Fashion Tech

Education and research

BENCHMARKING REPORT

E4FT
Education For FashionTECH

Erasmus+
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E4FT
Education For FashionTECH

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EDU4Fashion-Tech
Interdisciplinary Curriculum for Fashion in the Digital Era

ERASMUS+ programme, 2017

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The benchmarking report is a foundational intellectual output that aims at describing the state of the art of Higher Education programs and other high-qualitative didactic experiences, Research Centers and Companies. The benchmarking report maps players active in the field - in Europe and worldwide -, identifies the best practices and reads current and upcoming trends in the fashion-tech field.
Trough a desk research complemented by face-to-face and long-distance interviews, the benchmarking report offers a broad overview of processes, resources, tools and contents characterising the current fashion-tech offe .

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EXECUTIVE SUMMARY

This report is the result of a benchmarking research for "**EDU4Fashion-Tech project: Interdisciplinary Curriculum for Fashion in the Digital Era**" project. It is a foundational intellectual output that aims at describing the state of the art of Higher Education programs and other high-qualitative didactic experiences in the field of fashion-tech, and the activities of Research Centers and Companies in such sector, to elaborate design directions and suggestions to build up a fashion-tech curriculum.

The benchmarking report maps players active in the field, in Europe and worldwide, through desk research complemented by face-to-face and long-distance interviews to HEIs, research centers, and companies. All data have been collected, compared, and mapped following a qualitative analysis.
This report offers a broad overview of processes, resources, tools and contents for Smart Textiles, Wearables, and Digital Manufacturing which characterize the current fashion-tech offe .

This analysis underlines fashion-tech as a fragmented, disjointed reality that involves and activates various and heterogeneous professionals, disciplines, competences, methodologies, trends, products, and applications.
For this reason, it has highlighted the need to better understand the meaning of the three main areas of Fashion-Tech --Smart Textiles, Wearables, Digital Manufacturing-- and to create a shared and more comprehensive definition

Wearables are on body products such as clothing, footwear, accessories and jewellery designed to create a communication/interaction enabled by technologies (such as digital and virtual) to amplify and extend natural ability and performance of the human body, or add new functions to the user connecting him with his body, with other persons or objects and with the environment.

Smart Textiles are knitted, woven, non-woven fabric systems designed to sense and response to external stimuli (mechanical, thermal, chemical, biological, magnetic and electrical) enabled by advanced, physical and digital technologies.

Digital Manufacturing is an integrated approach to manufacturing that is centered around a computational system using tools such as 3D technologies, robotics, AI and AR and the integration between digital technologies for manufacturing processes and embedded digital technologies in products-services (IoT) to enable open and distributed manufacturing that can reshaped design, production, distribution and retail processes. The extent of applications ranges from large scale industrial systems, industry 4.0 and DIY/ mini and microfactory up to digital service platforms and bottom up innovation processes, on-demand manufacturing, collaborative and on-site manufacturing (fab-lab and maker space), and repairing and remanufacturing systems.

Combining desk research and results of the interviews, this report also provides an overview of current researches and emerging topics.
In particular, 5 macro areas emerged as representation of possible directions for the future development of the fashion tech sector:

1. <u>Protection and body enhancement through artificial second skin</u>: wearables and smart textiles with embedded sensors are able to monitor physiological, neurological and body kinematic parameters that are critical for healthcare.

2. <u>Culture driven wearable: art, technology and innovation</u>: generating thoughts and knowledge around human behaviors, interaction with the body, other people and the environment.

3. <u>Hyper-body: connecting senses and materials</u>: involving three of the five senses (eyesight, hearing, touch) enhancing or "substituting" the

4. <u>Fashion takes care</u>: sustainability across design, production and retails covering the entire supply chain and it is intended as efficien , recyclability, transparency, mission orientation and ethical upgrades.

5. <u>Real/Virtual mixed environments</u>: analogical/digital places created and customized with mixed reality as result of the addition of virtual and augmented reality; new dimensions for self-assembly and programmable materials; artificial intelligence for all the supply chain.

According to the fast pace and variability of the fashion-tech field, the report describes its contemporary state of art and its hidden opportunities. In particular, a design-driven perspective, human-centered and processes-driven, has a central role in the evolution of fashion-tech both in the development of specific approaches and in the creation of new and shared knowledge among involved actors and sectors.

We hope you will enjoy the reading and will engage in a dialogue with us on the proposed topics to enrich this research and start further collaborations.

FOREWORD

The University of Boras - Swedish School of Textiles, Politecnico di Milano – Dipartimento di Design and University of the Arts London - London College of Fashion have started a strategic partnership for higher education within the novel field of Fashion-Tech. The project is called "Education4Fashion-Tech: Interdisciplinary Curriculum for Fashion in the Digital Era", it started on the 1st of September 2017 and ends on the 31st of August 2020. The project is financed by the European Union through the Erasmus+ action KA203 - Strategic Partnerships for higher education.

The aim of EDU4Fashion-Tech is to bridge the fashion field with that of innovative technologies by creating a new training pathway to improve the level of key competencies and skills of students and trainers, and to break down barriers between technologists and creative communities and build meaningful collaboration. The objectives of the project will be achieved through the delivery of: intellectual outputs; learning, teaching or training activities; and multiplier events.

<u>The specific targets of the p oject are:</u>

- Development of digital capabilities next to design skills (3D virtual design & prototyping, AR/VR, HMI, coding embedded in the design process).
- Enhance craftsmanship skills hybridizing them with digital manufacturing.
- Technological insights enabling designers to work with scientists, computer-engineers and biologists in order to develop and innovate for material, products or manufacturing processes to invent new applications.
- Equipping designers with collaborative design and innovation capabilities to deliver more effective ways of developing disruptive products and product/services.
- Mastering co-creation and user-driven innovation processes.
- Strengthening capabilities to interpret socio-technological trends, consumer insights and narratives.
- Industrially relevant transferable skills necessary for innovation management and product development.
- Enhance creativity and innovation, critical thinking and problem-solving, communication and collaboration (21st-century skills).

State of art

Analysis of the intersection between fashion and technology in:

- *measuring*
- *designing*
- *producing and testing*
- *embedding*
- *communicating*
- *retailing*

From design to retail, from product to communication, fashion and technology are interconnected and the shift from craft to industrial production, from analogue to digital involves all stages of the production process, improving them and making them quicker and more efficient.

STATE OF ART

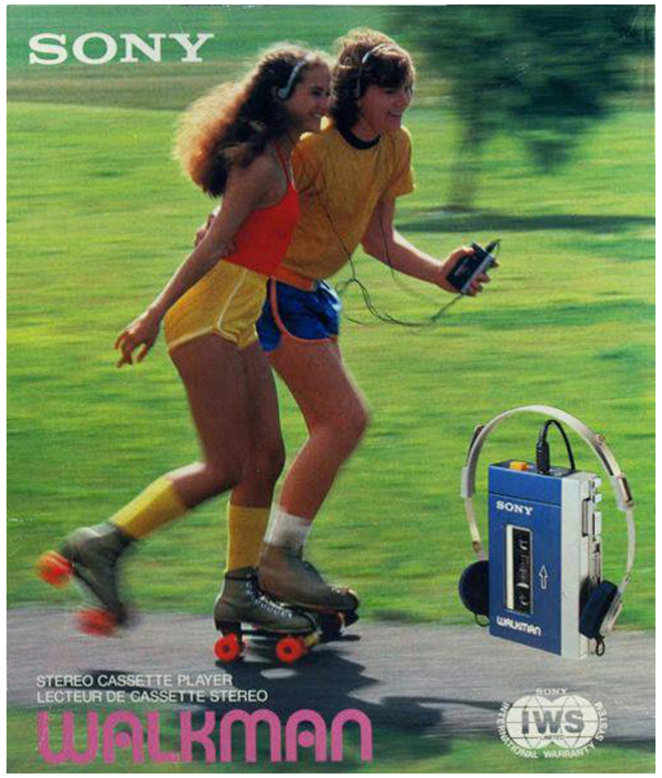
Fashion meets technology

Over the years, fashion and innovation have often come to collide, growing closer and contaminating one another in attempts at testing each other's limits, guaranteeing better performing products or systems, essentially to improve one another. In history, technological innovation reached peaks of progress identified as industrial revolutions and, interestingly always presented some connection with the fashion world. The first industrial revolution, between the end of the eighteenth century and the beginning of the nineteenth century, deeply changed the textile sector, not just for the invention of the Jacquard loom that significantly sped up production times, but also for the birth of a new industrial model aimed at homologation and ready-made garments. Production became quicker and by consequence changes too experienced acceleration. (*Tenuta L., Futures for fashion, 2017*)

With electric power stations and light bulbs, the product of the second revolution, the activity of the industrial machines had increasingly growing rhythms and once again fashion was directly involved. The new chemical techniques and the invention of steel introduced less costly materials: mechanical weaving accelerated the production of fabrics, as well as the print of patterns with industrial pigments; corsets and underskirts were no longer reinforced by whalebones but by metal rods, and were easily reproducible in series. The shift thus involved the product just as much as the process. The third industrial revolution that began around the 1950s brought further developments in electronics, telematics and information technology. It is hard to establish its exact beginning but it is widely agreed that the year 1947 can be taken as a marker for the moment in which technological development underwent significant acceleration. This is when the first transistor was born, the father of all the technological devices that would later reach the mass market.

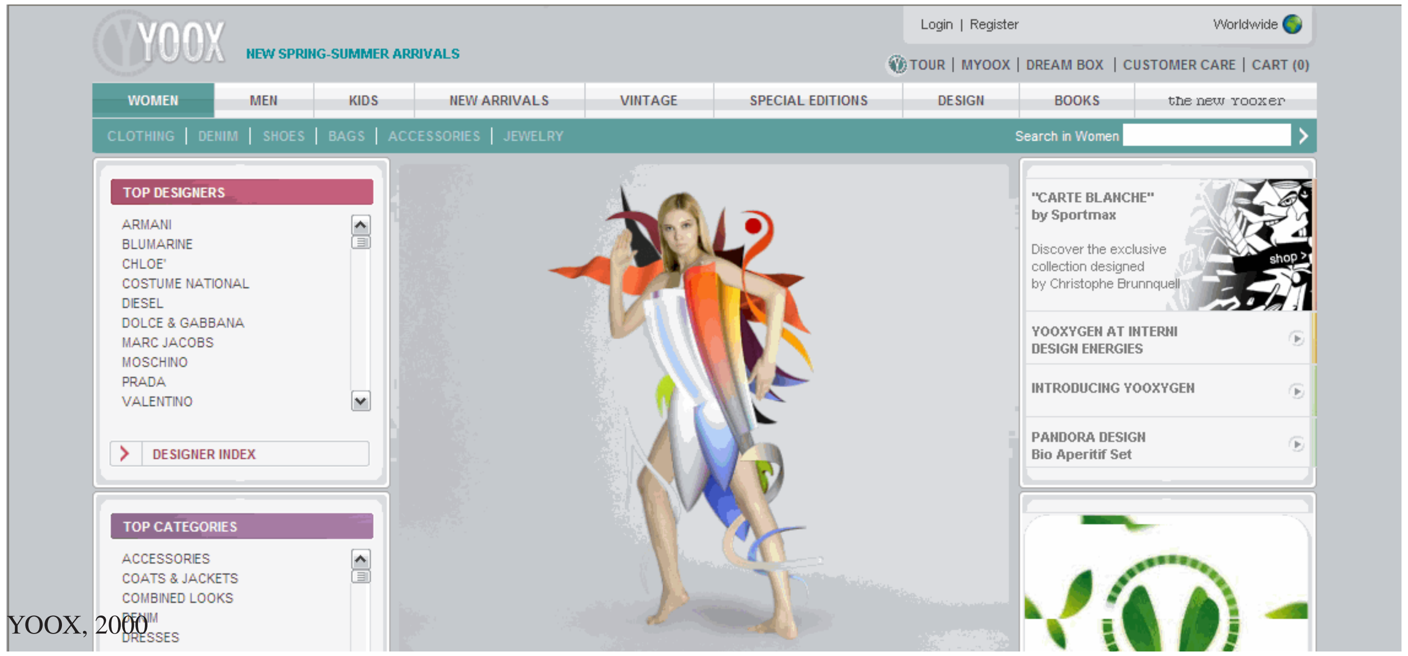
Immediately after in the 1950s, the radio, the television and the cinema all had their boom and also became the means through which fashion indirectly communicated. These were the years of James Dean wearing dark blue jeans in Rebel Without a Cause and Marlon Brando in The Wild One wearing button fly Levi's 501s that all young Americans started to long for. Communication had become immediate, transportation increasingly fast and a new frontier was opening up to man: the universe. The 1960s and the space age – with the race to space that followed the launch of Soviet satellite Sputnik 1 – are the years when information reaches people simultaneously and continuously (*McLuhan M., The Medium is the message, 1967*). This ferment is absorbed by fashion in the form of formal and material inspiration. In 1964, André Courrèges launches his Moon Girl Collection, followed by Couture Future, Hyperbole and Prototype. Not only are stylised stars and moons everywhere but also the materials have an avant-garde taste, and so do the fashion shows, leaving the atelier in favour of extra-modern films set in the symbolic locations of Paris, or innovative scenarios borrowed from films such as Stanley Kubrick's 2001: A Space Odyssey.

This sci-fi trend will make a comeback in the 1980s, accompanied by the explosion of artificial materials – though these were patented some years earlier, the first wearable technologies, Walkman, and transportable, such as mobile phones and portable computers, in parallel to the boom of the internet. With the birth of the computer, industrial machines make way for intangible goods, with the shift from hardware to



Walkman advertising, early 80s

Andre Courreges, Moon Girl collection, 1964



YOOX, 2000

software. (*Dery M., Escape Velocity: Cyberculture at the End of the Century, 1996*). By this point, the IT revolution was no longer the domain of only the research subculture; as Bill Gates had predicted, by then computers were on everyone's desks. In the fashion world, they were beginning to be used to design and colour garments, as the first brand websites appeared.

The 1990s are the years of the Internet and the web is increasingly seen by advertisers as a tool to help with the publication and spread of content. This invention has an impact similar to that of the printing press thanks to its democratisation. Widespread access to technology leads to a significant reduction in costs and to the shift to the new economy that produces a demand for technological innovation and optimism about technology-driven progress. These are the years in which Andrew Feenberg, a key thinker in the philosophy of technology, publishes Questioning Technology, in which he claims that the democratisation of technology has the effect of attributing new meanings to technological design. As inclusivity grows, the user, Feenberg maintains, becomes the designer and directly intervenes in the process, anticipating the contemporary DIY trend. Another great revolution comes in the first decade of our century: the birth of social networks, along with that which Henry Jenkins has defined participatory culture, which becomes a communication tool for fashion, alongside fashion blogging and the spread of platforms for the sale of products online, such as YOOX that was born precisely in 2000.

Thus, through the historical development of fashion and technology it can be concluded that both fashion and technology are interdisciplinary processes combining diffe ent fields and tools to create user experience (*Guler, Gannon & Sicchio, 2016*). Today, the joint field of fashion technology, or fashionable technology, introduces the intersection of design, fashion, science and technology (*Seymour, 2008*). Motivations for creating fashion technology range from expressing oneself to functionality (*Seymour, 2008*) to creating ways of communication and increased sustainability (*Forbes, 2016*). From design to retail, from product to communication, fashion and technology are interconnected and the shift from craft to industrial production, from analogue to digital involves all stages of the production process, improving them and making them quicker and more efficient

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The accessibility of new technologies for the creative process is resulting in designers becoming freed from the restrictions of their materials - they are no longer limited by their knowledge of how a material must behave, or what they can physically model.

”

Francis Bitonti
DIGITAL HANDMADE, 2015

Hypercraft: 3D to design and production

According to Miroslava Duma, the founder of Fashion Tech Lab, the textile industry that itself hasn't changed its technology for a century is now being introduced more to material science and bio- and nanotechnologies (*WWD, Oct 2017*). Furthermore, fashion technology can incorporate all technologies that are incorporating the body (i.e. biotechnology, nanotechnology, textile technology etc.) along with necessary tools and software utilized within textile technologies and fashion design (*Seymour, 2010*).

Designing today requires not only having the creativity and method to do so, but also knowing how to use the right tools. In the fashion field, increasingly specific software has been developed for clothing – Brozware and Optitex transform 2D patterns into realistic 3D patterns, creating virtual prototypes to test wearability, colour variants and materials – and for accessories – RhinoGOLD for jewels and 3DESIGN for example have a vast library of specific materials. What was once made on paper through collage, drawing on materials or prints or fitting directly on the mannequin, today happens in the third dimension, on the screen, in a simple and effective manner. Once the 3D shape is created, not only can its aesthetic impact and proportions as well as diffe ent colour variants be tested, but the garment or accessory can really be tested, even though they are intangible products.

This is made possible by the concept Virtual Prototyping that allows the user to directly interact with the digital product as if it were real. The shape, look, manufacturing and physical behaviour can be defined and the specifics of an accessory or garment subsequently obtained, and the designer is able to interact with it, test its usability, visualise and test it in diffe ent stages and for diffe ent users. The look, not defined in detail, can be immediately tested by the designer for its impact and emotional component on the user and, as the design becomes more complex and engineered, its structure, material, geometry and specifics for product development can be carefully defined – size, placement, cut, assembly. The final product can be shown to buyers and even be personalised before going into production, or it can be displayed in the point of sale for the final user (*Cugini U., Bordegoni M., Mana R., The role of virtual prototyping in the fashion sector, 2007*). The impact of this new testing method not only completely changes the traditional product development cycle from *design>build>test>fix* to *design>analyse>test>build*, but also improves communication between the parties involved in the product development process, bringing products to the market more quickly, with reduced costs and timescales, thus facilitating innovation. Making all the process faster and smarter is one of the goal of the combination of fashion, technology and design.

When it comes to automation in textiles and apparel production, ambition can be seen to shift from process focused automation to full automation in order to be able to produce with minimal human interaction, as explained by Palaniswamy Rajan, the Chairman and CEO of Soft Wear (*Innovation in Textiles, June 2017*). The increase in automation in order to respond better to customer demand can be illustrated by Amazon's patent for on-demand apparel manufacturing system (*Quartz, Apr 2017*), along with Zara´s RFID tags on their garments (*McKinsey, 2017*), which both take advantage of available data and automation possibilities. Furthermore, 3D modelling has gained momentum also in automating the production process, specifically with 3D printing, an Additive Manufacturing process through which an object is built layer after layer starting from a 3D model. Twenty years from its first patenting, 3D printing made a comeback in 2005 thanks to the RepRap project, but its real boom came in 2012, when several companies became interested. The subsequent increase in supply and the technology's increased accessibility brought about by the reduction in costs. The prices have fallen to such an extent that the 3D printer market today is aimed not only at the industry but also at the single users, "digital craftsmen who, with the new technologies of desktop manufacturing, can transform themselves from creators to entrepreneurs and directly manage the whole of the production process online with clear benefits in terms of times and costs" (*Cappellieri A., Del Curto B., Tenuta L., Around the Future, 2014*). Furthermore, the 3D printer market, that is more and more utilized in fashion, has grown by 200% in the US between 2013 and 2014, and the global market is projected to reach $9.6 billion by 2020 (*Sun & Zhao, 2017*). David Jones, co-founder together with Micheal Armani, stated "we might see a 3D printer in every home" which is reminiscent of Bill Gates' premonition of "a computer on every desk and in every home", at a time when computers still seemed like machines aimed primarily at industrial use, just like with early 3D printing.

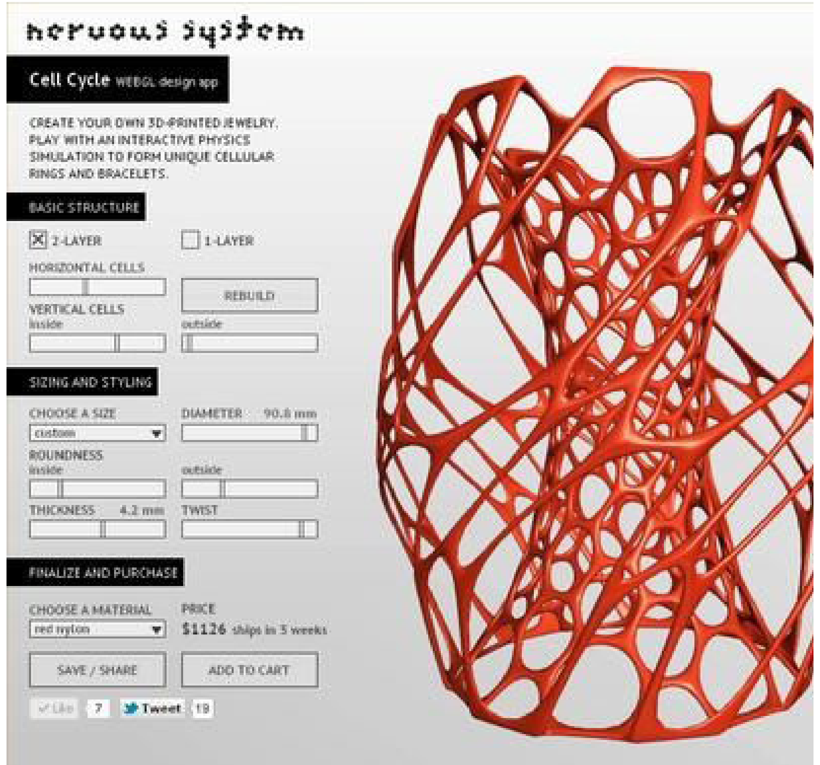
In terms of business, many markets gradually came to understand the potential of 3D printing, from architecture to bioengineering, from product design to medicine. In the medical world in particular, the advantages in the production and personalisation of external and internal prostheses was quickly intuited. One of the most interesting projects is Osteoid, a 3D printed medical cast designed by Denin Karasahin, a young Turkish designer. The cast is non-toxic, non-deformable and 100% customisable, and most of all, it connects to a low intensity LIPUS ultrasound generator to reduce the healing time of broken bones.

Fashion too understood and exploited the advantages of 3D printing very early.

"We are on the brink of the third industrial revolution"

claims Joris Debo – creative director of MGX by Materialise – (*Wired, 2016*) , referring to the new technologies and new materials and adding that nothing will be able to stop the entry of 3D outfits into our wardrobes. It is not by chance that MGX by Materialise engaged in the building of the first 3D printed garment by Iris van Herpen in collaboration with Daniel Widrig already as far back as 2009. The young Dutch designer was the first to show an interest in the innovative printing technology and to apply a method that is entirely representative of the changes the fashion system is undergoing – no longer the result of the ego of a single designer but of the cooperation between diffe ent professional figu es. Combining craftsmanship with the most recent technology, she works side by side with engineers and scientists – paying frequent visits to CERN (The European Organization for Nuclear Research) – as well as designers and architects, such as Austrian designer Julia Koerner, together with whom she

developed Biopiracy, a garment showing not only what definition of complexity can be obtained with 3D printing but also the advances made both in terms of materials and technologies.
Not only fashion but also the world of underwear and accessories has tried their hand at 3D printing production. In 2013 Victoria's Secret in collaboration with Swarovski created a set of lingerie, modelled by the beautiful Lindsay Ellingson that was as ethereal as a snowflake. More recently, New Balance launched the Zante Generate, the first 3D printed shoes that however still show the limits of the technology. Though born for mass production, 3D printing still presents high costs for mass production. The shoes are in fact printed in a limited edition and only the sole is 3D printed with a honeycomb structure that improves the distribution of the bodyweight. Experimentation has also involved hats, suffic it to look at the marvellous products by Gabriela Ligenza – complex, bold, but at the same time extremely light thanks to the use of nylon, and bags, such as the Armure Clutch, one of the latest projects by Maison203 in collaboration with Odoardo Fioravanti, with curved forms, almost suspended above an internal volume or jewellery.
Creating a system and not a single product, through generative design methods and complex forms, Nervous System offers users various personalisation possibilities thanks to their direct interaction with the system to determine the final result. Speaking of quick prototyping techniques, co-founder Jessica Rosenkrantz underlines the importance of personalisation, of the user interacting with the product, and maintains that "one-of-a-kind pieces can be produced every time. Complex geometries and moving assemblies can be rapidly manufactured without the need for moulds or factories".
Starting precisely with the user's entry into the production process, new virtual platforms are appearing – i.materialise, Shapeways, Sclupteo and Thingiverse are among the main ones – on which it suffice to upload a design for it to be produced and sold online. This process is very diffe ent from the traditional one and significantly shortens the production chain as well as giving users the possibility to personalise their products by choosing the materials of which they should be made.
The trend to personalisation in fashion is not new, and has been around for several years, as users want to wear something that is not only made exactly to their taste, but also for their body. Technology also gives an answer to this need for made-to-measure with 3D scanning, the new frontier of sizing, something like a virtual tailor. Today we can have a piece of clothing or accessory made to measure simply thanks to body scanning technology that scans one's body or a specific area that then becomes the basis for the construction of a 3D model that, worn by an avatar, anticipates what the real model will look like. Thanks to virtual prototyping, these models can be consulted, tested, modified, and perfected just as if they were real, yet without the use of productive or material resources. Several projects were born around this theme; not only to give the user products that fit perfectly, but also to reduce the returns of items purchased online that today has a high rate of 28%. Reducing returns means extending the cycle of clothes. mPort, for example, has the slogan "The last fitting room you will ever need" and takes the user's exact measures in such a way as to have a scan of the user's body onto which it models clothes and accessories. Other technologies that do not use scanning can nonetheless perfectly simulate body proportions. Fashion Metric has been doing this since 2012 with the construction of mathematical algorithms. In 2013, the Virtual Tailor technology was officiall launched on the e-commerce website with great success. Only a few questions hide the vast quantity of mathematical calculations behind the scenes.
Fits me on the other hand uses avatars that simulate the user's body, who is asked for their height, weight and age and wearability preferences. On the same wavelength is Virtusize, already used by retailers such as Asos, Oasis and Stylebop. This solution allows the consumer to compare specific measures of a garment they want to buy with those of a similar garment they have at home, whilst Clothes Horse and TrueFit suggest the size based on what they already own. All of these examples suggest a very diffe ent system to the contemporary one, a future increasingly made-to-measure and in which a new dimension – time – is added to the third dimension. We will have clothes and accessories that adapt to the changes in our bodies or perhaps to the changing fashions. In fact, as we will see in the following chapters, an MIT research group led by Skylar Tibbits in collaboration with Stratasys and Autodesk is working on 4D printing.



Nervous System, computational design

Studio Roosegard, Intimacy Project

> “I think we need to solve the technology and manufacturing challenges that will enable smart textiles to get to scale.”

Madison Maxey, founder of Loomia
A MEDIUM CORPORATION, 2017

Embedded technologies: apparel and accessories

If production and design technologies are widely used and spread, the field of integrated technologies in the fashion product is instead much more restricted. According to Seymour (*2008, 2010*), fashionable wearables in the shape of clothing, accessories and jewellery are epidermal interfaces that by incorporating elements from embedded technologies are interactive (i.e. by utilizing sensors, actuators, microprocessors etc.). The wearables can vary between diffe ent levels of expressiveness and functionality (*Seymour, 2008*), where the focus ranges between style and function with the purpose of fashionability to health and wellbeing. So 'Fashion product' refers to two diffe ent categories: clothing and accessories. Clothes usually make use of smart materials, whilst accessories integrate technology inside their shell and are defined 'wearables.' Although their approach to technology is very diffe ent today, in the past accessories were a sub-category of clothing and thus followed the same rules.

At the end of the nineteenth century, the first hints at wearable technology appeared in clothes, necklaces and hats with a dominant theme: light. Electricity is inserted in the outfit, like in the case of the Electric Light Company that designed and produced luminous clothes and ornaments for the bodies of young women, to be worn at cocktail parties and inside which were hidden the batteries feeding the system. The aim of the technology was to contribute to decorating the body, lightening it up, creating unusual 'performances', almost enchanted. This approach is not so diffe ent to the contemporary one, suffic it to think of the works of Moritz Waldemeyer such as the hat made of 6,000 LED lights for the Philip Treacy show at the Royal Courts of Justice in 2012, or of the collaboration with Erevos Aether for the presentation of the prototype of the new Audi A3 at the Geneva International Moto Show in 2013: four dancers wore futuristic, ultra-modern costumes decorated with LED lights that lit up in tune with the music during the event.

Going back to the past, only later was it understood that clothes could do many things, take on a life of their own and change the language of fashion. In 1968, the Museum of Contemporary Craft in New York hosted the exhibition Body Covering with the aim of analysing the relation between technology and clothing. Astronaut suits were on display next to clothes that inflated and deflated, lit up, heated up and cooled down and left open many application scenarios made possible by the interaction between fashion and technology; scenarios which were however not immediately understood and explored. The first research to give significant results were those that began in 1985 by Harry Wainwright who created a sweatshirt on the surface of which a cartoon was played. In the following years Wainwright himself continued research around fiber optics and LEDs integrated in materials until 2012, when he presented a smart phone-controlled material that could change colours at the Textile and Colorists Conference in Melbourne.

The 2000s saw intense experimentations on the integration of clothing and technology with diffe ent approaches. CuteCircuit launched the Hug Shirt that sent electronic hugs to the user through sensors – a more romantic version of Fundawewar, the male and female underwear thought by Durex to allow two bodies to communicate from a distance with the help of the iPhone that acts as controller and stimulator for specific sensitive areas of the male and female body. Moreover, clothes were made that respond to outside stimuli, such as the interactive dress by Ying Gao, made with photo luminescent threads and provided of an eye-tracking system that responds to eye contact by activating small motors that move the parts of the material; or the collection of dresses by Amy Winters, made in holographic leather that reacts to sound: the louder the volume of the music, the more the dresses light up obtaining what the designer calls 'visual music'. Alternatively, light is not the output but rather the input for the garment. Tommy Hilfiger presented Solar Panel Jacket with a pocket that charges mobile devices thanks to the presence of solar panels, as already proposed a year earlier, in 2013, by Pauline van Dongen in the Solar shirt.

Hussein Chalayan, Mechanical Dress

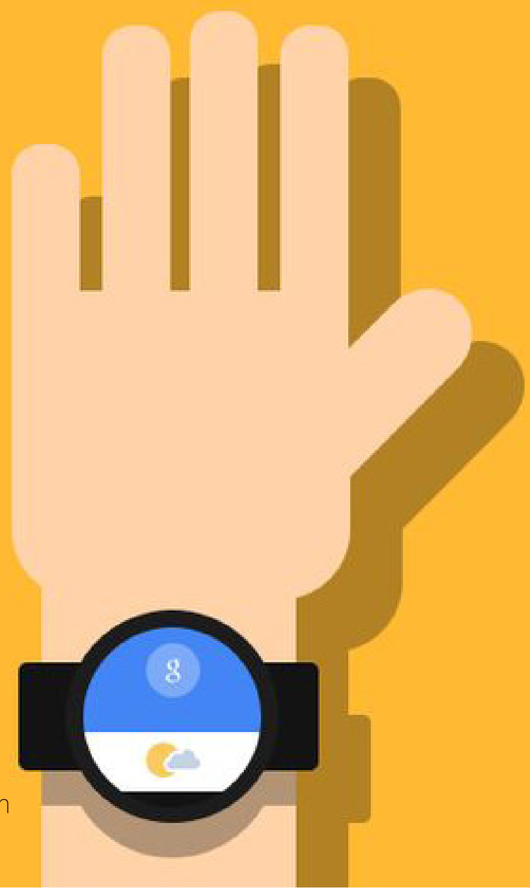
Further, clothes have been designed that base their concept on the theme of connectedness/ privacy. CuteCircuit made the dress worn by Nicole Scherzinger in 2012 during a concert, with 2,000 LED lights to visualise in real time the tweets posted by the participants; Daan Roosegaarde made Intimacy, a dress that becomes transparent based on the number of the user's interactions with the social networks, to symbolise the exposure of the self to others; Brazilian designer and researcher Ricardo O'Nascimento made Paparazzi Lover, a dress with 62 small LED lights embedded across its surface that, when stimulated by a light flash such as that of a camera, react by lighting up.

And yet, although many solutions have been tested, due the limits of technology integrated into clothing, it mainly is utilized in haute couture with the making of highly scenographic dresses suited to a show or performance, but with little use in the real world, as well as being difficul to reproduce in big numbers. Hussein Chalayan is famously one of the main figu es of this experimental direction in fashion. One example is his One Hundred and Eleven Mechanical Dress from Spring/Summer 2007, that recalls Paco Rabanne's haute couture mid-1960s robotic style where pieces of aluminium were held together by rings that allowed for their

movement. Chalayan on the other hand makes his dresses really move by controlling them thanks to inbuilt circuits. The dress blooms like a flowe , it opens up. Even before, in 2000, the British-Turkish designer was fascinated by the controlled movement of a dress that opened up to reveal the presence of tulle underneath.
Albeit existing, the number of garments that are useful and practical is limited. One example is Move by Electricfoxy, a sports vest with four movement sensors that recognise the precise position the shoulders and back should occupy during a given exercise and detect the percentage of risk of injury; Kristin Niedlinger designed a line of Sweatshirts with electrodes in contact with the skin that capture and express the effects in the form of coloured lights – red to signal nervousness, blue to show calmness. In other cases, the technology has both ornamental value and a function such as in the case of the Wild Uniforms made by Glofaster and designed by Claire Barrow for the staff of London's W Club. Jackets and gilets are provided with a fib e optic light system that pulsates to the rhythm of the music played in the club by the DJ. The clothes do not only look good; they are uniforms to distinguish the staff from the crowd of clubbers. These are sporadic cases that mostly remain confined to specific and isolated field
Thus, although integrating technology with fashion presents opportunities from the point of view of scenography, mainly for haute couture, it presents two main limitations for ready-to-wear. First, such significant progress has been made in the properties of the materials that materials with smart features are preferable to the integration of technology and sensors in the fabrics. Innovation in the fashion world has often focused on the materials, at least since the 1980s with the boom of artificial materials, and incredible progress has been made in the properties of materials – initially in the military or sports world and later translated into the fashion world. Fabrics that change their characteristics based on the temperature of the body or of the environment and high-performance materials are no longer just a cover or shell, but rather a dispenser or container of functions.
Some examples are Fluotopo12, a membrane developed by Ferrari that protects from dirt and aging and that could have many applications in the world of fashion; the scented fabric launched in the shirt sector by Tessitura Taiana, the fib es of which are impregnated with natural essences, combining perfumes with colours; Mulberry with the Magic Aerogel jacket made with Aerogel, an extremely light isolating materials made of over 95% air. Among the Italian companies most committed to research and experimentation is certainly Stone Island, that in 1982 created the Tela Stella, the result of endless washes applied to military lorry tarpaulin on which enzymes were applied to soften the material; other examples are the Ice Jacket in the 1990s, that changed the colour of the jacket with variations in temperature, and more recently the latest collaboration with Nike featuring Metal nylon, a material patented by Stone Island with a metallic shine that embellishes the chest of the jacket, coated in PrimaLoft. These materials are much easier to manage, both in terms of production and use, than integrated technology that on the contrary can represent an important burden for clothing.
While it is a success point for wearables, the first sign of wearable technological accessory can be found during the Sixteenth century with the invention of the clock worn on the body, followed by the Pulsar Calculator during the half of the Twentieth century and then the Bluetooth headphones in the 2000s and the first GoPro in 2004 to arrive to their success in 2014. 2014 was pinpointed as the year of wearables. Apple Watch was featured on the cover of TIME magazine with the caption 'Never Offline proclaiming the officia entrance of wearables and their diffusion in the contemporary society, a new always connected lifestyle; Google Glasses were on the Diane Von Furstenberg's catwalk and Fitbit announced its partnership together with Tory Burch. According to Statista 2018 the wearables market is now predicted to grow to around 72.5
million units by 2021: from 79.5 in 2017 to 148.5 in 2021.

Statista 2018* expects the worldwide smart wearables market to grow to around 72.5 million units by 2021.

from 79.5 in 2017 to 148.5 in 2021



* www.statista.com

> With virtual reality, you're essentially hacking the visual-audio system of your brain and feeding it a set of stimuli that's close enough to the stimuli it expects that it sees it as truth. Instead of suspending your disbelief, you actually have to remind yourself not to believe.

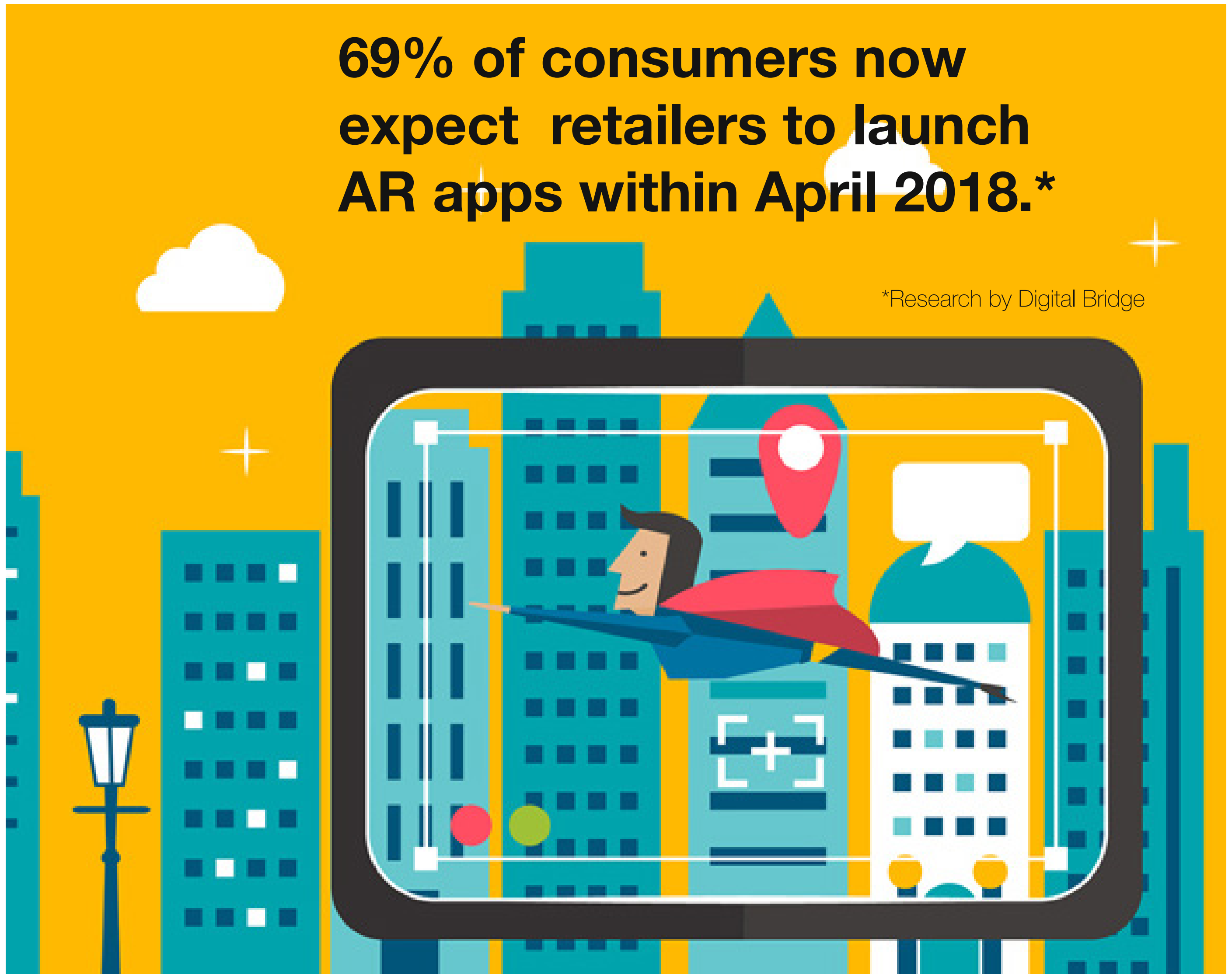
Chris Milk
2014

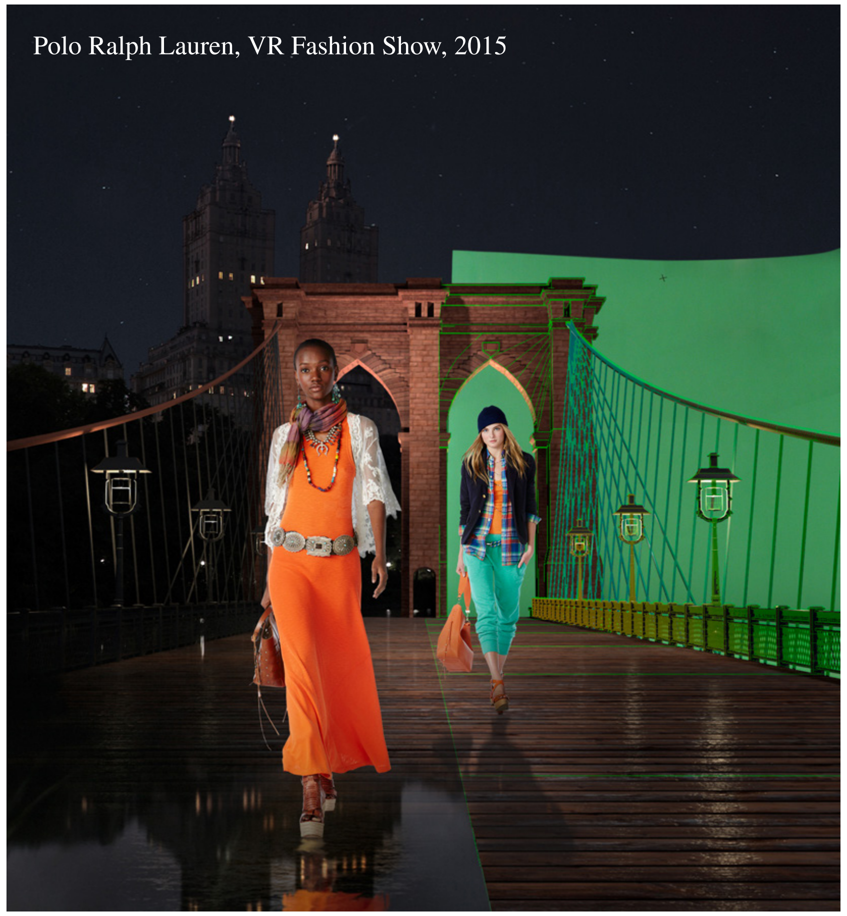
Tommy Hilfiger store, VR headset

Augmented/virtual reality and retail

Communication today plays a key role in the spread and perception of products, and this is why the world of fashion is constantly searching for increasingly spectacular performances that can enchant and capture the public's attention. In July 2016, Fendi celebrated its 90 years of activity by staging a fashion show on the Trevi fountain, a spectacular event in which the clothes were almost overshadowed by the fie ce media action.

Similarly, Dolce and Gabbana's shows invaded the city of Naples for four days, launching a new experience: fashion shows are no longer elitist and enclosed in a physical space but apparently open and visible by all. There are two main ideas here: mass accessibility and the spectacular element. Technology is increasingly used for these goals, mainly in fashion shows and for trying on garments in the shops or digitally.




Polo Ralph Lauren, VR Fashion Show, 2015

In terms of fashion shows, technology is not only the protagonist on the catwalks such as in Diane von Furstenberg's shows in which the models wore Google Glass, it is also a tool for the production of the shows themselves. For Spring/Summer 2015, Polo Ralph Lauren produced a surprising virtual show on the waters of the lake in Central Park. An anticipation of the Fendi show on the Roman fountain? Yes, also because the models were suspended mid-air, not for the presence of see-through platforms but thanks to the use of holographic technology that gave an evanescent and pictorial result. The models virtually walked the catwalk in diffe ent corners of the city on a rotating basis, inciting surprise and admiration. Even before this, for Autumn/Winter 2012, Alfred Dunhill had staged an impressive holographic installation in Shanghai with 64 models, this time real, immersed in a virtual environment that transported London's Trafalgar Square to Shanghai and projected the changing of the seasons. The combination of cutting edge technology, architecture, lighting and music created an extremely suggestive show, in which the seasons changed inside a holographic dome. A virtual reality diffe ent to that which in 1996 Mark Dery defined as "a simulation technology that uses big glasses with integrated displays and quadraphonic sound to immerse users in 3D worlds generated by computer graphics".

Technology today is no longer heavy and bulky. It is light and easy to use and it involves its user to such an extent that it has become difficul to distinguish virtual reality from the real one. Due to increased use of technology and incorporating it to the fashion industry, retail has seen the benefits of innovative technologies, with many being adopted by both start-ups and established companies (*Fashionbi, 2017*). Besides wearables and digital manufacturing, technology has shaped fashion first by the start of fashion blogs, to live streaming fashion shows and the introduction of the "see-now buy-now" concept, to digital fitting rooms (Snugg, n.d.) that all bringing the supply chain closer to the customer. The adoption of AI has been seen in business-to-consumer-interactions, along with customer service and marketing, while

interactions between brands and customers are predicted to grow to 85% by 2020 (*Fashionbi, 2017*). Augmented Reality has allowed brands to introduce virtual fitting rooms, where customers can try on garments virtually from their homes, and in stores to enhance the shopping experience (*Digital Pulse, 2015; NXP, 2016*).
So, moving from virtual reality to augmented reality, some examples: British luxury brand HEMYCA for Spring/Summer 2014 during London Fashion Week. The real catwalk was transformed into its digital 3D version that came to life through an ad hoc designed solution. Framing a scene with the tablet, models walking with diffe ent dresses magically appear. The project is a winner not only because it is new and awe-inspiring, but because it is functional to staging the show in diffe ent parts of the world by simply moving the scene. The user however still remained a passive spectator, unlike in the application proposed by Alexander McQueen which allowed spectators to digitally try on the make-up used for the brand's most salient shows. This application designed by Holition for Alexander McQueen is called Face and not only allows users to try on diffe ent types of make-up but also to go into stores and scan the product code to virtually try it on their faces thanks to the use of a smart device.
Virtual try-on is the future of clothes and accessory buying. An example of 'smart' selling is Uniqlo, which has provided one of its stores with a magic mirror, a technology that integrates physical and digital reality and allows users to add a direct in-store experience. Whilst wearing the same garment, users can see in the mirror the diffe ent available colours and take photos to share via email or on the social networks, as well as having all of the product specifications. This attention to user experience showed first emerged already a few years ago with the use of RFId technology to improve the inventory phase and customer experience through touch-screen tables with which to obtain more information on the garments such as the available colours and sizes.
Even more avant-garde is the Triumph and OgilvyAction proposal for the launch of the Triumph Essence collection which could be worn by clients without taking off their clothes. In this case, the interface is also a screen, the Fantasy Mirror provided with a cam that tracks movements and uses 3D technology with infrared rays to scan the body underneath the clothes and create a digital avatar with the same proportions as the consumer, follows their movements and reproduces the underwear on them.

"AR is set to reconnect physical and digital retail,"

Greg Jones, director VR and AR, Google

If these are the innovations in the shops, in the physical and real space, we must however take a look also at the virtual space that is increasingly the place where new buying dynamics are forming that are close to the new generations. This means that future consumers will crowd the real shops less and less as they increasingly buy on the web. Fashion understood this and responded with the creation of virtual stores in which consumers can buy and try on the product.
In 2010 Boucheron inserted augmented reality in its marketing strategy, seeing a 50% increase in its web traffic Part of the strategy included giving consumers the possibility of trying on the most iconic jewels from Boucheron's collections. A luxury for the few that thus opened up to all those who wanted to experience the pleasure of wearing a Boucheron product from the comfort of their home, by simply selecting it and dragging it onto the appropriate body part. And for those who cannot renounce the experience of entering a boutique, then, also thanks to augmented reality, Boucheron also gave clients the opportunity to visit one directly from the website.
Immediately after this the virtual try-on craze exploded and many jewellery brands were attracted to the possibility of opening up their doors to a wider public. Cartier, Chanel Fine Jewellery, Chopard, De Beers, Fabergé, Graff, Harry Winston, Louis Vuitton, Mikimoto, Tiffany and Van Cleef & Arpels collaborated with Tatler Magazine in a project based on the fact that many women have a desire to try on rings with extremely precious diamonds and stratospheric prices. It suffice to buy the September issue of the magazine, cut out the desired ring, download the Tatler augmented reality software, aim the finger in front of the webcam and be dazzled by the image of the consumer's body embellished by jewels that are out of the reach of most people.
Democratisation and awe. These are the key words for the future of fashion and technologies.

Research methodology

- *Definition of three main areas of interest*
  - *. Smart textiles*
  - *. Wearable technologies*
  - *. Digital Manufacturing*

- *Mapping of Higher Education programmes or courses within programmes within the fashion-tech field.*

- *Mapping of other high-qualitative experiences of companies within the fashion-tech field.*

- *Mapping of applied research experiences by public or private research centres that can have relevant implications for didactic purposes within the fashion-tech field.*

The initial research concluded in 60 HEIs, 57 RCs and 171 companies (total of 288) globally, with all working within the previously defined areas. Most institutions (178) were identified within Europe, and consisted of HEIs (47), research teams and/or centres (44), along with companies (87) active within the fashion-tech field.

RESEARCH METHODOLOGY

Wearables, smart textiles and digital manufacturing across HEIs, Research Centers and Companies

The initial desk research entailed researching higher education institutes (HEI), research centres (RC) and companies in Europe and worldwide in order to identify the ones active in the areas of wearables, smart textiles or digital manufacturing. Additionally, the goal was to identify best practices and current and/or upcoming trends in the fashion-tech field. As the apparel and technology industries have traditionally been separate, their cross-disciplinary working can be problematic due to issues related to diffe ent languages, working practices, development time-frames and marketing strategies (McCann & Bryson, 2009). Thus, the structure, teams, products and methodologies of the identified practitioners were explored in order to understand educational and research approaches to the area of fashion-tech.

In order to identify institutions active in the areas of wearables, smart textiles and digital manufacturing, it was crucial to define the specific areas for the project. Wearables, originating from wearable computers that have operational and interactional constancy (*McLuhan, 1967*), relate and have the goal to be the amplifier of the human body, enable interaction and communication, while also combining aesthetics and style (*Tenuta L. Futures for Fashion, 2017*). While wearables can be in the shape of clothing, accessories and jewellery (*Seymour, 2008; 2010*), research and market has mainly had a focus on accessories with embedded technologies. As previously described, accessories integrate technology, while garments normally utilize smart materials due to embedded technologies not being developed enough to be able to be integrated into ´soft´ textiles. Additionally, wearables that have gained momentum are in the form of watches connected to apps with the goal of a quantified self, among others. Thus, wearables are identified as accessories and jewellery utilizing embedded technologies to demonstrate an input and output enabling body-environment interaction and communication, while combining style and aesthetics with the technology.

Within the area of smart textiles, where the fabric can sense and response to external stimuli (*Koncar, 2016*), mainly apparel related to health, wellbeing and protection has been developed, with the focus ranging between function and aesthetics. Technologies are interwoven in the fabric itself, and can measure vital body signs, have warming or cooling properties, along with garments designed by artists or fashion designers for visual or communication motivations. Therefore, smart textiles are defined as apparel utilizing interwoven technologies in order to sense and response to internal and external stimuli of the body. Lastly, digital manufacturing entails cutting-edge technologies or processes,

such as 3D printing (*Sun & Zhao, 2017*), AI and AR (Fashionbi, 2017) that are focused on production, retail and distribution. So far 3D technologies, such as 3D visualization and printing, have gained momentum in production related processes, while AI and AR are of interest in retail and communication with customers. Thus, digital manufacturing is identified as innovative processes for design, production, distribution and retail.
The initial research concluded in 60 HEIs, 57 RCs and 171 companies (total of 288) globally, with all working within the previously defined areas. The state of art of higher education programmes was of interest, along with high-qualitative didactic experiences and applied research experiences by public or private research centres or companies. Thus, initial research entailed filling out forms (*ATTACHED A at the end of the report*) for each HEI, RC or company found based on information found online, which included specifying their involvement within the three areas, a short description of their practices and contact information to interest them in participation in the project. Most institutions (178) were identified within Europe, and consisted of HEIs (47), research teams and/or centres working within those HEIs or independently (44), along with companies (87) active within the fashion-tech field. Thereafter, 97 institutions were identified in North and South America, with again the biggest part consisting of companies (76), with HEIs (9) and RCs (12) following. Lastly, 13 institutions were identified mainly from Asia along with Israel, Australia and New Zealand, entailing 8 companies, 4 HEIs and 1 RC.
While health and wellbeing is mainly in focus within the companies active, HEIs concentrate on specific fashion-tech related courses or workshops primarily concentrating on wearables and smart textiles, rather than digital manufacturing. RCs, along with independent artists/researches, were seen to be focused on invention of new technologies and developing prototypes rather than commercial products. Due to the reality of the fashion-tech field being relatively fragmented, a phenomenon can be seen in the increase of hubs, such as fashion accelerators or fab labs that are dedicated to fashion-tech. These hubs combining investments, incubators and research (independent or connected to HEIs) are found globally, such as the Fashion Tech Lab in New York, The Mills Fabrica in Hong Kong, and Fashion Zone at the Ryerson University in Canada, and are aiming to connect students, artists, designers and start-ups among others. This could be seen as creating better connections between diffe ent areas and disciplines, but also enable students and start-ups to access the help they need, while bigger corporations can access drive and innovation.
The institutions were contacted through email and personal contacts, and 14

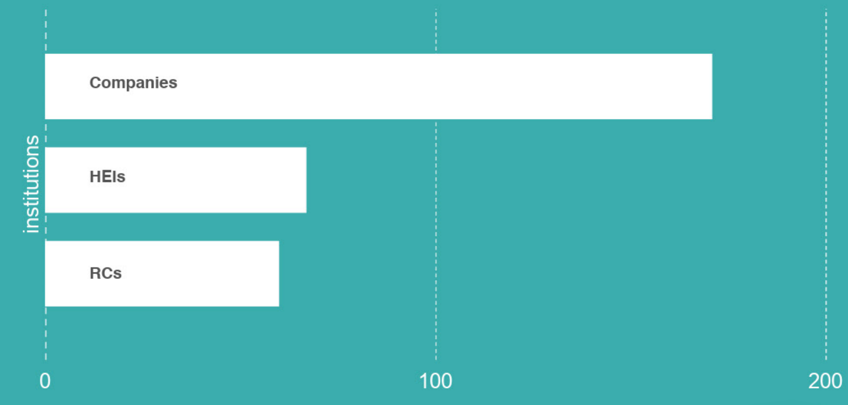
Research Requirements

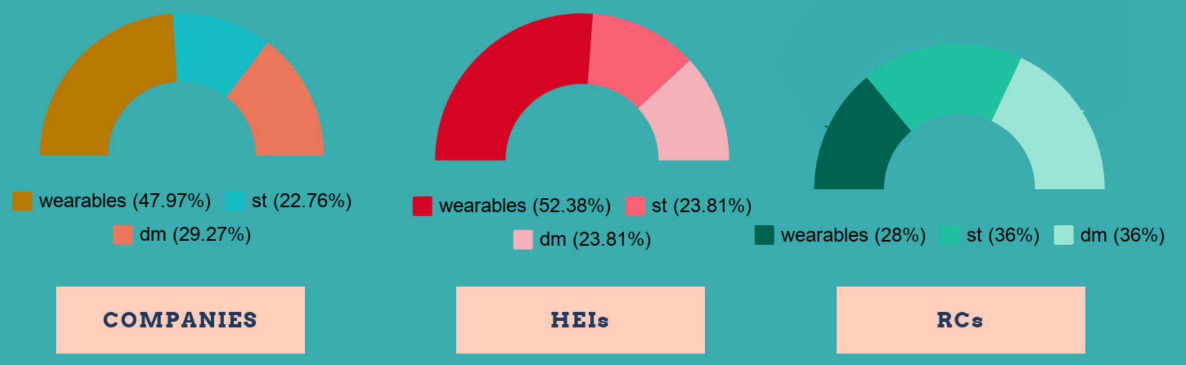
wearables, smart textiles and digital manufacturing

across companies, HEIs and research centers

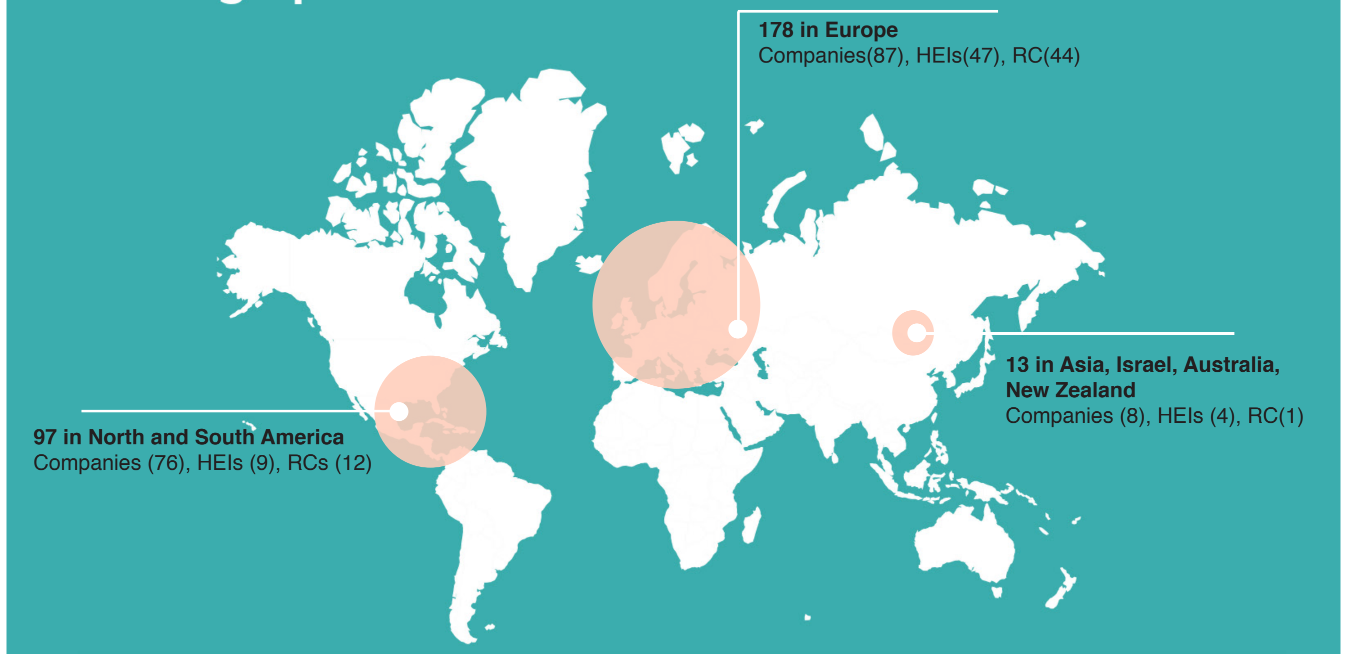
Desk research

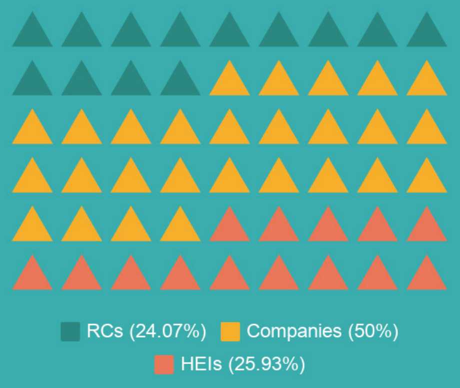
The initial desk research entailed researching higher education institutes (HEI), research centres (RC) and companies in Europe and worldwide in order to identify the ones active in the areas of wearables, smart textiles or digital manufacturing.





Geographic distribution

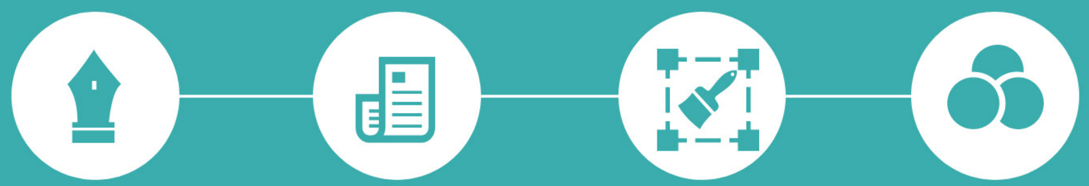




Interviews

The institutions were contacted through email and personal contacts, and 14 HEIs, 13 RCs and 27 companies globally showed interest in being involved with the project.

Structure of the interviews



#1 Area of interest

#2 Team

#3 Methodology and Tools

#4 Collaborations

HEIs, 13 RCs and 27 companies globally showed interest in being involved with the project.
The interviews were sent at the beginning of November 2017 and we indicated as deadline one month to the companies, HEIs and research centers to express interest in the project and to be part of it by answering the questions. In the second half of December 2017 we collected all the data and we compared them, so all the info below is updated in January 2018. The information has been analyzed, revised, compared and mapped in two months. The findings that follow are mainly the result of a qualitative analysis. The data were in fact analyzed thematically in relation to the outcomes, as we will see in the following chapter.
All the examples examined were mapped, a brief description was made, the area of belonging - if wearables, smart textile and or digital manufacturing - was localized and the result is an interactive map available at www.e4ft.eu which, being digital, can be continuously updated and increased over time, intensifying the network of companies that deal with fashion-tech.
At the end of this same report (page 122-125) the forms can be downloaded, completed and sent to the partners' contacts to be inserted in the map among the case studies.
To further understand their involvement with the areas of fashion-tech and their relevant implications for educational experiences within the fashion-tech field, face-to-face and long-distance interviews were carried out with those interested in the project. The interviews were carried out by following a previously prepared organization specific form (*ATTACHED B,C,D at the end of the report*) to assist in identifying aspects related to the area of interest, team, the methodology, the product (if relevant), the tools, the research and collaborations, and funding. Additionally, if unable to carry out interviews, participants were enabled to fill out the previously defined form in order to describe their work within the field. The filled out forms were then examined, and if necessary, the participants were contacted once more if any additional questions were raised or something needed further clarification. Completed forms were collected and analysed in relation to processes, resources, tools and contents, as previously described. The results of the research are presented in the following chapter.

Findings

- *Modelling of approaches, processes, resources, and tools for education and design experimentation in following areas*
    - *Smart textiles*
    - *Wearable technologies*
    - *Digital Manufacturing*

- *Description of Best Practices (in regard to teaching fashion-tech oriented contents or applying fashion-tech oriented approaches) for the following areas*
    - *Smart textiles*
    - *Wearable technologies*
    - *Digital Manufacturing*

- *Evaluation and identification of opportunities and requirements for development of*
    - *Pedagogical principles for fashion-tech subject*
    - *Pedagogical media and tools for both traditional education and e-learning, and blended methods)*

“Technology disrupts everything: the economic model, creativity, manufacturing, textiles ... But the real challenge lies in the connection between innovations brought about by new technologies and traditional methods. transcend it.”

Pascal Morand

EXECUTIVE PRESIDENT OF THE FÉDÉRATION DE LA HAUTE COUTURE ET DE LA MODE

FINDINGS

Starting from the interviews and the analysis of the case studies the main and general observation is about the nature of fashion-tech: a fragmented, disjointed reality with various and heterogeneous professionals, trends, disciplines, products, competences, methodologies and applications.
The research focuses on Companies, Research Centers and Universities: a set of highly heterogenous players among them and inside each category for what concerns their size, nature, scope.

Fragmented: Companies’ approach towards innovation starts (up) from scratch

The category “Companies” groups together FabLabs, consultancy offices hubs, accelerators, but the Company category also and large scale organizations, as well as long established business and start ups.

According to the data collected, 18% of the companies is in the early stages, 28% has been operating by less than 5 years and 54% for more than 5 years. This clearly shows how startups are rapidly growing within the fashion tech world: this might be explained by the fact that long established fashion houses strive to integrate technology within their brand identity. On the other hand a completely new project can easily avoid to focus on tradition and can embrace innovation in a more smart and disruptive way. Due to an urgent and intense need for innovation across the industry, a growing number of fashion companies will aim to emulate the qualities of startups such as agility, collaboration and openness. Traditional and heritage players will continue to be compelled to open their minds up to new types of talent, new ways of working, new kinds of partnerships and new investment models.(*The State Of*

experience of companies in fashion-tech

18%
< 1 year

28%
1- 5 years

54%
> 5 years

Fashion, 2018). The mantra “innovate or die” has never felt more relevant. Experts expect fashion players in 2018 to be all about delivering an all-new and integrated innovation that will be able to encompass the many stages ranging from design to the after-sale. Said so, innovation will be evermore interdisciplinary and cross-field driven as will spring from the ability to put in practice trends and tools from other ecosystems. This will require start ups to open up, incorporating new types of talent, new ways of working, new kinds of partnerships and new investment models. This all-new hunger for hybrids is actually perfusing funding procedures - the main way in which innovation is sustained and fostered and shows relations between long established realities and the emerging ones. Born within the financial and smart/ startup funding milieu, acquisition of innovative businesses is today the way to promote innovation. Mc Kinsey expects that a rise in capital investment in 2018 along the fashion ecosystem will grow, while competition among investors for the most attractive startups will intensify as the fashion industry’s significant market size makes it ripe for further technological and digital disruption. Fashion entrepreneurs will be driving venture capital infusion. These include intakes like the one by former owner of La Perla Group Alberto Masotti that recently established Fashion Research Italy foundation and recently signed to promote fashion technology in Bologna, Miroslava Duma, who set up the hybrid venture FTL to invest in and market new technologies in fashion; Net-a-Porter founder Natalie Massenet, who is setting up a fashion and lifestyle venture capital fund; designer Rebecca Minkoff who launched a fashion tech venture capital fund in partnership with Quotidian Ventures. Large heritage players will be involved too, establishing their own venture capital arms to invest in innovative startups, like for Diesel owner Renzo Rosso, spreading innovation among his Holding bends by acquiring minority shares in groundbreaking startup projects Red Circle Investment. Interviews shows the state of the art of Companies is that “Big is not necessary Better”. In fact in order to merge and not to collide with an existing brand identity it’s better to keep innovation in a stand alone mode. Purposed subsidiary companies are in fact set up in the form of start ups, so to be able to easily identify the correct problems and scenarios, run tests and address problem solution and keep research ongoing, without being suffocated by company’s boundaries. These ongoing branded research centers are employed by larger holdings in order to develop specific solutions that might be extended to all the subsidiary companies.

Disjointed: Research Centers technicality’s fails to formulate scenarios

With 85% operating for longer than 5 years, 15% between 1-5 years and none for less than 1, Research Centers stands out for their prolonged activity within the field of fashion technologies when compared to companies and universities. As opposed to the fragmentation that has been recorded when interviewing the companies, what strikes here is the deep state of disappointment that these institutions works in. Mostly spinning around scientists - professionals like textile, electronics and software engineers, physics and chemicals - research centers seems more focused on the dry side of technology and on technicalities per se, failing to investigate the scenarios or the market opportunities to leverage and tune the development of the technology. Apparently not committed to deliver complete projects but just a working technology as they can easily develop the technical features and components, the majority (42%) of the 26 Research Centers interviewed focus on Smart Textiles, 35% are working on the technological interface for wearables, while the remaining 23% focus on digital manufacturing. While on one hand this way of operating seems to be conceptually detrimental to adapt the technology itself to a certain purpose, it prevent research centers to practically liaise with companies and Universities and benefit of mutual interaction while resulting in increased amount of time and funds necessary. This marks another distinctive feature of the research centers as opposed to the increasing demand for cooperative projects and cross field collaborations in Companies and Universities standing out for and increased and balanced offer of c eative and technical skills. According to the data collected, it seems that

experience of research centers in fashion-tech

0%
< 1 year

15%
1- 5 years

85%
> 5 years

level of fashion-tech course in HEIs

37%
bachelor

58%
post-graduate*

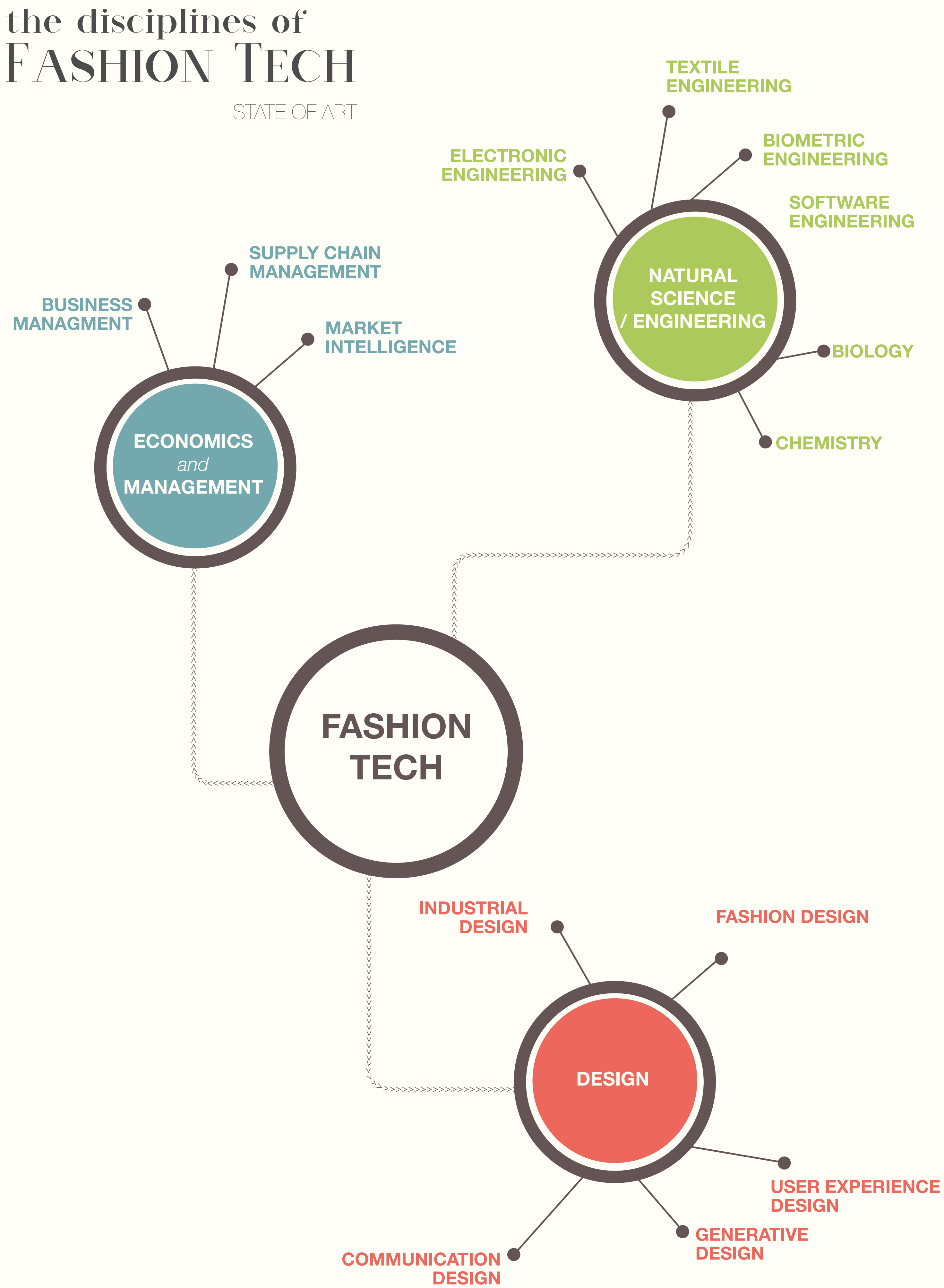
5%
MA level**

* second cycle degree equivalent to a master's degree, two-year programme after the bachelor degree
**specialization courses, PhD

Research Centers should be those that would benefit more from an integrated cross-field approach, as they are the main player who owns the direct knowledge of the technology process. If the research they bring on as "pure scientists" might benefit from intakes for other professionals like designers or marketers and be blend with consideration concerning widening the picture to the scenarios and use cases their performance eight arise considerably.

Unfocused: Universities' generic approach to innovation fails to hit the market

The interview conducted on 28 Universities selected on a global scale stigmatizes an unfocused approach to technology relying on an excessive heterogeneity and lack of unified vision for what concerns course topics, themes and trends. With 39% focuses on wearables, 39% on smart textiles and 22% on digital manufacturing, Universities seems to be missing a shared academic vision on priorities when it comes to smart technologies. This lack of vision affects times and modalities too. Courses mainly groups 10/20 students (70%). Smaller (15% groups with 0-10 students) or larger (15% groups made by over 30 students) are a residual choice as fashion and technology courses are delivered to students mainly in their formative academic years instead of addressing to those already working. In fact the research shows that fashion technology courses are set at Bachelor level for 37% of universities, at 58% for Post Graduate and just 5% for MA level. This fails to value and strength the relation between Universities and Companies, failing to create a virtuous synergy that, combining market needs and fresh technical and creative views, might benefit innovation's evolution within the entire ecosystem. Shining a light on the relationship between Companies and Univeristies, student's hiring rate after such course - by all means a very important data - couldn't be collected, mostly due to the discrepancy between the high recency of the courses and the natural time span for a student to be hired. But a clear critical factor about this topic could be find in the high number of projects that fails to pass onto the prototype phase. With just 4 out of 19 working prototypes Universities' tehoric approach seems to affect the relationship with companies in a quite negative way. The interview shows that most of the educators employed in the university comes from the same university and in some cases have attended a specific fashion technology course. Yet their background show some very little cross-field contamination, with the majority coming from design (61%) and engineering (22%) while other important fields are not adequately represented. One the other hand a positive consideration arise from the data collected about the educators. As experts coming from the world of the company, they are asked to cooperate. This is the case of 1 outstanding course with 5/10 and 7 out 12 course with 2/5 educators coming from the fashion tech field. Sadly 4 courses still reside on a single specifically trained educato .
According to the information collected, Universties need to elevate their course tracks to a more hands on all-new way, this can be achieved by focusing on fostering those research threads that are able to make technologies available for consumption as they are ready to be undertook by such consumer patterns that are about to be quickly incorporated into their behaiviour.



Fashion-tech: a critical reading

"Technology disrupts everything: the economic model, creativity, manufacturing, textiles [...] But the real challenge lies in the connection between innovations brought about by new technologies and traditional methods. High-tech products must also be fashion products, embodying a sensory appeal, an emotion and therefore a desirability. You have to use technology but also transcend it." P. Morand, Executive President of The Fédération de la haute couture et de la mode.

As previously mentioned, the world of fashion-tech is characterized primarily by an extremely heterogeneous nature. This can also be applied to the disciplines that characterize it.
As shown in the map, there are three areas that converge in the fashion-tech field: design, natural science/engineering and economics and management.
The design area includes fashion design and industrial design that deal with the specific product (garments or accessory), communication design has the task instead of transmitting the communication of the product, the user experience design studies the interaction with the final consumer and finally the generative design that is placed halfway between the creative and technical field
The technical field, named natural science/ engineering, instead indicates all the purely technical skills that cover the development of embedded technologies, smart textiles and machinery or real-life technologies for digital manufacturing. Among these skills in electronic, textile, biometric and software engineering but also in chemistry and biology stand out.
The economics and management follows. It refers to areas such as business management, supply chain management and market intelligent that have an informative and management role along the entire production chain.

These three sectors, we will see, are crossed transversely in the following paragraphs, being directly involved both in the methodology, as in the expertise of the professionals or in the tools.
It is important to specify that among the diffe ent case studies, cases of best practice have not been identified, as they are very recent and difficul to evaluate in an objective way. There are some interesting points of each methodology analyzed, so best practices are the result of portions of case studies. This critical analysis aims to take the best of each and remotely together to arrive at the definition of an effective methodology for the design of fashion-technologies.

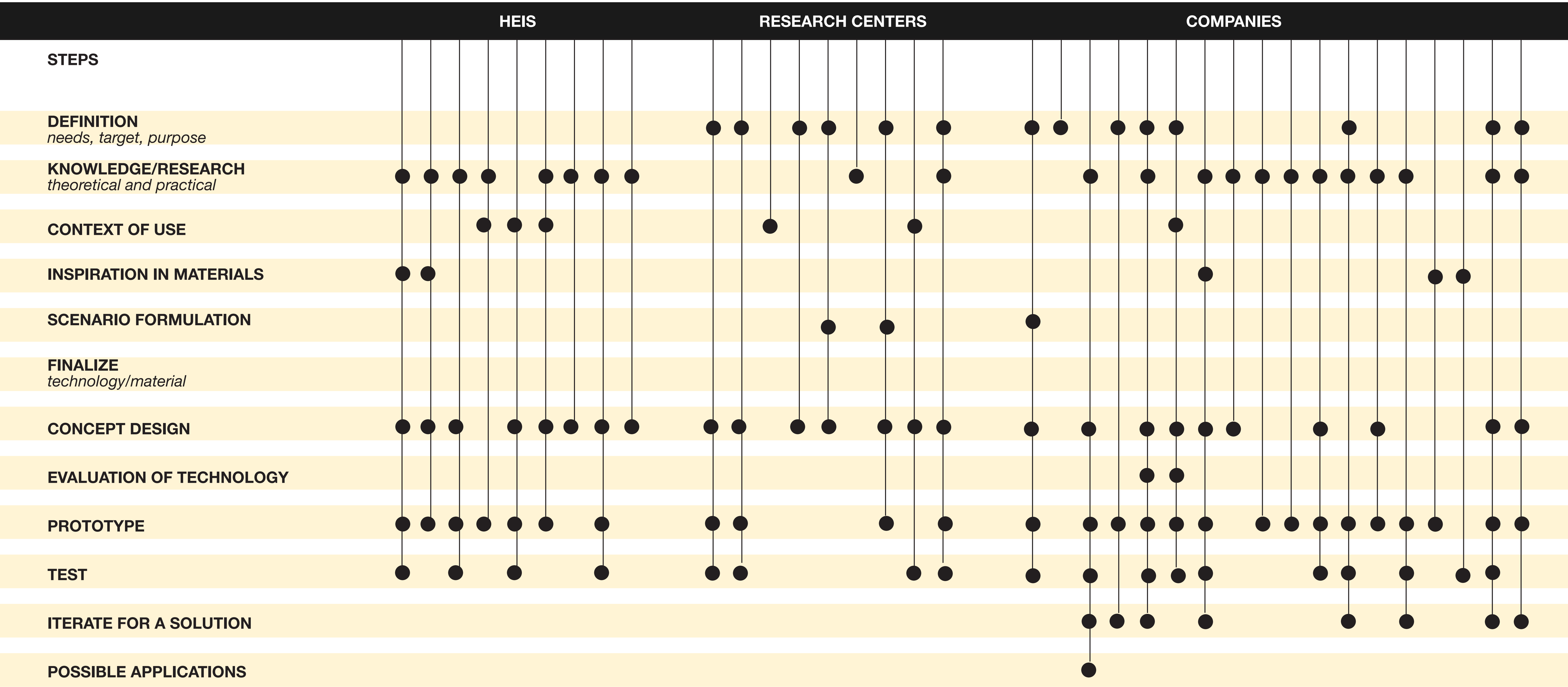
When it comes to the methodology, by combining all the results collected for the methodologies identified for universities, companies and research centers, we have defined a distinct set of steps to be added to the basic methodology of design.

In the first step we define the **needs of a target and the objectives to be achieved**; this is interesting because on the one hand, for companies or for research centers it means to discuss and decide this with designers while for companies it translates into an observation of one's own target and analysis of the user, usually mind for universities, if there is a reference company, takes its target audience, most of the time this does not happen.

The second aspect is that of **knowledge and research**, both theoretical and practical, which translates into the acquisition of knowledge and it is desirable that at university this happens

VISUAL MAP

Comparison among methodologies applied by HEIs, companies e research centers to approach the topic of fashion-tech. The vertical line represents each institution; the dots are the steps that form the methodology. All the findings are result of interviews (January 2018).



with theoretical courses or practical dedicated applications, which concern knowledge related to technology.
Thisphasefocusesontechnology,thedevelopment of new technologies, actual technologies and the right way to manage them including design. The same principles applies to such skills coming from other fields than design, like for example Smart textiles and Digital manufacturing. However our findings shows the development of Digital manufacturing involves scientists and technicians. It even impacts on the design field yet it does not involve the designer in the development phase but just in the application one.

Following is the important step of the formulation of the **scenario**. In fact it is within the scenario that design finds its maximum expression. This is the phase where new gestures, new behaviors, new societies, new cultures are planned. once the scenario is defined, which act as a sort of storyboard, it will host forms, materials and technologies that will be defined in a coordinated way by the engineers and designers to arrive at the development of the **concept**. This is all about connecting the world of technology with the one of creativity, in order to develop all the technical components of the project.
Now the components will not only concern the form the choice of materials but will also encompass the integration of technologies, so to to define an idea of performance. It is necessary that the latter is functional and that it can be evaluated. This is why the best technology will be going to be chosen. This does not only mean choosing the working technology, but it must also be considered if it is industrially reproducible, if it is currently on the market and if it is, of course, working.

Subsequentlythetechnologyis **prototyped and tested**. A double path opens up in the test phase. On one hand there is quantitative analysis, while on the other the qualitative one. While the first one examines the object's correct functioning, the second examines the object's relationship with the user, like for example the usability, the relationship with the material, the understanding of how the object was made.
This subject is highly discussed in contemporary research. In fact when asked how the final product was perceived, the interviewees answered that this is strongly connected to the context and the way in with it is presented. For example, a test performed in a research center or university will position the object as technological; if presented during a catwalk it will be perceived as fashionable, while it will be perceived as art if the test and the presentation will be run in a museum.

The role of marketing and communication, now increasingly central to the positioning and penetration strategies of a given product/ market paradigm, becomes even more central to the technological field, as a greater number of mechanisms necessary to understand how the objectworksandtransmitallthereal characteristics of the product.

Regarding the **test phase as product's perception** it is interesting to see how in the interview the Companies 26% are perceived as design objects, 26% as technological objects, 48% as both. as arguable, the target does not support it by giving any confirmation of the attitude thus detected.

Some ask for feedback during the presentation, through interaction and usability. Others use facilities designed to act as a laboratory in which they run beta testing sessions.

It is right to frame the training pact between professionals and students, who wants the first intent to train the professionals of tomorrow, claiming the central role of research, focused on the figu e of universities. It is precisely the university that gives direction and conduct of research and companies.

From the interviews it emerges that **time** is one of the most dramatic factors. In fact, both companies and universities assess they have little time, and that this is not enough to reach a level of sufficientl large project development. Probably during the training and education period, we should dedicate more time to a theoretical module, with professionals from the scientific world and related to diffe ent fields, such as marketing, to give an appropriate direction to the students and teach them how to behave, as well as lessons also practices techniques dedicated to technologies such as assembly of circuits for wearables, or experiments on materials for smart textiles, or laboratories to which we can arrive at the real definition of the p ototype.

Another problem that has been registered is concerning costs. When connected to education, it will be necessary to deliver a much more real part related to technology. That's because, if on the one hand and students with a background in design are trained to consider and quantify the cost of materials. This, however, does not happen for technology. This attitude leads to the creation of projects that may have their own scenario. This might even ideally be sustainable with a well-defined scenario, but in practice it's found that these are actually too expensive and are not even addressed to the target initially identified

About the **tools** employed, the data collected indicates that both analogical and digital tools are used (Adobe Software, CAD programs, textile softwares, Prototyping machines, Arduino, electronics and sensors Max/sp, Ableton Ai, Laser cutter, sewing machines, Tunneling machines, Design tools for electronic circuits, standard tools for mechanical design, EAGLE, 3D printing). There are few advanced laboratories allowing to experiment on materials and on technologies, with three-dimensional and vector softwares, laser cutting technologies and tools like Arduino but in most of the cases tools employed are the standard and classics ones such as three-dimensional printers, software, sewing machines.

As for the **collaborations**, all the interviewed realities claim to be very attentive to collaborations. In the case of universities, for example, 12/14 have collaborations in progress with companies and research centers. For companies and research centers, the figu e is 21/26 and 12/13 respectively.

There are many diffe ent fragmented realities that are defining a sha ed methodology,

defining the features of a new hybrid figure

that is able to control every phase of the methodology.
This professional is able to connect the dots between the diffe ent professional figu es that we will encompass later, by making sure that shared

tools for knowledge are defined
We have to define their skills as well as the ideal number of professionals involved in Fashion-tech projects.
Results from interviews show that in the HEIS the biggest part of professionals have competences both in the field of design (fashion, industrial, architecture), and in science (electronic engineering, chemistry, physical computing, textile technology). The same attitude come from the analysis of Companies: industrial, fashion and graphic designers work together with textile, biometric and electronic engineers, software developers and programmers, chemist, microbiologists and experts in robotics and learning technologies but also with professionals more focused on marketing, e-commerce, fashion consultant. These various competences are also suggested from the company department involved in fashion tech. In the biggest case studies (52%) the entire company is involved in fashion tech, while the remaining case studies (48%) R&D, Investments, Agency Services, Experimental Laboratory, Innovation, Sales Department, Developing department, Marketing are specifcally dedicated to fashion-technologies.
At least, RCs, as previously described have mainly professionals from science such as textile, electronics and software engineers, physics, chemist.

An increase in collaboration and interdisciplinary skills within fashion-tech are needed, which has been described as problematic by both literature (*Seymour, 2008*) and practitioners (e.g. Suzi Webster). As the number of employees, their education and skills within the explored areas differ greatly within the organizations, diffe ent strategies are utilized to tackle this issue. HEIs, RCs and companies all are outsourcing knowledge not available within their structure, for example through collaboration or employing freelancers to reach a bigger variety of technical skills. This has been demonstrated for example by VTT Technical Research Centre collaborating for design skills (with approximately 100 employees working within fashion-tech), but also by LYS Technologies (only 1 person working full time) for everyday business and marketing. Thus, it can be concluded that the lack of interdisciplinary skills and need for external knowledge is not related to the size of the organization. Additionally, companies are organizing internal education activities to ensure the employees´ knowledge of diffe ent disciplines (i.e. Lunch & Learn at Myant Inc. and Inuheat Group AB).

However, the presence of figu es who are able to know the scope of design is required. They can be Fashion Designers or engineers who are able to deal with the development of technologies. In the case of Smart textiles these professionals will probably be chemists, biologists or Textile engineers. On the other hand, those who will be able to control the part of wearable technology will certainly be most likely electronic or mechanical engineers.

The research also highlights the necessary presence of professionals from the marketing field, in order to give directions about market orientation. For example, technology is a constantly growing market, even if actually these realities do not evolve, with the exception of sporadic and interesting examples, which however can not evolve and become truly cross-fields and trans-disiplines
This cross-field approach should drive professionals training and should born out of such short training courses.

During these training experiences, a designer, for example, should develop the basis for understanding programming or fabric and material components features. We will discuss this preliminary knowledge in a more specific way in the section on the methodology.
In this process, instead, a scientific figu e like an engineer, should instead acquire the bases of design.
These data open up some really interesting perspectives, given that the research objective is precisely that of trying to aggregate these realities to generate a shared model. This should not only be able to map small and limited cases of study, elevating them to successful examples of the fashiontech universe, but must really be able to define a method, to be able to clear a real thought based on the actual interpenetration of fashion and technology.

Integration is the keyword of all the research

intended not only as integration of technologies in products but also as integration of processes, languages and professional figu e and this is nothing else but the learning of the masters of the design that is that designing doesn't means inventing new shapes but creating new behaviors.
Findings starts by specifying the need to redefine the world of fashion tech, diffe entiating the product from the process in a very cler-cut way. In fact, if on one hand the product involves the designer in the phase of considering the development and the analysis of need, the integration of cross-cutting skills ranging from science to marketing and design. For example, specifically to the realm of Digital manufacturing specificall , the designer can usually benefit from employing innovative technologies, although he is not involved in their design phase, limiting itself only to using the tools (as in the case of 3D printing and laser cutting in order to derive the benefits that come from technological development).

Our interviews and desk research highlighted specific features, professional figu es and copetences for the areas of wearables, smart textiles and digital manufacturing that can be summarized as follows.

Wearables are products often in contact with the body that create a communication between what user wears (garments/accessories) and digital technologies (electronics) to enhance or add new functions to the user connecting him with his body, with other persons or objects and with the environment (IoT). The methodology to design wearables see the simultaneous or deferred participation of professionals with skills in in fashion/design, natural science/engineering and economics and managment.

Smart Textiles also known as E-textiles, smart garments, smart clothing or smart fabrics, smart textiles are fabrics that enable digital technologies (components/electronics) to be embedded and interwowen in them and provide added value to the wearer reacting to body and environmental stimuli (mechanical, thermal, chemical, biological, and magnetic). Smart textiles are the result of the simultaneous or deferred participation of (industrial, apparel, textile, system) designers and

(textile, electronics, computer) engineers.
Designers focus both on innovating product perfomances and functions through the use of smart textiles and on innovating the scenario of use of the product because of redefined performances and functions. Engineers focus on experimenting and innovating the textiles perfomances and functions.

Digital Manufacturing is an integrated approach to manufacturing that is centered around a computational system. It is part of the fashion system but it is mainly managed by manufacturing engineers using 3D modeling software to design the tools and equipment necessary for their intended applications. The design field benefits from embedding this innovative technologies along the all process and not only in the manufacturing and prototyping phase, promoting process innovation.

Yet a shared and more comprehensive definition of the three areas is needed that can be the basis for a comparison on the fashio-tech among the various players.
It is necessary to know that we are talking about the same thing and that there are shared meanings, to avoid misunderstandings and added fragmentation.
Specificall , it is useful to demonstrate the importance of a design driven and human-centered approach, specifically in the wearables field, to contribute to the generation of innovation and the vision of the three areas as a system and content and not specifically as products or process.

So it is necessary to

reshape the definition of the three main areas

part of the Fashion-Tech:

Wearables are on body products such as clothing, footwear, accessories and jewellery designed to create a communication/interaction enabled by technologies such as digital and virtual to amplify and extend natural ability and performance of the human body or add new functions to the user connecting him with his body, with other persons or objects and with the environment.

Smart textiles are knitted, woven, non-woven fabric systems designed to sense and response to external stimuli (mechanical, thermal, chemical, biological, magnetic and electrical) enabled by advanced, physical and digital technologies.

Digital manufacturing is an integrated approach to manufacturing that is centered around a computational system using tools such as 3D technologies, robotics, AI and AR and the integration between digital technologies for manufacturing processes and embedded digital technologies in products-services (IoT) to enable open and distributed manufacturing that can reshaped design, production, distribution and retail processes. The extent of applications ranges from large scale industrial systems, industry 4.0 and DIY/mini and microfactory up to digital service platforms and bottom up innovation processes, on-demand manufacturing, collaborative and on-site manufacturing (fab-lab and maker space), and repairing and remanufacturing systems.

wearables: |ˈwɛərəbəls|

are on body products such as clothing, footwear, accessories and jewellery designed to create a communication/interaction enabled by technologies such as digital and virtual to amplify and extend natural ability and performance of the human body or add new functions to the user connecting him with his body, with other persons or objects and with the environment.

smart textiles: |smɑːt ˈtɛkstaɪls|

are knitted, woven, non-woven fabric systems designed to sense and response to external stimuli (mechanical, thermal, chemical, biological, magnetic and electrical) enabled by advanced, physical and digital technologies.

digital manufacturing: |ˈdɪdʒɪtəl mænjʊˈfæktʃərɪŋ |

is an integrated approach to manufacturing that is centered around a computational system using tools such as 3D technologies, robotics, AI and AR and the integration between digital technologies for manufacturing processes and embedded digital technologies in products-services (IoT) to enable open and distributed manufacturing that can reshaped design, production, distribution and retail processes. The extent of applications ranges from large scale industrial systems, industry 4.0 and DIY/mini and microfactory up to digital service platforms and bottom up innovation processes, on-demand manufacturing, collaborative and on-site manufacturing (fab-lab and maker space), and repairing and remanufacturing systems.

Future directions

- *Identification of main keywords/emerging topics starting from desk research/interviews*

- *Identification of future possible directions in regard to new fashion-tech products, consumption habits, markets*

- *Evaluation and identification of opportunities and requirements for development of main topics within the areas of smart textiles, wearable technologies, and digital manufacturing.*

1. Protection and body enhancement through artificial second skin

2. Culture driven wearable: art, technology and innovation

3. The silent body: connecting senses and materials

4. Fashion takes care

5. Real/Virtual mixed environments

FUTURE DIRECTIONS

Combining desk research and results of the interviews with Companies, Research Centers and Higher Education Institutes, as previously described, an overview of current researches and emerging topics has been obtained. In particular, 5 macro areas emerged that may represent a direction of future development for the fashion tech sector:

- 1. Protection and body enhancement through artificial second skin
- 2. Culture driven wearable: art, technology and innovation
- 3. Hyper-body: connecting senses and materials
- 4. Fashion takes care
- 5. Real/Virtual mixed environments

Starting from the idea that a trend is a direction of movement or change in an observed value (M. C. Thomsett, 2015), information is the common denominator among all the emerging future directions

Cloud of keywords from on-going researches and emerging topics from interviews that are described in the following sections. These are not market trends, but indicators, results of an observation and an analysis of emerging issues in the latest researches that represent the macro areas of tomorrow's products and processes within fashion-tech. Some still in an early stage, others decidedly advanced.

The 5 macro areas are, in fact, the potential applications of the products that today are designed and prototyped as future scenarios by the students, professionals of tomorrow. Furthermore, they are the applications of the current research that foresees a development time of 1-3 years and which automatically are concepts for the near future as the emerging realities that foresee more and more evolved and contaminated competences. This opens up a reflection on how the intersection between fashion and technology is having a significant impact on the times - mainly in fashion - and the durability of products. Technology is also changing the speed of fashion, which on one hand makes it faster and more ethical in its processes, while on the other fashion has to wait for technology that is much slower in development and especially in times of market acceptance.

For each fashion-tech direction, recent case studies have been identified directly or transversely related to wearable technologies, smart textiles or digital manufacturing, along with analyzing their area of origin. Most of the products, technologies, fabrics or techniques come from worlds apparently far from that of fashion design, and are only the result of the meeting of different disciplines and fields. Medicine, architecture, gaming, robotics and automotive are just some of the areas where most of the innovations we are seeing are being implemented. Each will be studied in depth ranging from engineering to computer science, from fashion design to art.

Furthermore, it is also assessed how the future directions are connected to the wearable, digital manufacturing and smart textiles areas on the basis of the interviews and case studies. Evaluation parameters are utilized to indicate the future directions based on marketing, design and engineering to indicate the maturity, technology readiness and marketability of the direction. Among the evaluation parameters, the level of maturity of the future direction is included, and qualitativa evaluated by utilizing the diffusion of innovations theory (Rogers, E.M., 1983). Furthermore, the Technology Readiness Level, TRL (Horizon 2020) is evaluated, starting from the European Community's Model and taking into consideration whether the projects examined are in an embryonic, intermediate or advanced phase of development, and therefore already available for industrial production. To evaluate these aspects, an observation of the institution of origin of the project was necessary. Projects related to universities, research centers or start-ups are mostly in an embryonic phase. The research centers do not yet have a reference market for the application of the "inventions" that are developed; the projects or prototypes resulting from universities most of the times do not take into account the costs and time of development of the technologies; and start-ups do not have the funds to activate an industrial production.

Furthermore, the marketability of the projects and/or products was evaluated, that is the ability to be sold or marketed and also the attractiveness to potential employers or clients. We asked ourselves if these fashion-tech products already have a market, if they are the answer to the existing social needs and/or desires. Additionally, it was important to "quantify" the contribution of both technology and fashion. The identified trends, which are specified in the following sections, speak to:

. Professionals: inform them about emerging issues, what are the necessary skills or the other professional figures to deal with;

. Companies: inform them about the evolution of the processes;

. Research centers: on the possible applications of "inventions" developed but lacking in an application area.

1 PROTECTION

AND BODY ENHANCEMENT
THROUGH ARTIFICIAL SECOND SKIN

#1. PROTECTION AND BODY ENHANCEMENT THROUGH ARTIFICIAL SECOND SKIN

PROTECTION AS TAKING CARE OF YOUR OWN BODY, ENHANCING AND MONITORING HYSIOLOGICAL, NEUROLOGICAL AND BODY KINEMATIC PARAMETERS THAT ARE CRITICAL FOR HEALTHCARE. PROTECTION MEANS ALSO SAFETY AND COMFORT.

SOURCE
(area of application)

MEDICINE
MILITARY & DEFENSE
AUTOMOTIVE
ROBOTICS

MAIN COMPETENCES

FASHION DESIGN
PRODUCT DESIGN
MATERIALS ENGINEER
TEXTILE ENGINEER
ELECTRONIC ENGINEER

AREA

ST
WEARABLES
DM

LEVEL OF MATURITY

TECHNOLOGY READINESS LEVEL

MARKETABILITY
(consumer demand/industry offer)

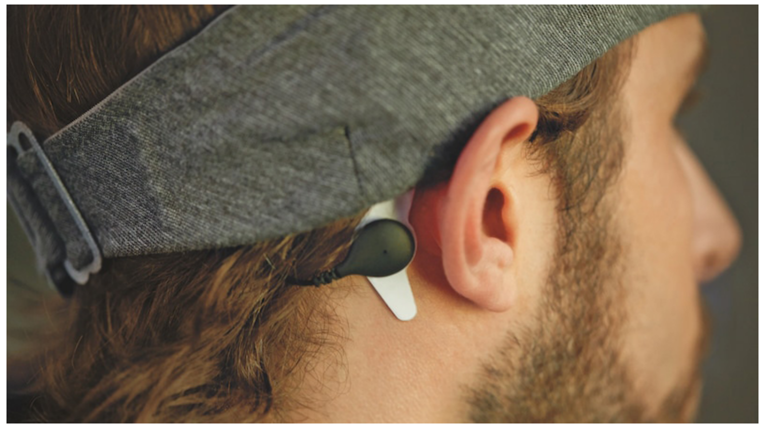
APPROACH

TECH DRIVEN
DESIGN DRIVEN

WRISTIFY

L'OREAL

PHILIPS, SMART SLEEP

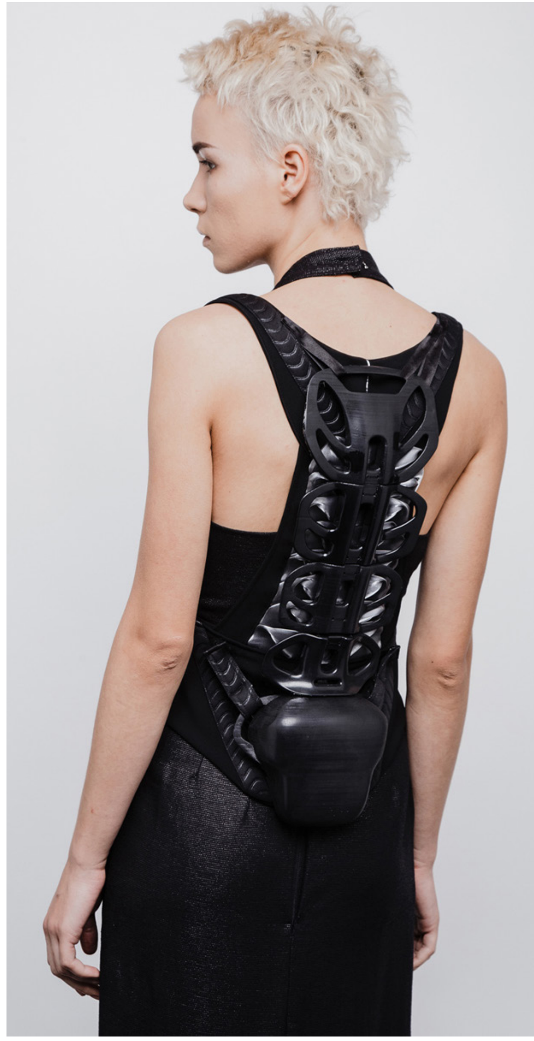


INVI BRACELET

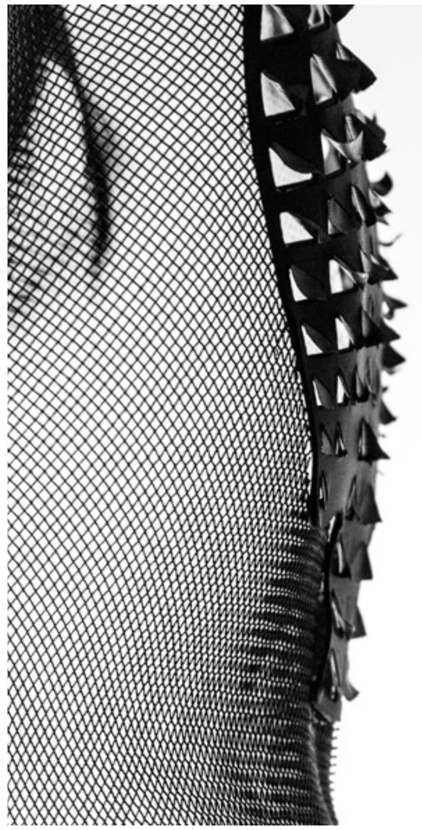
CRISTINA ALASIO, ISEEU

LVS

DE WALLEN INDUSTRY



GS[3]



LINING YAO, SECOND SKIN

Protection and body enhancement through artificial second skin

While products related to health and wellbeing have previously been focused on providing information on the users vital signs for a quantified self to improve lifestyle and control it, the wearables and smart textiles with embedded sensors are able to monitor physiological, neurological and body kinematic parameters that are critical for healthcare (Cho, 2010). Body signs, such as heart rate, respiration and motion patterns, can provide data to detect behavioral changes and health risks, and diagnose at early stages (McCann & Bryson, 2009; Cho, 2010). The biggest part of these products is connected more with the area of smart textiles and wearables than with the one of digital manufacturing. In fact fashion and product designers, and textile, electronics and material engineers are the main professional figu es involved in this macro area. It is a mature and marketable trend, mainly design driven, that come from the robotics, automotive, military and defense and medicine fields.

The most innovative example, both in terms of design and technology, is the Second Skin by Lining Yao and her team at MIT Media Lab. A new behavior of an ancient bacteria has been unearthed: the expansion and contraction of the natto cells relative to atmospheric moisture. These animate cells are harvested in a bio lab, assembled by a micron-resolution bio-printing system, and transformed into responsive fashion, a “Second Skin”. It can be observed the self-transforming biological skin activated by living bacteria. The synthetic bio-skin reacts to body heat and sweat, causing flaps around heat zones to open, enabling sweat to evaporate and cool down the body through an organic material flux

More medicine focused, LYS Technologies is focusing on the measuring the circadian rhythm that influences sleep, energy levels etc. and is related to lifestyle diseases. Similarly, Wristify is a personal, intelligent, heating and cooling bracelet regulating the body temperature to the comfort level. The device is developed by EMBR Labs established by the team of MIT engineering students. The patent-pending technology of the wearable thermostat uses high rates of temperature change applied directly to the skin giving a user body-wide sensation of thermal comfort. In addition to greater physical well-being, this thermal comfort solution helps lower energy costs and, as a result, reduce the environmental impact caused by the energy usage.

Additionally, Philips has announced a new solution to help you get some more shut-eye. Launched at CES 2018, the SmartSleep headband plays customized tones to drive you into a deeper slumber. It’s a rather medical looking soft foam headband meant to be worn in bed. But this is not just about monitoring the quality of your sleep which we’ve seen far too often. Once the headset is on, its duo of built-in sensors will connect to your forehead and behind your ears and monitor brain activity. On detecting slow-wave sleep, more commonly referred to as deep sleep, the headband starts playing white noise in a slowly repeating pattern. According to Philips this encourages your brain to remain in deep sleep.

Again from the medical field GS[3] designed by Snezhana Paderina and Nikita Replyanski is a graduated spine support system that provides dynamic back support for patients suffering from medical conditions, which cause joint hypermobility and chronic musculoskeletal issues that require daily spinal support. Using data assessed by an integrated neural network, the lightweight cable mechanism of the graduated spine support system can easily and precisely adjust to the wearer's rigidity and support level. Furthermore, VTT Technical Research Centre is interested in creating wearable sensors and technologies to understand human movement and behavior, while CCT Group is developing protection sensors and actuators, and artificial muscles and second skin interface.

A focus group for protective wearables is often sick or the elderly, who normally are not well connected to technology, which can predict future accidents or health problems. According to a study published in Smart Clothing Technology and Applications, people in general are interested in smart clothing that would satisfy physiological and safety, which are the lowest human needs (Cho, 2010). Thus, the need for protective garments is further proven. Protection is not only connected with monitoring body but also with safety. Invi Bracelet is an interesting new type of safety wearable. Designed to be a non-violent form of self-defense, this innocent looking device has a nasty surprise in store for any potential attacker. How it works is simple. If you feel you are in danger, unlock the small safety clasp and yank hard on the leather strap. This breaks the canister containing the company's stink solution. The two-step activation system is in place to ensure the device is not activated by accident. The idea is that the foul odor emitted by the bracelet will distract and demotivate the attacker. The fashionable gadget has apparently been piloted by more than 100 people in Rotterdam last year. The study found that people felt more empowered with a significant positive effect on feelings of personal safe .

With the same goal, the IseeU shapeshifter bag by Cristina Alasio that incorporates an aesthetic and a functional part. The fulcrum of the transformation is the strap in which the technology is contained which, when it is not in use, acts as an ornament but once activated becomes a system of monitoring and security for the user by tracing the position and communicating it to loved ones.

De Wallen Industry turns bike technology features into style details to deliver the most desirable and fashionable urban bike experience. Reflective textiles are used to improve the visibility of the biker during the night and, therefore, his own margin of safety. Also for safety and more recent, is the Uv sensor by L'Oréal and Yves Béharto protect against skin cancer. It is a small UV Sense device that works without the need for a battery so it is so small to be worn on the nail and track sun exposure, as a way of lowering the risk of skin cancer. "By working with L'Oréal, we are able to pair deep expertise in beauty tech with an effective design that enhances consumers' wellbeing without distracting from their everyday lives" said Yves Béhar underlining the importance of protection.

2CULTURE

DRIVEN WEARABLE:
ART, TECHNOLOGY AND INTERACTION

#2 . CULTURE DRIVEN WEARABLE: ART, TECHNOLOGY AND INTERACTION

EXPLORING HOW HUMAN AND TECHNOLOGY RELATE AND COMMUNICATE ENABLED BY DATA AND CO-CREATION, ALONG WITH HOW TECHNOLOGY AFFECTS PEOPLES LIVES AND LIVELIHOOD AND SHAPES NOTIONS SUCH AS TRUST, ETHICS AND POWER.

SOURCE
(area of application)

ROBOTICS
AI
SOCIAL STUDIES
ART/FASHION

MAIN COMPETENCES

ART
FASHION DESIGN
ARCHITECTURE
ELECTRONIC ENGINEER
ADDITIVE MANUFACTURING

AREA

ST
WEARABLES
DM

LEVEL OF MATURITY

TECHNOLOGY READINESS LEVEL

MARKETABILITY
(consumer demand/industry offer)

APPROACH

TECH DRIVEN
DESIGN DRIVEN

PAULINE VAN DONGEN

ANOUK WIPPREKT, SMOKE DRESS

ADIDAS, FUTURECRAFT

HUSSEIN CHALAYAN, ROOM TONE

IVYREVEL, CODED COUTURE

KATE HARTMAN, EAR BENDER

Culture driven wearable: art, technology and interaction

Fashion-tech plays a role in in being human, its relationships, activities and related consequences – it can communicate and articulate what we stand for; public expressions demonstrating our beliefs, values, politics and cultural contexts. Thus, a culture-driven wearable approach opens up new possibilities that allow and support social conversations about democracy, ethics, behaviour, trust and resilience. Design has the potential to change attitudes and has the power to change culture in a single gesture (M. Mattus, 2008) and that is the core of the last future direction. Designers and artists have the power to generate thoughts and knowledge around human behaviours, interaction with the body, other people and the environment. Substantially the idea is to have a strong impact on human behaviours, relationships, gesture, and more in general, on contemporary culture. In society, we must develop an awareness of how technology is constantly changing and evolving, therefore new questions arise, and are explored through creative provocations, ideas and explorations sometimes enabled data-driven design. Design invites responses to rethink and reimagine our relationship with technology and re-shaping cultural shifts in a hyper-connected world. By involving areas of wearables and digital manufacturing, expertise of fashion designers, artists, architects and electronic engineers are necessary and are often enabled by additive manufacturing.

Artists that explore the interaction between human and technology often develop new means of communication by considering human activity in relation to technology and surrounding social spaces. Anouk Wipprecht, a fashion designer, and Niccolò Casas, designer, architect and professor, have designed the Smoke Dress, which is 3D printed for the Electrified Volkswagen collection. The designers are interested in fashion-tech due to its potential impact on contemporary society, as fashion in combination with technology enables new ways of communication between people, and the body and technology. According to the designers, technology will be more intimate with the body; thus, the relation the society has towards technology needs to be redefined. With the Smoke Dress, intimate space around the wearer is explored, where with someone entering the personal space of the wearer, the dress consequently creates a veil of smoke. The dress utilizes a tangible micro-controller, proximity sensor and a smoke system, while the dress itself is fully 3D printed by Materialise to have the look and feel of ultra-futuristic fabric. Another project facilitating communication of one's emotions is Room Tone by Hussein Chalayan in collaboration with Intel, where biosensing accessories detect emotions and project imagery reflecting the emotions to display them for the outside world. In 2016 he presented biosensing sunglasses in Paris as a part of his collection that were powered by Intel Curie module which utilized Bluetooth to measure EEG signals in the brain, along with another sensor to measure heart rate and pulse. An Intel Compute Stick was used to collect, translate and communicate the data by incorporating it in a belt. Using the idea of repressed emotions, everyday anxieties and emotions, the models stress levels were translated and projected onto a wall. According to Chalayan he explored diffe ent moments related to human and surrounding environments in which he described himself as a storyteller.

Artist and technologist Kate Hartman is utilizing wearable electronics to explore how humans relate and communicate to themselves, other people and the world. In series of projects such as the Talk to Yourself Hat, Gut Listener and Nudgeables, Hartman focuses on the body as the interface to communicate to the world. She utilizes everything from radio transceivers to funnels and plastic tubing to enable communicating your thoughts to yourself and others, express your feelings and mediate experiences. According to Hartman, the focus is not on the object but the space around the object. Additionally, Pauline van Dongen has explored human interactions through the project Issho that with a denim jacket encourages the wearer to be present in the moment. In collaboration with ItalDenim, the designer released the jacket that can hold a dialogue with its wearer, and based on the wearer´s behavior the jacket acts as a mediator of revived experiences in daily life. In general, the focus of artists is on researching and developing new ideas and concepts, which most likely reach the prototype stage but never industrial production phase as the technology readiness level is not high and their work is displayed in exhibitions and museums.

Design enabled by data has gained momentum and often includes the customer and their lifestyles to design the product, and presents the opportunity to exploring collaborations enabled by technology or agile approaches to production. Adidas with their Futurecraft 4D project has developed high performance running shoes based on data-driven design enabled by digital light synthesis technology for 3D printing. Liquids are used for 3D printing as they have the most flexibility in material design and provide long-lasting cushioning and stability with controlled energy return. The goal of the project and products is to change the way the consumers experience the product, and how it is changing the life of an athlete. Additionally, data-driven design is utilized in the Speedfactory, where co-creation and data gathered from athletes guides the design of the running shoes, which are then produced in high speed, hyper flexible local production. Thus, both projects combine data and the consumer for a novel product enabled by innovative materials and production systems. Another example here is the Coded Couture App developed by a digital fashion house Ivyrevel supported by H&M in collaboration with Google. The outcome is the Data Dress, which is personalized based on data gathered by the app by tracking each user's activity and lifestyle to reflect the way they live their lives and tell their story. Google´s technology is used to design the dress, which is unique, on-trend and most importantly, affo dable. Besides Google, Amazon has also focused on understanding how fashion develops, and thus developed algorithms that understand what is stylish based on analysing images and the labels attached to them. Furthermore, an algorithm has developed by an Amazon team at Lab126, which can generate new styles from scratch based on previously examined styles from fashion images. Using data and AI in such way for fashion design raises the question of how will the role of the fashion designer change?

Another aspect to be taken in consideration is how the interaction between humans and machines will affect humans. On one hand, it is interesting to explore and understand how the use of automated digital manufacturing technologies will impact people´s jobs and livelihood. Technologies, such as Sewbo - a robot that by chemically stiffens the fabric to enable automatic sewing robots to produce a garment - will disrupt fashion manufacturing by shortening supply chains and long lead times while producing high-quality clothing at a lower cost than when utilizing human labour. While the fear of robots stealing jobs is justified, according to Wired (2018), machines are taking over parts of the jobs. Furthermore, as explained by Michael Chui, a partner at McKinsey Global Institute, humans and robots or AI working together can produce higher quality products than any of them working alone. On the other hand, as AI is utilized to build smart customer data sets for creating hyper-targeted campaigns or solutions to engage customers more, consumer´s concerns regarding the use of AI will grow (The Future Laboratory, 2018). Even more, it raises the question of how consumer awareness regarding who owns their data and how it is used can be increased. Invading people's private lives was already explored by James Bridle in 2013 with his project Surveillance Spaulder. The Spaulder, a CCTV surveillance detector, receives a signal once the wearer is under the radar of the CCTV camera. The detector then sends feedback to the wearer as a reminder of living in a world of power inequalities. According to Bridle, instead of utilizing wearable technology in its common way of the gathered data emitted to the environment, the Spaulder focuses on gathering external information to notify the wearer. While the issues related to privacy of data collected is concerning, the previously described examples, such as the projects developed by Amazon, are providing insights of human behaviour in their daily lives and changes in culture. Thus, the rise of AI will be shaping aspects related to power, trust and ethics, even more as according to The Future Laboratory´s compilation of trends for 2018, AI and automation are concepts brands will be focusing on in 2018, which further strengthens the identified futu e direction.

3 HYPER-BODY

CONNECTING SENSES AND MATERIALS

#3 . HYPER-BODY: CONNECTING SENSES AND MATERIALS

TECHNOLOGY INTEGRATE THE SENSES OF THE BODY - EYESIGHT, HEARING, TOUCH - TO GIVE ADDITIONAL LANGUAGES AND CONNECTION TO THE USERS.

SOURCE
(area of application)

MEDICINE
ENGINEER
MILITARY & DEFENCE

MAIN COMPETENCES

ART
FASHION DESIGN
TEXTILE DESIGN
ELECTRONIC ENGINEER

AREA
ST
WEARABLES
DM

LEVEL OF MATURITY

TECHNOLOGY READINESS LEVEL

MARKETABILITY
(consumer demand/industry offer)

APPROACH
TECH DRIVEN
DESIGN DRIVEN

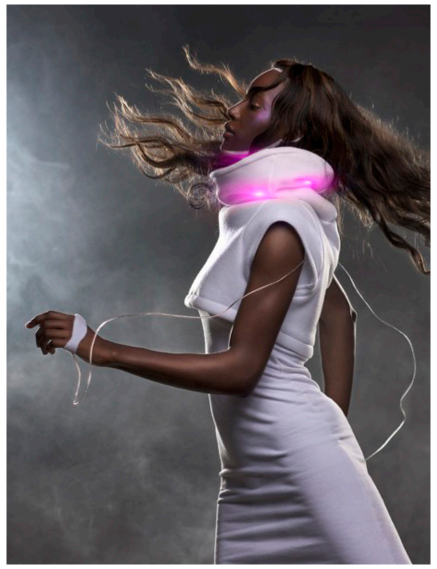
CV DAZZLE

NISSEY CORP., PRIVACY VISOR

MIT,DUOSKIN

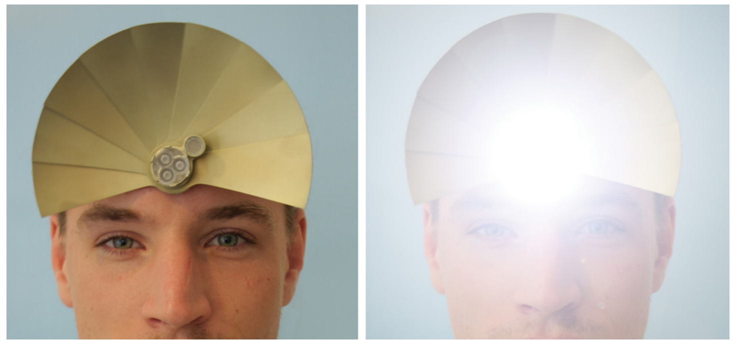
SENSOREE, AWELECTRIC

SENSOREE, MOOD SWETER



SENSETONE

BETABRAND



FORMAFANTASMA, MY OWN SHOW

E-MOTION PROJECT

Hyper-body: connecting senses and materials

In the relation between technology and design, the body plays an important role. While on one side the technologies are becoming contactless, wireless, on the other side products with embedded technology are becoming more and more connected with body and skin, in some cases they become part of them. Starting from medicine, engineering, military and defense fields, artists, fashion and textiles designers together with electronic engineers can explore how to create new languages for the body, specifically designing wearables and smart textiles.

The direction involves three of the five senses: eyesight, hearing, touch. Eyesight is specifically connected with the increasingly widespread facial recognition. Facial recognition is a common biometric modality used by military and law enforcement for homeland security and border patrol. The technology however, is increasingly utilized by the commercial sector, airports, social media sites and cities (S. Porter, 2017) (D. Vena, 2017). Facebook's facial recognition algorithm, for example, can identify a person in an uploaded photo with 98 percent accuracy (N. Lachance, 2016). Typically, facial recognition software identifies facial landmarks and characteristics, such as the nose and cheekbones, and a computer algorithm measures certain features such as nose width and distance between the eyes. The facial recognition software then compares the measurements and landmarks with images in an existing database to make a match (S. Higginbotham, 2015).
Researchers are responding by developing clothing and accessories that thwart the software's recognition capabilities. For example, CV Dazzle explores how fashion can be used as camouflage from face-detection technology, the first step in automated face recognition. The name is derived from a type of World War I naval camouflage called Dazzle, which used cubist-inspired designs to break apart the visual continuity of a battleship and conceal its orientation and size. Likewise, CV Dazzle uses avant-garde hairstyling and makeup designs to break apart the continuity of a face. Since facial-recognition algorithms rely on the identification and spatial relationship of key facial features, like symmetry and tonal contours, one can block detection by creating an "anti-face". Another example is Nissey Corp., based in Fukui Prefecture, Japan designed a privacy visor that claims to scramble digital facial recognition software. The Privacy Visor consists of a titanium glasses frame with a mesh-like screen one can see through. Because facial-recognition technology analyzes the shadow patterns around one's eyes, the design of the visor prevents programs from doing that by reflecting light to those areas, altering the shadows. Technology used to prevent technology's invasion.

There are other projects against recognition that are more connected with properties of the materials. The first one was made by Beta Brand. Flashback Collection are garments made from highly reflective material — perfect for anyone who doesn't want his or her picture taken, or for photobombers who really want to make a lasting impression. The second one is My Own Show by Formafantasma. Hacked flashlights mounted on a golden radiating wire construction will flash as a reaction to other cameras, resulting in overexpose of the face of the wearer. The headpiece questions the thin borderline between the private and the public, and the way we daily 'sculpt' our own image on network communities.
The second sense, hearing, can be exemplified for example by Sensetone that is a hearing wearable, a portable stylish voice recorder that can automatically dictate user's notes to text through a mobile app. It syncs with a mobile device and transcribes anything into text. It is a sort of digital

secretary, a real support for the user while the second project is more connected with emotions and interaction with the user. Furthermore, Quietude by Glitch Factory and with the coordination of Santa Chiara Fablab, University of Siena is a jewel that enhances the experience of deaf women in a sound-oriented world. The accessories detect sounds and translate them into vibrations and shape changes. When wearing these accessories, the deaf women will be able to perceive voices and other sounds through their body.

The last micro area for such trend is dedicated to touch, more in general to the contact with the skin. The E-motion Project by Max Schäth, utilizing shape memory alloy and integrated sensors, it is a jacket's hood that changes with the wearer's mood, not acting as an analogue to the mood, but attempting to make the wearer aware of the changes. The mood of the user is also detected by two project designed by Sensor. The GER MOOD SWEATER interprets emotion and displays excitement levels instantly with an illuminated collar. It is a whimsical approach to new forms of communication inspired by the body. The Galvanic Extimacy Responder (GER) is a soft sensor based on the GSR – Galvanic Skin Response which reads electrodermal activity. This sensor has been used in classic lie detector tests to show excitement levels. The sensors are located on the hands and reads excitement levels then translates the data into a palette of affective colors. The Mood Sweater design of the bowl shaped, high collar is positioned with LED lights that reflects onto the self for instant biofeedback as well as act as a tele-display or external blush to communicate to the other. Located around the larynx, the visual interface offers new forms of speaking

AWElectric is bioresponsive animatronic fashion that exhibits extimacy – externalized intimacy. These wearable soft robotic designs are composed of embedded fabrics with visual and tactile displays. The AWElectric is a duet design that animates the emotionally charged goosebumps, amplifies them, and shares the thrill.
The AWElectric animates awe – the subtle mix of fear and wonder that gives the chills, the shivers up your spine that provoke emotionally based goosebumps called frisson. This feeling is often achieved from vast views of nature, music, or the Ah-ha moment. Finally, the last example is directed build on the skin. It is made by MIT and named duoSkin. DuoSkin is a fabrication process that enables anyone to create customized functional devices that can be attached directly on their skin. Using gold metal leaf, a material that is cheap, skin-friendly, and robust for everyday wear, we demonstrate three types of on-skin interfaces: sensing touch input, displaying output, and wireless communication. DuoSkin draws from the aesthetics found in metallic jewelry-like temporary tattoos to create on-skin devices which resemble jewelry. DuoSkin devices enable users to control their mobile devices, display information, and store information on their skin while serving as a statement of personal style. We believe that in the future, on-skin electronics will no longer be black-boxed and mystified; instead, they will converge towards the user friendliness, extensibility, and aesthetics of body decorations, forming a DuoSkin integrated to the extent that it has seemingly disappeared.

4FASHION-TECH

TAKES CARE

SUSTAINABILITY GOES ACROSS DESIGN, PRODUCTION AND RETAIL COVERING THE ENTIRE SUPPLY CHAIN AND IT IS INTENDED AS EFFICIENCY, RECYCLABILITY, TRANSPARENCY, MISSION ORIENTATION AND ETHICAL UPGRADES.

SOURCE
(area of application)

BIOLOGY
SCIENCE/EXPERIMENTATION ON MATERIALS
SUPPLY CHAIN MANAGEMENT

MAIN COMPETENCES

MATERIALS ENGINEER
TEXTILE ENGINEER
SYNTHETIC BIOLOGY
COMPUTER SCIENCE
FASHION/PRODUCT DESIGN
MANAGEMENT

AREA
ST
WEARABLES
DM

LEVEL OF MATURITY

TECHNOLOGY READINESS LEVEL

MARKETABILITY
(consumer demand/industry offer)

APPROACH
TECH DRIVEN
DESIGN DRIVEN

PATAGONIA, DON'T BUY THIS JACKET

BUY ME ONCE, ONLINE SHOP

CRADLE TO CRADLE CERTIFIED T-SHIRT

SILK PAVILLION, NERI OXMAN

H&M, RENEWCELL

CIRCULAR FIBERS

PAULINE VAN DONGEN, ENERGY HARVASTING TEXTILE

SPIBER, NORTH FACE

Fashion-tech takes care

Sustainability goes across design, production and retail covering the entire supply chain and it is intended as efficien , recyclability, transparency, mission orientation and ethical upgrades. Involving mainly smart textiles and digital manufacturing, the level of maturity of this trend is very high as also its marketability. Usually the presence of technology is beyond the scenes and it is managed by material and textile engineers, biologists, computer scientist and at least fashion and product designers.

Due to the fashion industry´s high impact on the environment, investing in technological solutions to decrease the impact is crucial (Forbes, 2016). While digital technologies, such as the “see-now buy now” concept or digital solutions offe ed by companies such as Berge and Teko Solutions can decrease waste by producing only what is in demand, involving microbiology and biotechnology into fashion to produce biodegradable garments can close the cycle of production, disposal and reuse (Seymour, 2010). Thus, new sustainable fibers and production techniques that advance sustainability, developed for example by BioCouture and Bolt Threads. While BioCouture´s aim is to grow garments from bacterial-cellulose (Seymour, 2010), Bolt Threads is brewing spider silk protein to then spin it into yarn (Forbes, 2016). According to Danielle Wilde, an associate professor from University of Southern Denmark, designers should learn from biology in order to shift their design process to more sustainable practices. On the other hand, a sustainability related issue requiring attention relates to diffe ent theoretical life spans of textiles and the electronics utilized in wearables (McCann & Bryson, 2009), which can be challenging for a workable integration of the two (Seymour, 2008).

The goal is trying to combine artificial and natural for being sustainable. A great example not in the fashion field is the Silk Pavilion by Neri Oxman that explores the relationship between digital and biological fabrication on product and architectural scales. The primary structure was created of 26 polygonal panels made of silk threads laid down by a CNC machine. Inspired by the silkworm’s ability to generate a 3D cocoon out of a single multi-property silk thread (1km in length), the overall geometry of the pavilion was created using an algorithm that assigns a single continuous thread across patches providing various degrees of density. Overall density variation was informed by the silkworm itself deployed as a biological printer in the creation of a secondary structure. A swarm of 6,500 silkworms was positioned at the bottom rim of the scaffold spinning flat non-woven silk patches as they locally reinforced the gaps across CNC-deposited silk fibers. Following their pupation stage the silkworms were removed. Resulting moths can produce 1.5 million eggs with the potential of constructing up to 250 additional pavilions. Affected by spatial and environmental conditions including geometrical density as well as variation in natural light and heat, the silkworms were found to migrate to darker and denser areas. Desired light effects informed variations in material organization across the surface area of the structure.

It is a great sustainable model not so far from what’s happening in fashion. Let’s think to the MMON PARKA, developed by Spiber together with The North Face, made from artificial spider silk, designed to endure the harsh conditions and intense cold of the South Pole. Spiber staged a five-step innovation cycle in order to produce ever better qualities of artificial spider silk. It starts with molecular design: designing amino acid sequences, on the basis of bioinformatic analyses, that deliver better tensile strength, elasticity and heat tolerance. The second step is gene synthesis: synthesising genes that produce the desired amino acid sequences. Then, microbial fermentation. The synthesized genetic DNA is introduced into microorganisms. Test spinning can begin as soon as 10 days after gene synthesis is complete, once fermentation and refining conditions have been fine-tuned. The fourth step is spinning. The fib oin proteins produced through microbial fermentation are refined and formed into fib es. Spiber established a scalable spinning process that paves the way for mass production of artificial spider silk. Finally: prototyping. Spiber produces textiles and composites from their new materials; they assess their productivity and functionality. They feed back this data into the next generation of molecular design, after which a new cycle begins. The result of all this hard work is enormous: compared to when they started in 2008, they have dramatically increased productivity and decreased costs, bringing us to a place where large scale adoption of protein materials is finally becoming a reality.

The proof of the interest in sustainability comes also from the news that H&M group have partnered with Swedish company re:newcell, whose unique technology recycles used cotton, viscose and other cellulosic fibers into a new, more sustainable dissolving pulp. The pulp can be turned into new textile fibers and be fed into the textile production cycle. The partnership is another step towards H&Ms goal to use 100% recycled or other sustainably sourced material by 2030. Also the birth of the first global retailer in fashion launching Gold level Cradle to Cradle (C2C) CertifiedTM T-Shirts. C&A produces in consideration of the environment, in a way that does not create excess waste, uses only safe chemicals and dyes, produced in a socially responsible way and is designed for its next life.

Taking care of environment does not only mean recycling, but also saving energy. The experimentations of Pauline van Dongen are designed with the aim to harvest energy. She has created a backpack from a single piece of knitted fabric, which incorporates tiny solar power beads enabling wearers to charge smart devices on the go. Like Van Dongen's clothing with integrated solar panels, the Radius backpack features a strap that utilises the sun-powered charging technology. This section of the bag is composed of small spherical beads functioning as solar cells. Made by solar textile company Sphelar Power, energy harvested through the strap is then fed through a charging cable that can be accessed by opening a magnetic clasp on the top pocket of the bag.

Regarding product to supply chain, buying cheap can cost more in the long run, so it's often frugal to spend more on quality. With this idea, Buy Me Once was born, to find quality brands that last. The site's goal is to promote affo dable, quality products that are also sustainable and socially conscious. A lot of the products come with lifetime warranties, because as the name suggests, the aim is to buy stuff once. Of course, these products are typically more expensive, but we often spend more on throwaway items that we regularly replace. They are promoters of brand such as Patagonia, which has earned a large and loyal customer base through its relentless focus on sustainability from product development to innovative campaigns and involvement in sustainability initiatives. Millennials in particular are interested in more-sustainable solutions (The State of Fashion, 2018); 66 percent of global millennials are willing to spend more on brands that are sustainable (Nielsen). Today, consumers buy less, but more intelligently to reduce consumption (Trendhunter 2018)

Digitalization and sustainability, which includes transparency, are two of the most powerful market influences in today's corporate landscape. The digitalization-sustainability convergence in business and society offers executives both opportunities and challenges, within the organization and across organizational boundaries. Within, companies are using digital tools to map their environmental footprint and assess the impact of environmental shifts on their business. (MITSloan Management Review, 2018)

It is recent the news of the Amazon's patent for bracelets useful to track where warehouse employees are moving to help them being more efficien but also fashion companies have started to embrace the importance of sustainability, with 42 out of 100 fashion brands in 2017 disclosing supplier information (S. Ditty, 2017). All these examples confirm fashion is moving in a sustainable way. According to a report by the Business and Sustainable Development Commission, sustainable business has the potential to unlock $12 trillion in new market value. Companies have recognized the importance of pursuing sustainable development to create maintainable strategies, answering consumer demand for environmental awareness and supporting the implementation of the circular economy. This willingness has run alongside the efforts of officia powers such as national governments and collective international bodies like the United Nations. The organization's ambitious Sustainable Development Goals (SDGs) will increasingly feature on the innovation agendas of businesses.

5 REAL/VIRTUAL

MIXED ENVIRONMENTS

#5. REAL/VIRTUAL MIXED ENVIRONMENTS

EXPLORATION OF NEW ENVIRONMENTS: THE SPACE AND THE IDEA OF CREATING SPECIFIC GARMENTS OR ACCESSORIES FOR IT; NEW "UNREAL" PLACES CREATED WITH MIXED REALITY AS RESULT OF THE ADDITION OF VIRTUAL AND AUGMENTED REALITY; NEW DIMENSIONS FOR SELF-ASSEMBLY AND PROGRAMMABLE MATERIALS.

SOURCE
(area of application)

GAMING
MILITARY
ARCHITECTURE
FURNITURE
BIOLOGY
AERONAUTICS

MAIN COMPETENCES

COMPUTATIONAL DESIGN
MATERIALS ENGINEER
SYNTHETIC BIOLOGY
ADDITIVE MANUFACTURING
COMPUTER SCIENCE

AREA

ST
WEARABLES
DM

LEVEL OF MATURITY

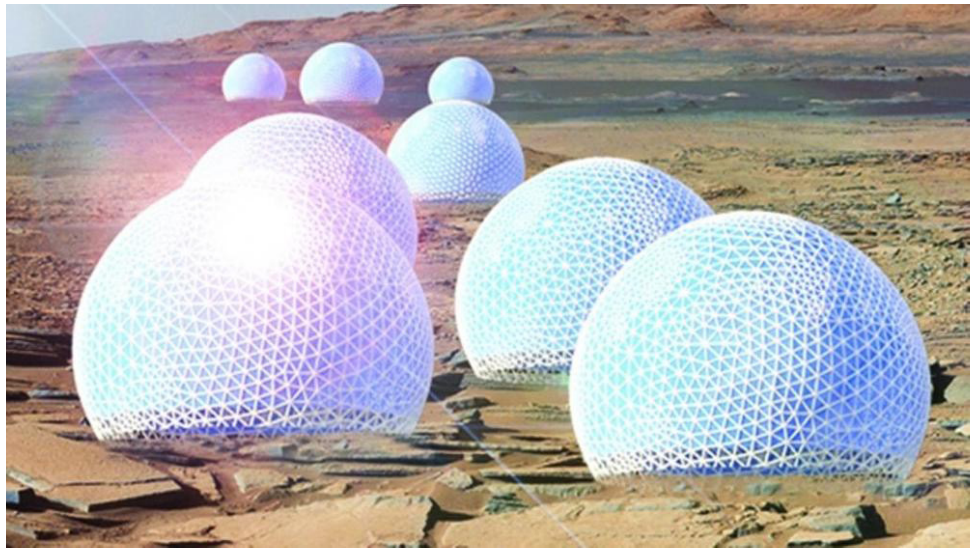
TECHNOLOGY READINESS LEVEL

MARKETABILITY
(consumer demand/industry offer)

APPROACH

TECH DRIVEN
DESIGN DRIVEN

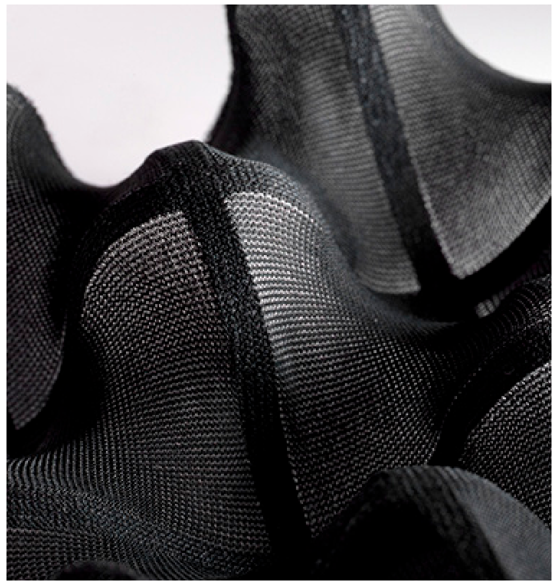
MARS CITY DESIGN COMPETITION 2017



NERI OXMAN, WANDERERS

TILT BRUSH I HTC VIVE MIXED REALITY

BURBERRY'S AR INTEGRATION IN IOS 11 APP



4D PRINTING

Real/Virtual mixed environments

Fashion architectures, real or digital, as a result of technical and material innovation and inventions guarantee an experience to the consumer. Fashion architecture also means exploring or building environments: the space and the idea of creating specific garments or accessories for it; analogical/digital places created and customized with mixed reality as result of the addition of virtual and augmented reality; new dimensions for self-assembly and programmable materials; artificial intelligence for all the supply chain.

Technologies and application scenarios such as gaming, military fields, architecture, furniture, biology and aeronautics are explored. It emerges the coexistence of diffe ent skills in the design and development of products or processes. Specificall , professionals with skills in computational design, materials design, synthetic biology, additive manufacturing and computer science are able to fit mainly in the development of smart textiles and digital manufacturing, areas most affected by this trend. The predominance of a technology-driven approach is evident which has, however, as a consequence, a still low level of maturity in terms of production possibilities and more often than not there is still a specific eference market.

Space, 60s inspiration for André Courrèges Moon Girl Collection, Couture Future, Hyperbole and Prototype, becomes a real and possible destination for consumers. An MIT team developed a design concept addressing “how will people live on Mars?” as part of Mars City Design 2017, an international competition focused on sustainable cities on Mars to be built in the next century. MIT’s winning urban design, titled Redwood Forest, creates domes or tree habitats that can each house up to 50 people. The domes provide open, public spaces containing plants and abundant water, which would be harvested from the northern plains of Mars. The tree habitats sit atop a network of underground tunnels, or roots, providing access to private spaces and easy, shirt-sleeve transportation to the other tree habitants in the community of 10,000. In addition to connectivity, the roots offer residents protection from cosmic radiation, micrometeorite impacts, and extreme thermal variations.

These new frontiers directly affect the fashion world, therefore it is no coincidence that many of the institutions identified as a case study in the research are carrying out or have collaborated with the European Space Agency to develop smart fabrics and collections that take into account the diffe ent environmental conditions. Ohmatex, for example is collaborating with The European Space Agency in order to develop muscle performance monitoring equipment. Neri Oxman, professor at MIT Media Lab, with the Wanders collection explores how traveling to destinations beyond planet Earth involves voyages to hostile landscapes and deadly environments. Crushing gravity, amonious air, prolonged darkness, and temperatures that would boil glass or freeze carbon dioxide, all but eliminate the likelihood of human visitation. 3D printed wearable capillaries designed for interplanetary pilgrims are infused with synthetically engineered microorganisms to make the hostile habitable and the deadly alive. Each design is a codex of the animate and inanimate with an origin and a destination: the origin being engineered organisms, which multiply to create the wearable within 3D printed skins; and the destination being a unique planet in the solar system. The setting for this exploration is the solar system where, with the exception of planet Earth, no life can exist. Design research at the core of this collection lies at the intersection of multi-material 3D printing and Synthetic Biology.

Regarding innovative materials, it is also important to discuss research around 4D printing. Skylar Tibbits, an MIT Researcher, architect, designer, computer scientist and TED Senior Fellow, is working on BioMolecular Self-Assembly and human scale 4D printing as well as a technology called 4D Printing: Multi-material Shape Change Over Time. MIT is not the only lab to be exploring the world of 4D printing, the ARC Centre of Excellence for Electromaterials Science (ACES) at Wollongong University is also conducting research in the field. ACES is looking into applications in the production of soft robotics for the medical field. Whilst still in its infancy, the field of 4D printing is expected to be used extensively in the future, leading MarketsandMarkets to predict that the 4D printing market will reach $63m by 2019 and more than half a billion by 2025. A lot of excitement surrounds 4D printing technology as a nucleus of creativity. Ideas in the development stage include the development of clothing that responds to environmental stimuli maximize wearer comfort. The idea of 4D printed clothes is being taken further by the military who hope to produce camouflage that actively blends into the surrounding environment. While these first examples are more connected to real spaces and products the next are more referred to processes and experience.

In the 17th “Technology, Media & Telecommunications” Deloitte Annual Report, some of the most emerging trends are highlighted and we find very interesting innovations in terms of digital economy. “Enterprises are finally ready for the integration of advanced digital technologies, such as machine learning - said in a statement Paul Sallomi, Vice President of Deloitte - with the real goal of accelerating innovation to achieve better business results, develop quicker and more effective decision-making processes and bring new products and services to the market”. According to the study published in December 2017, over 1 billion smartphone users will develop content in augmented reality at least once in 2018, with an additional estimate: 300 million of them will do it at least once a month and tens of millions at least once a week. We already have previously seen some examples connected to augmented reality, but while AR has been around for many years, 2018 will be marked as the beginning of mass consumer uptake, thanks to the smartphone integration we’re starting to see. The forecast is for 900 million AR-enabled smartphones by the end of 2018, according to consulting firm Digi-Capital (Forbes 2018).

Already we’re seeing multiple retailers and brands taking note. There have been more than 20 million downloads of L’Oreal’s Makeup Genius app, for instance, which uses AR to let users virtually try-on beauty products on their phones. Others brands including Sephora, Charlotte Tilbury and Rimmel have followed suit. Burberry has taken a particularly playful and interactive approach with ARkit, for instance, allowing users of its iOS app to overlay digital illustrations by artists Danny Sangra on their own pictures through the camera lens, and then share them on social media. “At some point, we’re going to look back and think, how did we not have a digital layer on the physical world,” Greg Jones, director of VR and AR at Google, said at Shoptalk Europe earlier this month. This is what augmented reality achieves and mixed reality makes better.

Mixed Reality is the merging of real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real time. Mixed reality takes place not only in the physical world or the virtual world (de Souza e Silva, Adriana; Sutko, Daniel M. (2009). Digital Cityscapes: merging digital and urban playspaces. New York:

Peter Lang Publishing, Inc.), but is a mix of reality and virtual reality, encompassing both augmented reality and augmented virtuality (P. Milgram and A. F. Kishino ,1994) via immersive technology. Also in this case it is not a recent invention - the first mixed reality system was developed in the 1990s by US Air Force's Laboratories - but the innovation is in its application. Specifically in fashion, there are all the tools to push mixed reality. One of the best examples is the performance of Angela Haddad - VR Creative Director and artist based in Los Angeles and creator of One Third Blue - for Tilt Bruch wearing HTC Vive creating digital models in real world. It is an example of how innovation can change the way in which designers work today and test their project. But the intersection of technology involves all the supply chain to make it smarter.

Textiles, today, are not anymore labor-intensive craft. IoT, artificial intelligence and ERP give the opportunity to make textile a heavily technology-driven process and being part of Industry 4.0. That means automated control over textile fabrication process from design and coloring to fiber construction, creation, finishing and delivery. According to 2017 findings by McKinsey & Company, an AI-based approach could also reduce forecasting errors by up to 50 percent, while overall inventory reductions of 20 to 50 percent are feasible. Stichfix currently uses AI to improve its clothing designs by analysing images and learning about specific styles of clothing. The subscription company generated $977 million in net revenue in 2017, up from $730 million in 2016, helping it to edge in on the likes of Asos. A good example of artificial intelligence is Farfetch's "Store of the Future." Automatic customer recognition at the store's entrance, RFID-enabled clothing racks and digital mirrors that allow customers to choose sizes, colours and directly check out, all demonstrate how AI can be employed to excite customers in-store while seamlessly integrating the online and offlin experiences and to satisfy the high-quality expectations of the consumer. Now the customer is in charge because technology has really given the customer access to so much information. So they're really determining what is relevant. They have high expectations with customer service, the product, and the cost. Furthermore, they can go on an app and compare pricing globally and instantaneously. "She has more knowledge and is more savvy than she has ever been" (Tory Burch, The State of Fashion, 2018). Additionally, shoppers with more important things to do – and that's all of them – will embrace the outsourcing of certain retail experiences to algorithms and smart devices. That means the automation of hunting, negotiating, purchasing, delivery arrangements and more (Trendwatching 2018).

GLOSSARY

AI (Artificial Intelligence)
Artificial intelligence (AI, also machine intelligence, MI) is intelligence demonstrated by machines, in contrast to the natural intelligence (NI) displayed by humans and other animals. In computer science AI research is defined as the study of “intelligent agents”: any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals.

AR (Augmented Reality)
Augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are “augmented” by computer-generated perceptual information, ideally across multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory. The overlaid sensory information can be constructive (i.e. additive to the natural environment) or destructive (i.e. masking of the natural environment) and is spatial registered with the physical world such that it is perceived as an immersive aspect of the real environment.

Design Driven Innovation
Design-driven innovation is an approach to innovation based on the observation that people do not just purchase products, or services, they buy ‘meaning’ – where users’ needs are not only satisfied by form and function, but also through experience.

Digital Manufacturing
Digital manufacturing is an integrated approach to manufacturing that is centered around a computational system using tools such as 3D technologies, robotics, AI and AR to enable open and distributed manufacturing that can reshaped design, production, distribution and retail processes.

DIY (Do It Yourself)
Do it yourself is the method of building, modifying, or repairing things without the direct aid of experts or professionals. Academic research describes DIY as behaviors where “individuals engage raw and semi-raw materials and component parts to produce, transform, or reconstruct material possessions, including those drawn from the natural environment (e.g. landscaping)”.

ERP
Enterprise resource planning (ERP) is a process by which a company (often a manufacturer) manages and integrates the important parts of its business. An ERP management information system integrates areas such as planning, purchasing, inventory, sales, marketing, finance and human resources.

Fashion-tech
Fashion Tech is technology that enables a fashion experience when the user wear it or interact with it.

IoT (Internet of Things)
The Internet of things (IoT) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these objects to connect and exchange data. Each thing is uniquely identifiable through its embedded computing system but is able to inter-operate within the existing Internet infrastructure.

Marketability
The ability of a commodity to be sold or marketed. Attractiveness to potential employers or clients.

MI
Machine Intelligence (synonymous of AI)

Millenials
Millennials (also known as Generation Y) are the generational demographic cohort following Generation X. There are no precise dates for when this cohort starts or ends; demographers and researchers typically use the early 1980s as starting birth years and the mid-1990s to early 2000s as ending birth years.

MR (Mixed Reality)
Mixed reality (MR), sometimes referred to as hybrid reality, is the merging of real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real time. Mixed reality takes place not only in the physical world or the virtual world, but is

a mix of reality and virtual reality, encompassing both augmented reality and augmented virtuality via immersive technology.

ML (Machine Learning)
Machine learning is a field of computer science that gives computer systems the ability to “learn” (i.e. progressively improve performance on a specific task) with data, without being explicitly p ogrammed.

Reflectables
Reflectables are a new concept being introduced to the eyeglasses industry that will allow the user to protect themselves from being spied on by surveillance camera systems, and improve their visibility while doing activities outside at night.

Smart textiles
Smart textiles are are knitted, woven, non-woven fabric systems designed to sense and response to external stimuli (mechanical, thermal, chemical, biological, magnetic and electrical) enabled by advanced, physical and digital technologies.

Technology Driven Innovation
Management philosophy that pushes for development of new goods or services based on a firm s technical abilities instead of proven demand: to make keys first and then look for locks to open

VR (Virtual Reality)
Virtual reality (VR) is a computer-generated scenario that simulates a realistic experience. The immersive environment can be similar to the real world in order to create a lifelike experience grounded in reality or sci-fi. Augmented reality systems may also be considered a form of VR that layers virtual information over a live camera feed into a headset, or through a smartphone or tablet device.

Wearables
Wearables or wearable technologies are on body products such as clothing, footwear, accessories and jewellery designed to create a communication/interaction enabled by technologies such as digital and virtual to amplify and extend natural ability and performance of the human body or add new functions to the user connecting him with his body, with other persons or objects and with the environment.

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FORM FOR PARTNERS . DESK RESEARCH

□ HEI □ RESEARCH CENTRE □ COMPANY □ OTHER _________

NAME:

PLACE (country, city):

WEBSITE:

AREA OF INTERST:
□ WEARABLES □ SMART TEXTILES □ DIGITAL

DESCRIPTION (200 words):

REFEREE/ROLE:

MAIL:

*attachment*B

FORM FOR COMPANIES

PUBLICLY AVAILABLE DATA

SECTION #1: GENERAL DESCRIPTION

1. MAIN AREA OF INTEREST IN THE FIELD OF FASHION-TECH:
□ WEARABLES □ SMART TEXTILES □ DIGITAL MANUFACTURING
2. INDICATE THE EMERGING TOPICS (max 3) YOU ARE FOCUSING ON RELATED TO YOUR MAIN AREA OF INTEREST IN THE FIELD OF FASHION-TECH:
3. COMPANY'S DEPARTMENT INVOLVED IN THE FIELD OF FASHION TECH:
4. HOW LONG HAVE YOU BEEN INVOLVED IN THE FIELD OF FASHION-TECH?
□ 0-1 YEAR □ 1-5 YEARS □ MORE THAN 5 YEARS

DATA NOT TO BE PUBLISHED

SECTION #2: THE TEAM

1. NUMBER OF PROFESSIONALS INVOLVED IN THE FASHION-TECH AREA:
□ 1 □ 2-5 □ 5-10 □ MORE THAN 10
1.1 THEIR EDUCATIONAL BACKGROUND:
□ ENGINEER □ DESIGNER □ OTHER (SPECIFY) ______________
1.2 THEIR EXPERTISE:
2. DO YOU HAVE SPECIFIC TRAINING COURSES FOR PROFESSIONALS TO ENHANCHE THEIR SKILLS IN THE FASHION-TECH FIELD? □ YES □ NO
2.1 (IF YES) THEY ARE: □ INTERNAL □ EXTERNAL (SPECIFY) ______________
2.2 DESCRIBE THE COURSE (TOPIC, DURATION, TRAINERS, ACQUIRED SKILLS:

SECTION #3: THE PROCESS

1. METHODOLOGY USED DURING THE DESIGN PROCESS FOR FASHION-TECH:
□ TECHNOLOGY DRIVEN □ DESIGN DRIVEN □ OTHER ______________
1.1 PLEASE DESCRIBE EACH STEP OF THE METHODOLOGY:
1.2 INDICATE THE MAIN SUCCESS FACTOR IN YOUR METHODOLOGY:
1.3 INDICATE THE WEAK POINT(s) IN YOUR METHODOLOGY:
1.4 RESEARCH METHODOLOGY: □ BASIC □ APPLIED
2. DESIGN SUPPORT TOOLS USED IN THE PROCESS:

SECTION #4: THE PRODUCT

1. WHICH IS YOU BEST-SELLER PRODUCT/COLLECTION/PROCESSES?
1.1 INDICATE ITS MAIN FEATURES:
1.2 INDICATE THE MAIN SUCCESS FACTOR:
1.3 INDICATE THE SALES VOLUME:
1.4 IT IS PERCIVED AS:
□ TECHNOLOGICAL PRODUCT □ DESIGN PRODUCT
2. HOW DO YOU TEST THE EFFECTIVENESS/QUALITY OF YOUR PRODUCTS?

SECTION #5: COLLABORATIONS AND RESEARCH

1. DO/DID YOU COLLABORATE WITH HIGER EDUCATION INSITUTES (HEI) OR RESEARCH CENTERS IN THE FIELD OF FASHION-TECH? □ YES □ NO
1.1 (IF YES) PLEASE INDICATE THE NAME OF THE HEI OR RESAECH CENTER AND A SHORT DESCRIPTION OF THE PROJECT:
2. DO YOU HAVE ONGOING RESEARCH IN THE FIELD OF FASHION-TECH? □ YES □ NO
2.1 THEY ARE: □ FUNDED □ NOT FUNDED
2.2 (FOR FUNDED RESEARCH) WHICH INSTITUTION/PROGRAM SUPPORTED THE RESEARCH?

AUTHORIZATION TO USE COLLECTED DATA FOR EDUCATIONAL AND NON-COMMERCIAL PURPOSES: □ YES □ NO

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FORM FOR HEIS

PUBLICLY AVAILABLE DATA

SECTION #1: GENERAL DESCRIPTION

1. MAIN AREA OF INTEREST IN THE FIELD OF FASHION-TECH:
 WEARABLES SMART TEXTILES DIGITAL MANUFACTURING
2. INDICATE THE EMERGING TOPICS (max 3) YOU ARE FOCUSING ON RELATED TO YOUR MAIN AREA OF INTEREST IN THE FIELD OF FASHION-TECH:
3. NAME OF THE COURSE/WORKSHOP RELATED TO FASHION TECH:
3.1 LEVEL OF THE COURSE: BACHELOR MASTER
3.2 COURSE LEARNING OUTCOMES

DATA NOT TO BE PUBLISHED

SECTION #2: THE TEAM

1. NUMBER OF EDUCATORS/PROFESSIONALS INVOLVED IN THE FASHION-TECH COURSES/WORKSHOPS:
 1 2-5 5-10 MORE THAN 10
1.1 THEIR EDUCATIONAL BACKGROUND: ENGINEER DESIGNER OTHER (SPECIFY) ________
PLEASE SPECIFY THE NAME OF THE UNIVERSITY
1.2 THEIR EXPERTISE:
2. DO YOU HAVE SPECIFIC TRAINING COURSES FOR EDUCATORS TO ENHANCHE THEIR SKILLS IN THE FASHION-TECH FIELD? YES NO
2.1 (IF YES) THEY ARE: INTERNAL EXTERNAL (SPECIFY) _____________
2.2 DESCRIBE THE COURSE (TOPIC, DURATION, TRAINERS, ACQUIRED SKILLS:
3. NUMBER OF STUDENTS IN THE FASHION-TECH COURSE/WORKSHOP: 0-10 10-20 30-40 > 40
3.1 STUDENTS' PREVIOUS EDUCATION: ENGINEERING DESIGN OTHER (SPECIFY) _________
3.2 MAIN SKILLS ACQUIRED FROM STUDENTS DURING THE COURSE/WORKSHOP IN THE FIELD OF FASHION-TECH:
3.3 PERCENTAGE OF STUDENTS EMPLOYED WHITIN THE FIRST YEAR AFTER GRADUATION IN THE FIELD OF FASHION-TECH: 0-10% 10-30% 30-50% 50-70% MORE THAN 70%

SECTION #3: THE PROCESS

1. METHODOLOGY USED DURING THE COURSE/WORKSHOP TO DESIGN FASHION-TECH:
 TECHNOLOGY DRIVEN DESIGN DRIVEN OTHER _____________
1.1 PLEASE DESCRIBE EACH STEP OF THE METHODOLOGY:
1.2 INDICATE THE MAIN SUCCESS FACTOR IN YOUR METHODOLOGY:
1.3 INDICATE THE WEAK POINT(s) IN YOUR METHODOLOGY:
1.4 RESEARCH METHODOLOGY: BASIC APPLIED
2. EDUCATIONAL SUPPORT TOOLS FOR STUDENTS:
3. EXPECTED RESULTS OF THE COURSE/WORKSHOP: REAL PRODUCT FOR MASS PRODUCTION
 PROTOTYPES UNDELIVERED PROJECTS ON PAPER OTHER _____________
4. ASSESSMENT WORK CRITERIA:

SECTION #4: THE RESEARCH

1. DO YOU HAVE ONGOING RESEARCH IN THE FIELD OF FASHION-TECH? YES NO
1.1 THEY ARE: FUNDED NOT FUNDED
1.2 (FUNDED RESEARCH) WHICH INSTITUTION/COMPANY/PROGRAM SUPPORTED THE RESEARCH?
1.3 WHO IS THE PM OF THE RESEARCH AND WHAT IS HIS/HER ROLE IN THE UNIVERSITY?
1.4 WHO DOES THE RESEARCH TEAM CONSIST OF?
1.5 WHAT IS THE TOPIC OF THE RESEARCH?
1.6 RESEARCH METHODOLOGY: BASIC APPLIED
2. DO/DID YOU COLLABORATE WITH COMPANIES OR RC IN THE FIELD OF FASHION-TECH? YES NO
2.1 (IF YES) PLEASE INDICATE THE NAME OF THE COMPANY/RC AND A SHORT DESCRIPTION OF THE PROJECT:

AUTHORIZATION TO USE COLLECTED DATA FOR EDUCATIONAL AND NON-COMMERCIAL PURPOSES: YES NO

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FORM FOR RESEARCH CENTERS

PUBLICLY AVAILABLE DATA

SECTION #1: GENERAL DESCRIPTION

1. MAIN AREA OF INTEREST IN THE FIELD OF FASHION-TECH:
 WEARABLES SMART TEXTILES DIGITAL MANUFACTURING
2. INDICATE THE EMERGING TOPICS (max 3) YOU ARE FOCUSING ON RELATED TO YOUR MAIN AREA OF INTEREST IN THE FIELD OF FASHION-TECH:
3. HOW LONG HAVE YOU BEEN INVOLVED IN THE FIELD OF FASHION-TECH?
 0-1 YEAR 1-5 YEARS MORE THAN 5 YEARS

DATA NOT TO BE PUBLISHED

SECTION #2: THE TEAM

1. NUMBER OF PROFESSIONALS INVOLVED IN THE FASHION-TECH AREA:
 1 2-5 5-10 MORE THAN 10
1.1 THEIR EDUCATIONAL BACKGROUND:
 ENGINEER DESIGNER OTHER (SPECIFY) _____________
1.2 THEIR EXPERTISE:
2. DO YOU HAVE SPECIFIC TRAINING COURSES FOR PROFESSIONALS TO ENHANCHE THEIR SKILLS IN THE FASHION-TECH FIELD? YES NO
2.1 (IF YES) THEY ARE: INTERNAL EXTERNAL (SPECIFY) _____________
2.2 DESCRIBE THE COURSE (TOPIC, DURATION, TRAINERS, ACQUIRED SKILLS:

SECTION #3: THE PROCESS

1. METHODOLOGY USED DURING THE DESIGN PROCESS FOR FASHION-TECH:
 TECHNOLOGY DRIVEN DESIGN DRIVEN OTHER _____________
1.1 PLEASE DESCRIBE EACH STEP OF THE METHODOLOGY:
1.2 INDICATE THE MAIN SUCCESS FACTOR IN YOUR METHODOLOGY:
1.3 INDICATE THE WEAK POINT(s) IN YOUR METHODOLOGY:
1.4 RESEARCH METHODOLOGY: BASIC APPLIED
2. DESIGN SUPPORT TOOLS USED IN THE PROCESS:
3. EXPECTED RESULTS OF THE RESEARCH (PROCESSES, PRODUCT, REPORT, PROTYPES…):
4. HOW DO YOU TEST THE EFFECTIVENESS AND THE QUALITY OF YOUR RESULTS IN TERMS OF INNOVATION? QUALITATIVE TEST QUANTITATIVE TEST OTHER
4.1 PLEASE DESCRIBE IT:

SECTION #4: COLLABORATIONS AND RESEARCH

1. DO YOU HAVE ONGOING RESEARCH IN THE FIELD OF FASHION-TECH? YES NO
1.1 THEY ARE: FUNDED NOT FUNDED
1.2 (FOR FUNDED RESEARCH) WHICH INSTITUTION/PROGRAM SUPPORTED THE RESEARCH?
1.3 INDICATE THE PERCENTAGE OF YOU FUNDED PROJECTS RELATED TO FASHION-TECH:
 0-10% 10-30% 30-50% 50-70% MORE THAN 70%
2. DO/DID YOU COLLABORATE WITH HIGER EDUCATION INSITUTES OR COMPANIES IN THE FIELD OF FASHION-TECH? YES NO
2.1 (IF YES) PLEASE INDICATE THE NAME OF THE HEI (HIGHER EDUCATION INSTITUTION) OR COMPANY AND A SHORT DESCRIPTION OF THE PROJECT:

AUTHORIZATION TO USE COLLECTED DATA FOR EDUCATIONAL AND NON-COMMERCIAL PURPOSES: YES NO

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Eindhoven University of Technology
Estonian Academy of Arts
ETH Zurich, Wearable Computing Lab
Fashion CAD, De Montfort University
Fashion technology accelerator
Footwear Technology Center of La Rioja
Future Tech Lab
Gerber Technology
Ghent University
Glitch Factory
Google Project Jacquard
H&M CO:lab
Kristi Kuusk
IMEC
Institute of Textile Technology, RWTH Aachen University
Inuheat Group AB
LYS Technologies Ltd
Machina
Miralab - University of Geneva
Neff
NYU
Ohmatex
Olga Noronha
Pauline von Dongen
Popkalab
Pratt Institute
Principled Design
Santa Chiara Fab Lab
Saxion University of Applied Sciences
SKIIN / Myant Inc
Smart Textiles
Statex Produktions & Vertriebs GmbH
Studio SubTela
Suzi Webster
TamiCare
TEAM group, De Montfort University
TEKO Solutions
The Brooklyn Fashion + Design Accelerator
The Digital Design MA, De Montfort University
The Fashion Innovation Agency, LCF
The Fashion & Technology, University of the Arts Linz, Kunstuniversität Linz
The MA Wearable Futures, Ravensbourne University
The Mills Fabrica
The University for the Creative Arts, Farnham
Tinker Design
Universität der Künste Berlin - DRLab
University of Bolzen
University of Minnesota
University of Southen Denmark
Unmade
UX.FTT
VTT Technical Research Centre of Finland

The benckmarking report is a foundational intellectual output that aims at describing the state of the art of Higher Education programmes and other high-qualitative didactic experiences, Research Centers and Companies.
The benchmarking report maps players active in the field - in Europe and worldwide -, identify the best practices and read currend and upcoming trends in the fashion-tech field.
Trough a desk research complemented by face-to-face and long-distance interviews, the benchmarking report offers a broad overview of processes, resources, tools and contents characterising the current fashion-tech offe .

FASHION TECH

Education and research
BENCHMARKING REPORT