRY RECONSTRUCTION

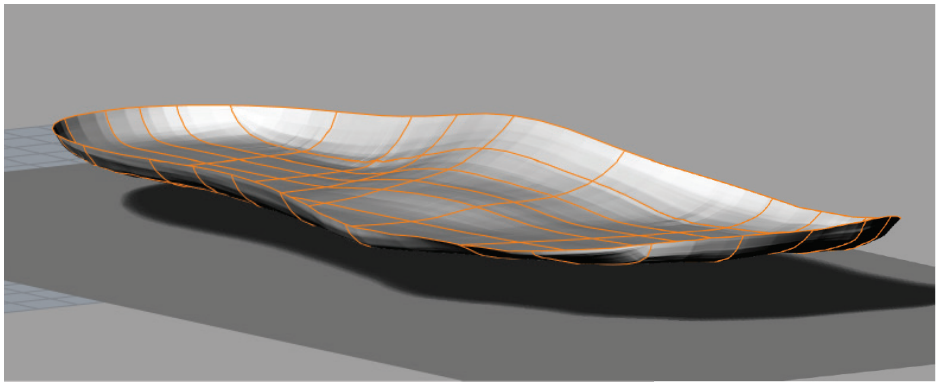
Having a per- region data , the modular design can follow the disposition of the pressure points in order to generate the components of the sole



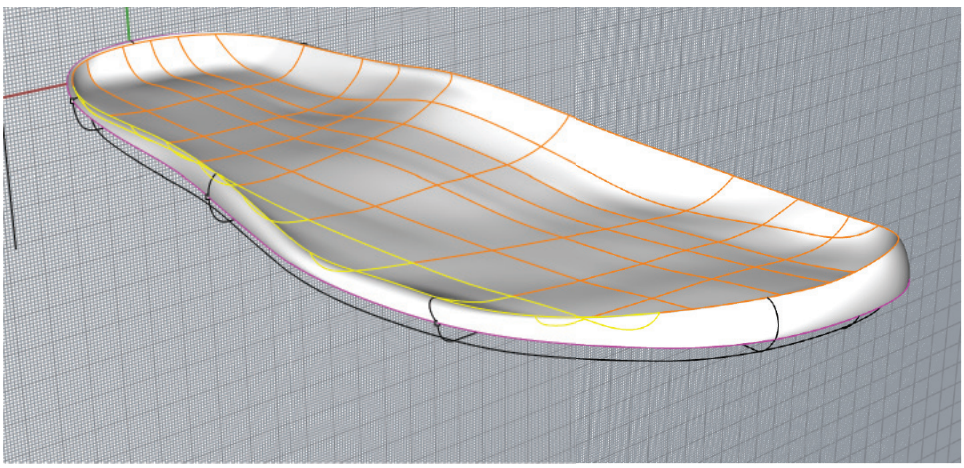
Extraction of the plantar area. The mesh .STL from the foot scan is passed to NURBS in order to be workable with Rhinoceros



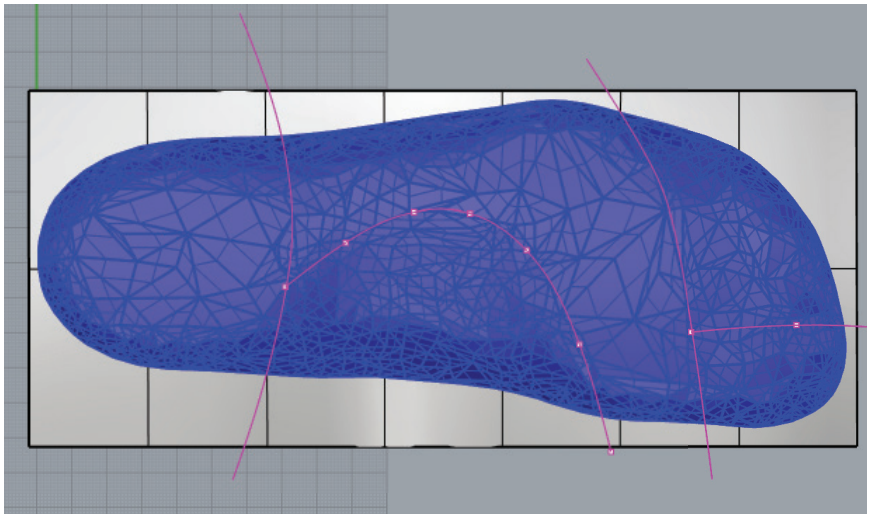
The raw surfaces must be reconstructed with new clean surfaces that allow designer to work

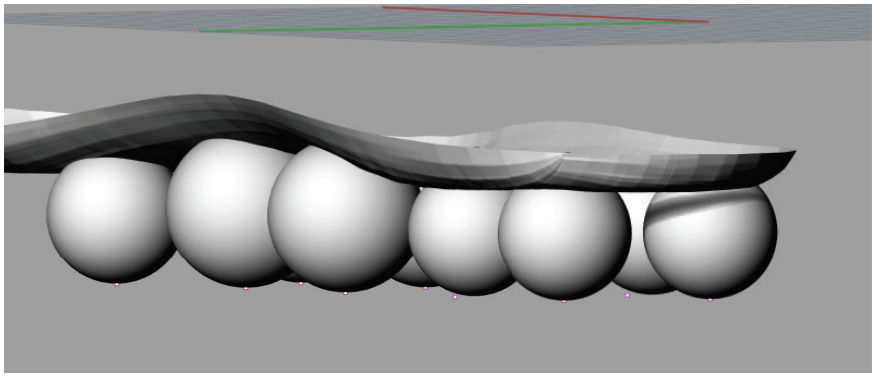


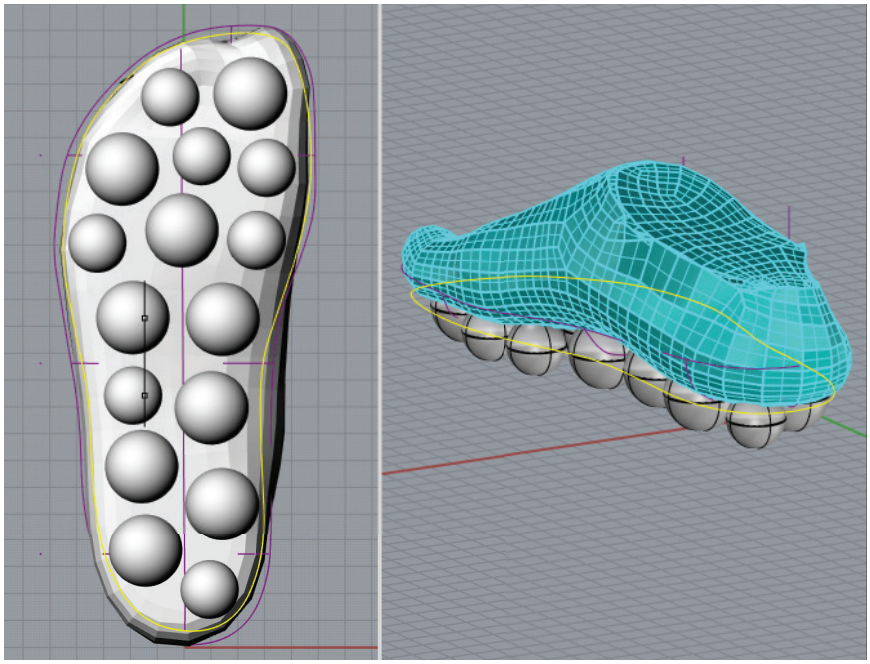
The reconstructed surfaces of the foot are now the starting point for the final model



2.3 3D DESIGN



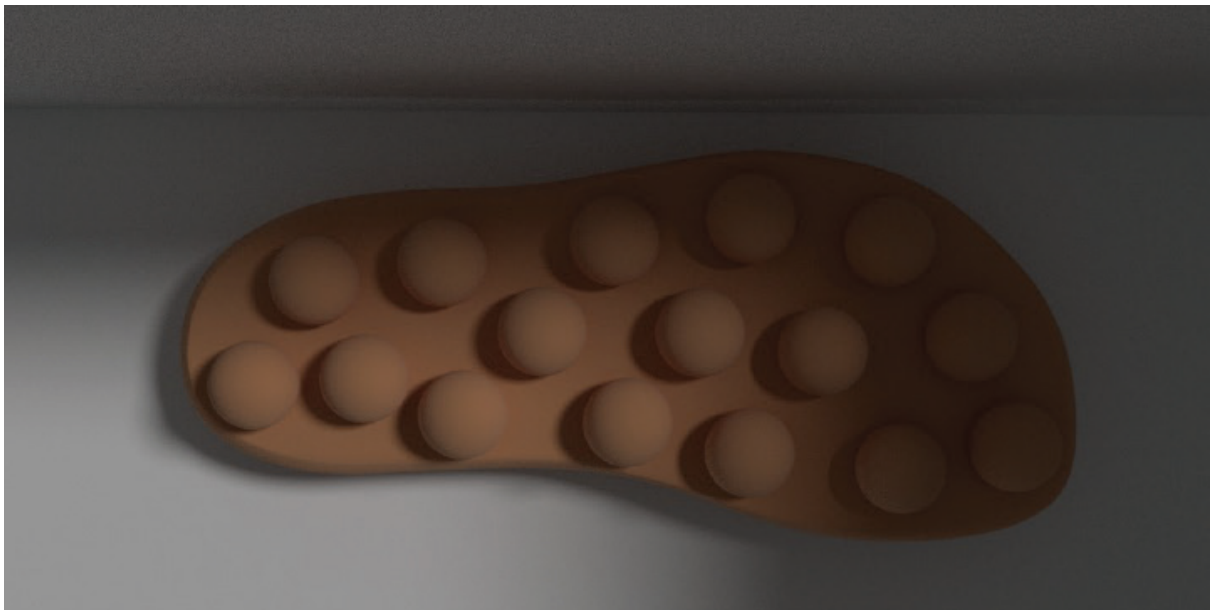


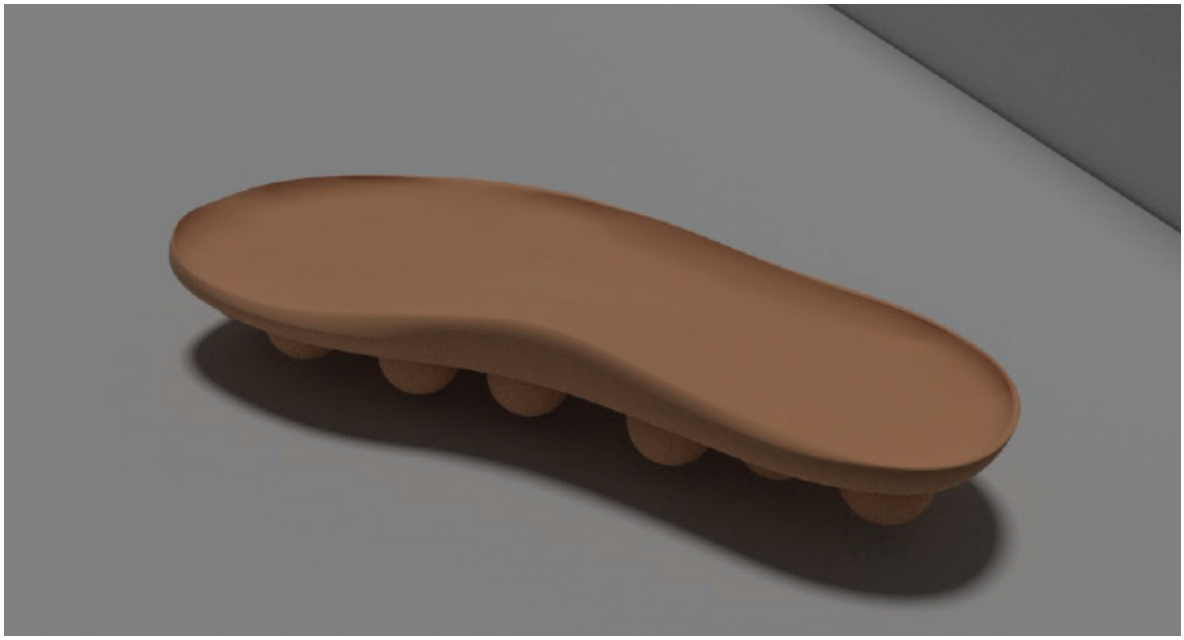


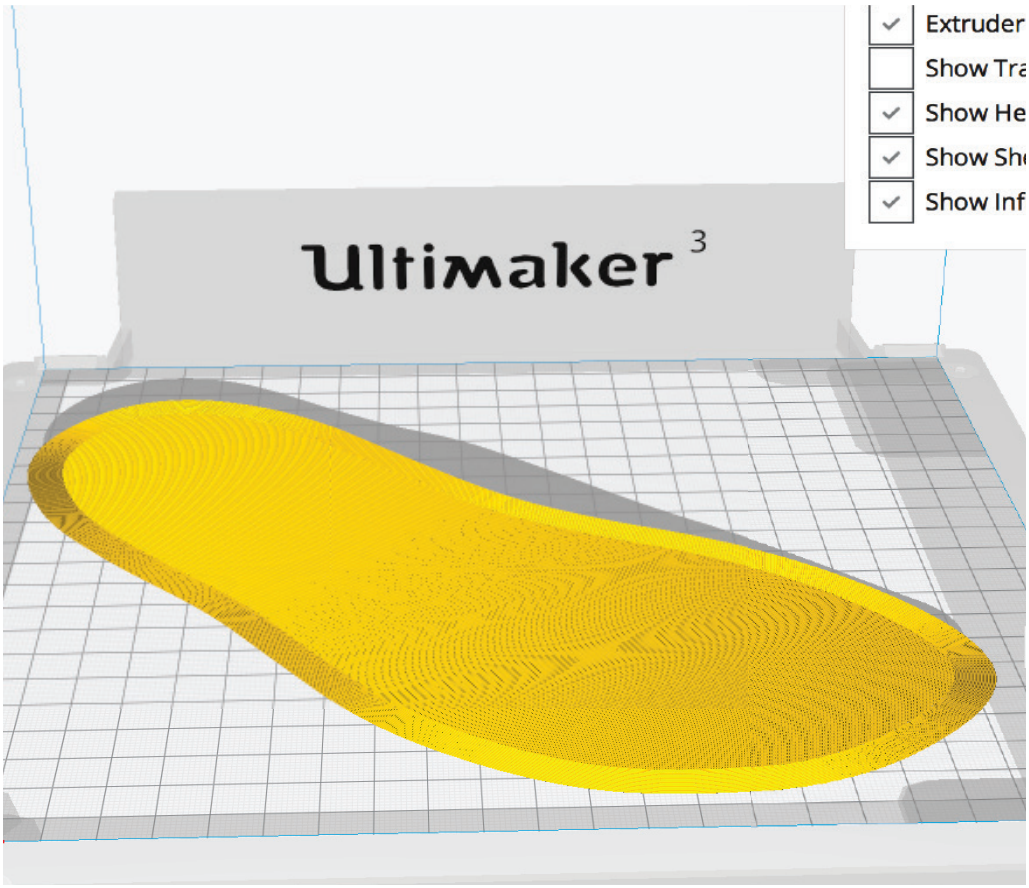
The location of the modules are done in relation to the studied areas from the plantar pressure map. Diameter of the spheres would affect the height of the sole and the final quantities of modules

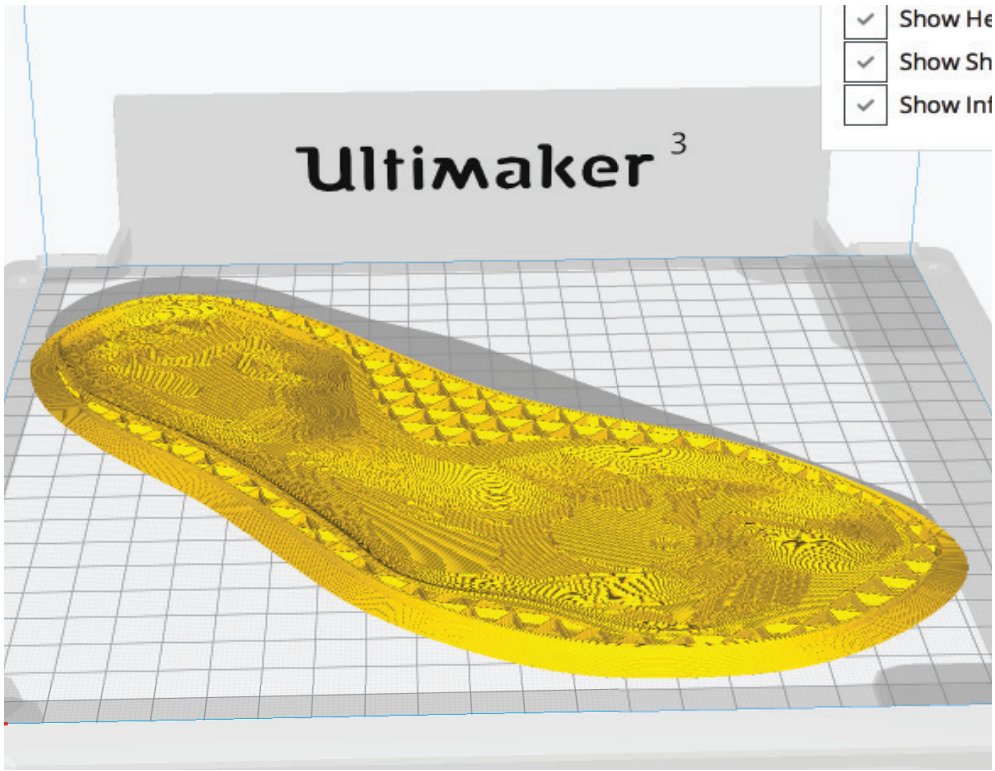
2.4 FINAL MODEL

At this stage , the quick render of the model permits the designer to generate a better idea and plan the final prototype



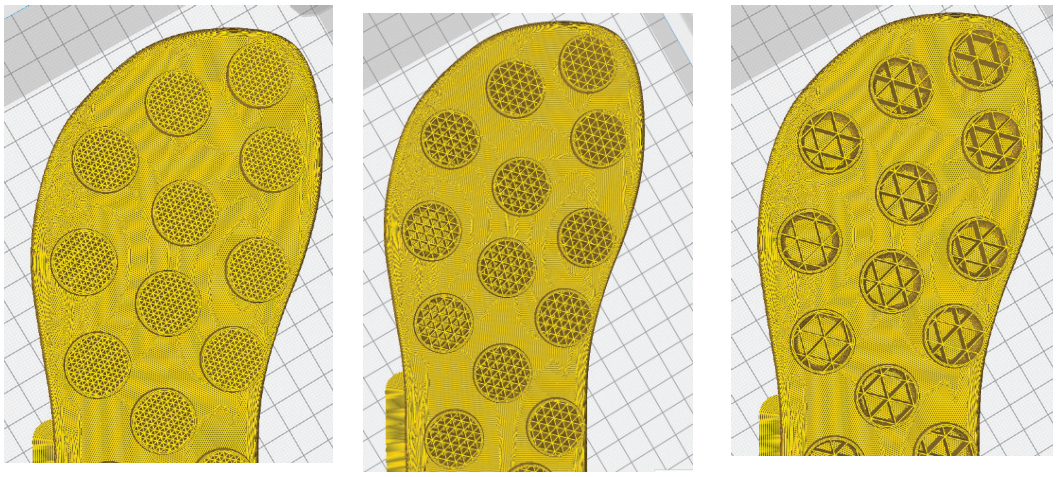


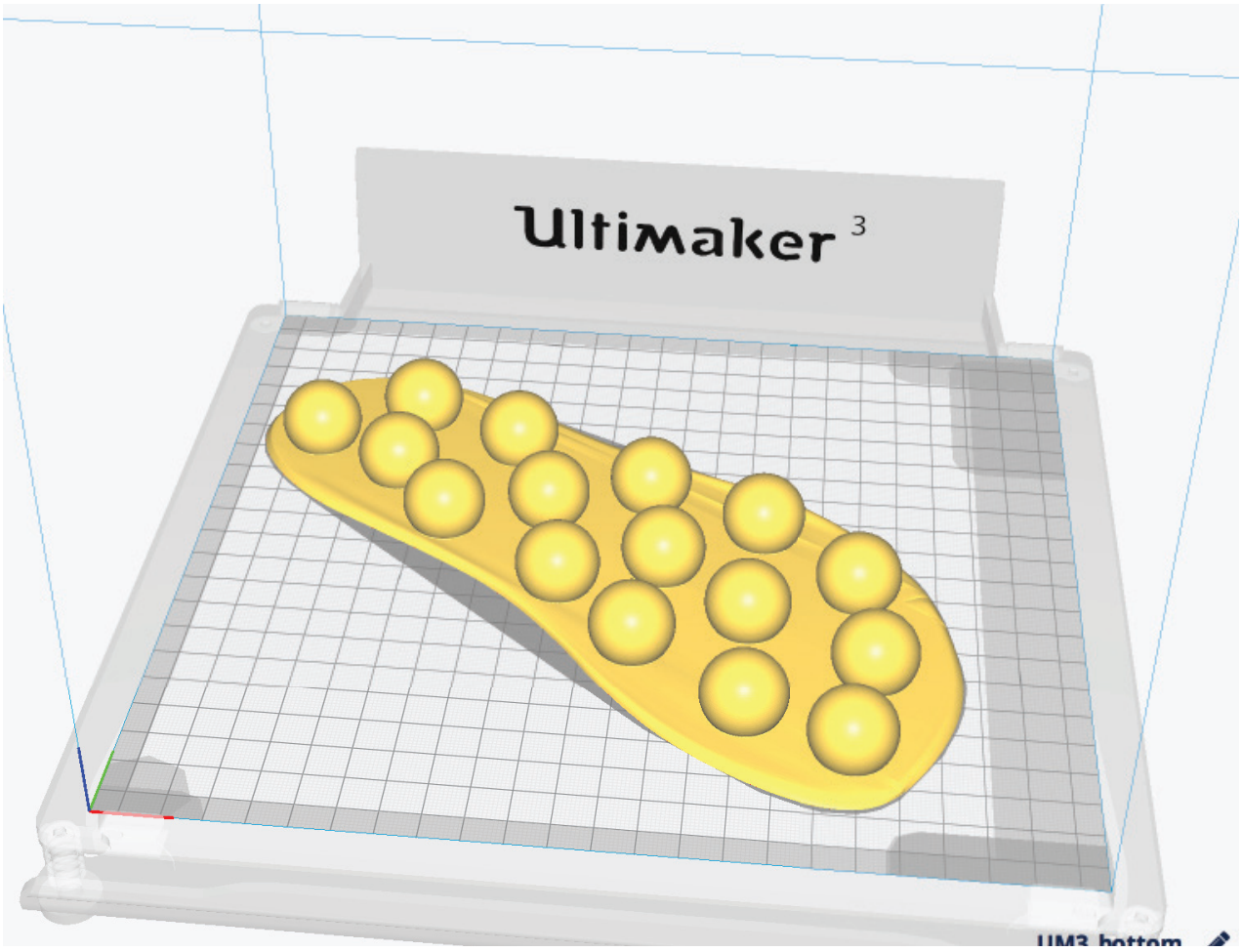




The final design must be adapted to the desired 3d printing process. In this case, a cut in half was done in order to have better final results

2.5 3D PRINTING





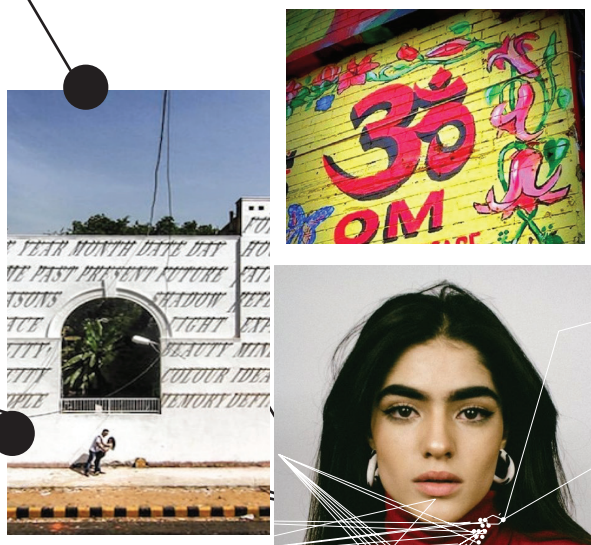
DIGITAL CITIZENS

We are citizens of an hyperconnected world, one in which we believe to know everything about each other.GPS to move,low cost flights to reach other continents, video chat to immediately communicate , and so on, Seems that we have all sources to create and move forward,

But in this accelerated peace we may get lost in the crowd, converted into codes, numbers,labels. Virtual and physical seem to mix each other, truth and fake is hard to difference.

But technology can also help us to know ourselves better and to celebrate our individuality. This project is a fusion between physical and digital,individuality and customization, unique and common-less.

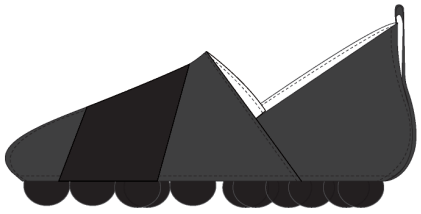
The ultimate technologies and tools for designers are applied into a generation of products that are unique for each person .

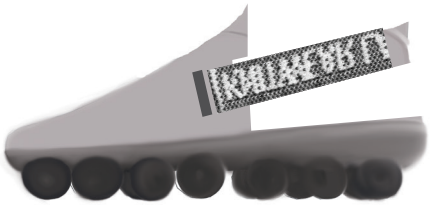


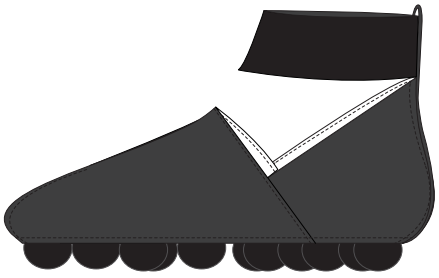
2.6 DIGITAL CITIZENS

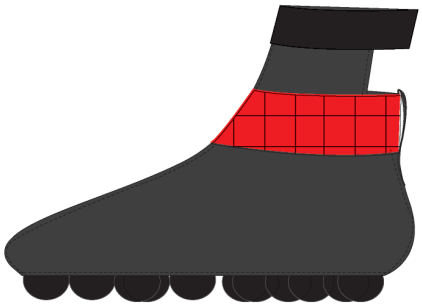
2.6.1 FINAL PROTOTYPE

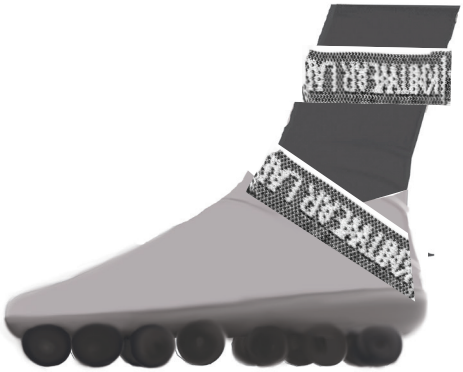
2.6.2 VARIANTS

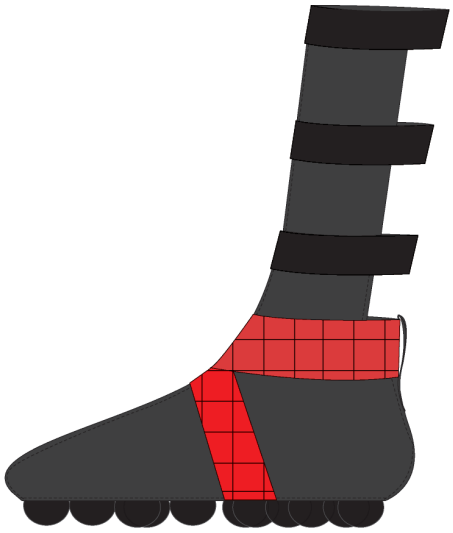






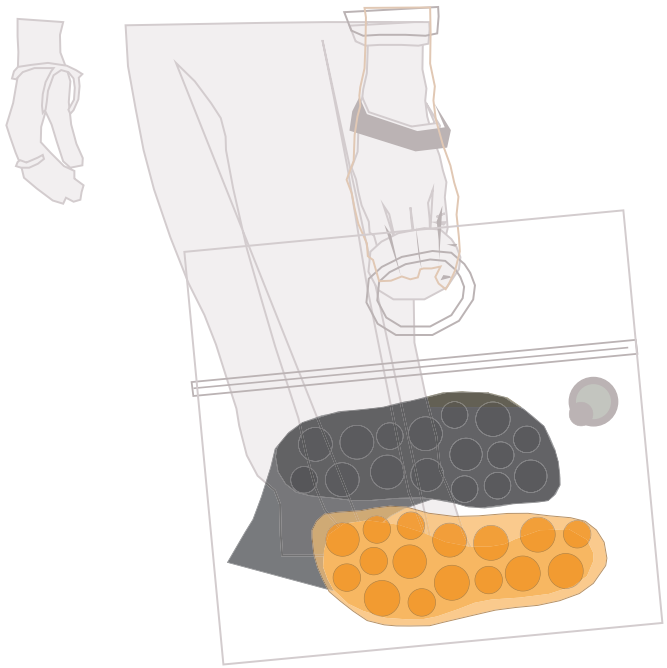






FOOT SCANNER — PLANTAR PRESSURE PAD — SELECTION OF MODEL

6.3 RETAIL AND MERCHANDISING



ORDER READY

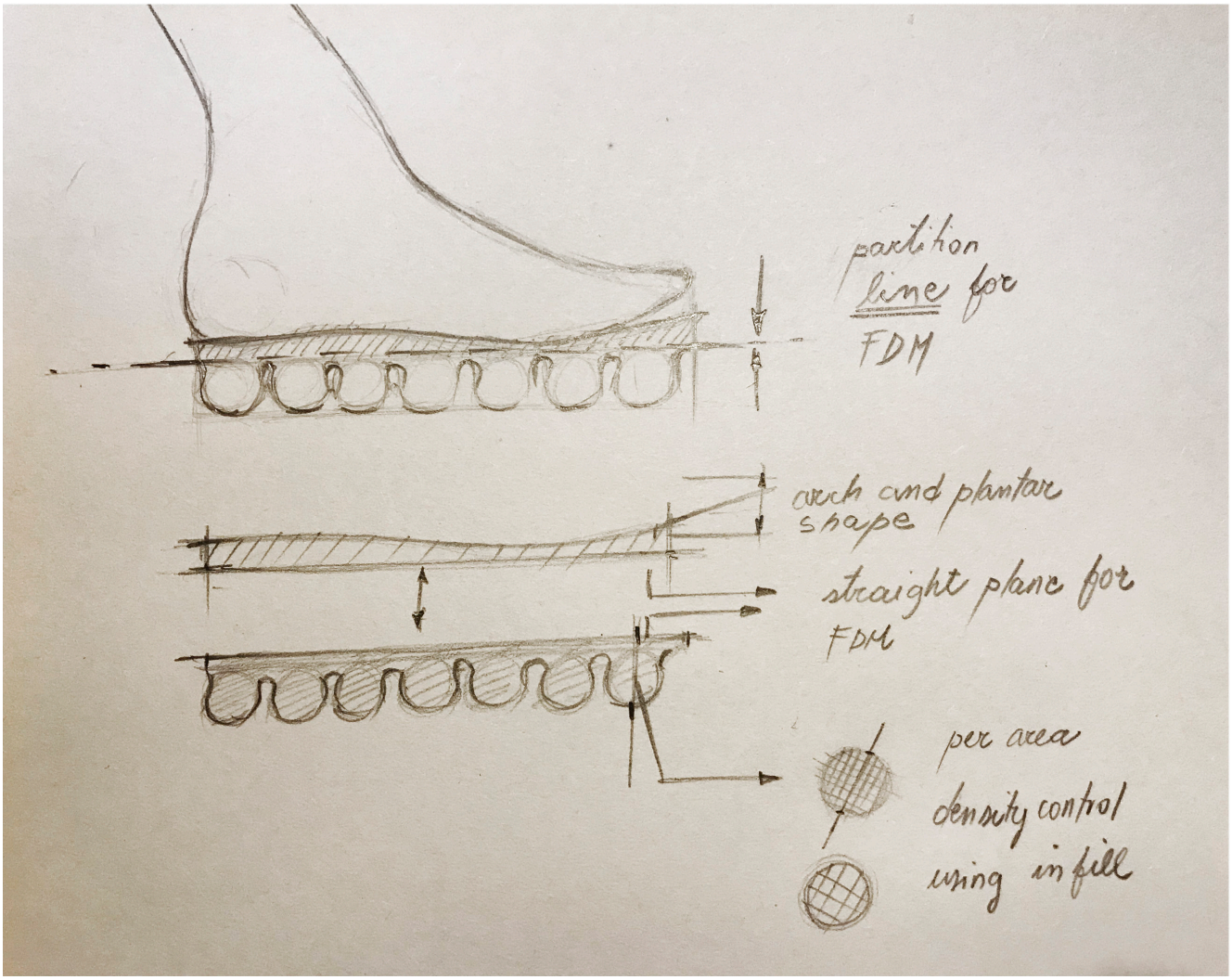
The temporary stores would be located in strategical points around the city. The customers could have their foot analyzed, starting with a foot scan and followed by the plantar pressure analysis. After the individual data is obtained, the 3d printing of the sole starts.

The design of the sole is different for each individual since the spheres would be relocated according to the foot shape and the infill reflects the pressure of each area of the foot. The client can choose the color of the material for the sole, and there will be a number of options for the upper.

The sole would cost around EUR 150, having the possibility to combine with any of the upper models, that will be around 50 EUR

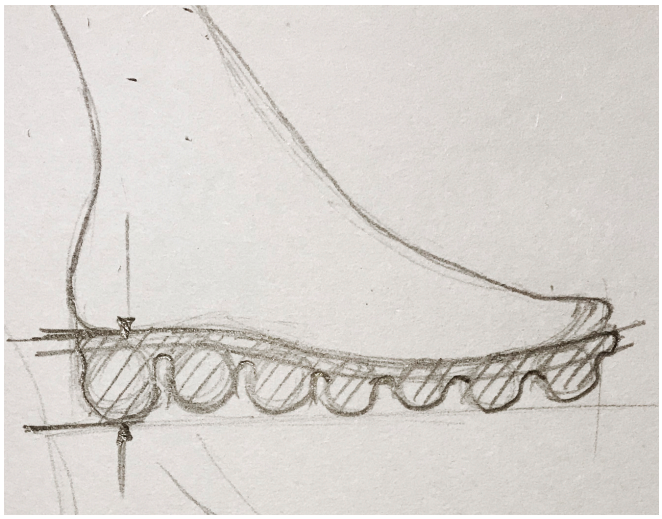
The customer journey starts at the pop up store, where the client could get data about themselves, the foot data analysis takes around 10 minutes. The configuration of the shoe will follow, and the order is done. The 3d printing process can take around 8 hours, so the delivery of the order would take 3 to 5 days.

The design and development of this project has been followed and guided by the experimental prototypes done with fused deposition modeling as the main manufacturing process. The 3D model of the sole has been evolving according to the necessities that this particular technique has. Because of the complexity of a design that is configured according to each person´s feet, the use of generative design would be a good choice in order to make the whole process efficient. In order to produce a whole sole without the need of partitions and with a much higher quality, the techniques of SLS, SLA or the one presented by the Easy Jet Fusion by HP are to be considered as a replacement of the more accesible FDM.



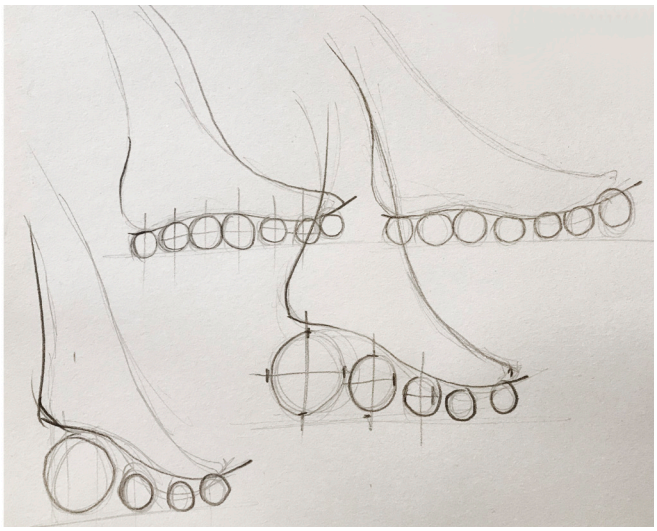
2.4 FURTHER DEVELOPMENTS

3D PRINTING TECHNOLOGY



A more advanced 3d printing technology as the SLS or SLA, would permit the generation of complex shapes and a high quality material and performance during the product cycle

GENERATIVE DESIGN



The implementation of generative design in this project could permit the the adaptation of the spheres diameters according to the foot shape of each particular case, as well as the desired heel height of the shoe.

PAPERWORK

´Identification of Foot Pathologies Based on Plantar Pressure Asymmetry´- Linah Wafai, Aladin Zayegh , John Woulfe , Syed Mahfuzul Aziz and Rezaul Begg -

Tecnologie per il manufatturiero moda avanzato / dottorando Viola Chiara Vecchi; relatore Paola Bertola. Milano : Politecnico di Milano, 2010

3D printing. The Next Technology Gold Rush. Future Factories and how to capitalize on distributed manufacturing, by Chritopher D. Winnam

Fashion Design Course: Accessories. Design Practice and Processes for Creating Hats, Bags, Shoes and more. Thames and Hudson

Handbook of footwear design and manufacture, The Textile Institute. Edited by A. Luximon, 2012

3D Numerical Modelling and Manipulation of a Shoe Last, Olga V. Gordeyeva, 1998

DIGITAL WORK

MySize.shoes: Individual Fitting for (Virtual) Footwear Retailing, Building a link from 3D CAD to Industrial Made to Measure-Andrey Golub,Taira Colah, ELSE Corp SrL

BIBLIOGRAPHY

LINKS

https://www.shoesofprey.com/shoe/7jBL3I

https://trya.it

http://www.likecool.com/3D_printed_XYZ_shoes--Shoe--Style.html

https://cargocollective.com/earlstewart/XYZ-SHOE

https://www.dezeen.com/2014/09/26/francis-bitonti-interview-fashion-technology-3d-printing/

http://news.mit.edu/2017/data-driven-3d-printed-midsoles-jessica-rosenkrantz-0302

https://feetz.com

https://www.nytimes.com/2016/09/15/business/smallbusiness/your-next-pair-of-shoes-could-come-from-a-3-d-printer.html?_r=3

https://feetz.workable.com/j/847A889522

https://www.businessoffashion.com

https://3dprinting.com

http://www.stratasys.com

http://interlaced.co/project/3d-printing-innovation-in-fashion/

http://news.mit.edu/2017/data-driven-3d-printed-midsoles-jessica-rosenkrantz-0302

https://www.wired.com/2016/04/new-balances-prototype-3-d-printed-kicks-will-set-back-400/

https://medium.com/@Tech_Charles/3d-printing-sensors-ai-shoe-insoles-8edba248126a

https://www.sq-lab.com/en/sqlab-ergonomics/the-foot/foot-pressure-mapping.html

http://www.outdoorsports.com/posts/superfeet.aspx

https://www.fitstation.com/

http://charlesfried.com/assets/charlesfried_thesis_pparp.pdf

https://design.mit.edu/projects/puma-biodesign

https://n-e-r-v-o-u-s.com/projects/sets/floraform/

https://www.footwearists.com/innovation-conferences

https://www.develop3d.com/blog/2017/09/hp-launches-new-3dprinted-footwear-solution-ties-with-siemens-nx-fitstation

AGOSTINA ISSOLIO

Master's Degree in Design for the Fashion System
A.A 2017/ 2018
School of Design

Tutors:

Prof. Alba Cappelieri
Prof. Viola Vecchi

Developed in Collaboration with Polifactory