



Fashion for the Metaverse (FAME) - Openings

AIVR – Special Session Track

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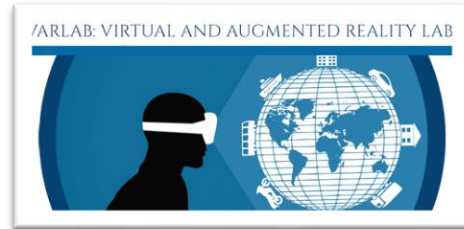
METAVVERSE



Lorenzo Stacchio – Short CV



VR*A*i



[Google Scholar profile](#)



Short CV

- Post-Doc Researcher, University of Macerata
- Ph.D. candidate in CS, University of Bologna
- Master Degree in Computer Science

Research areas

- eXtended Reality;
- Deep Learning;
- Mostly applied to:
 - Cultural Heritage;
 - Creative Industries (Fashion);
 - Industrial applications;

Pasquale Cascarano – Short CV



[Google Scholar profile](#)



Short CV

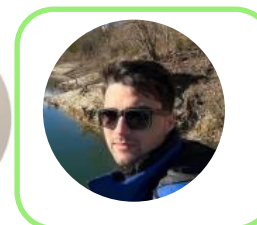
- Assistant professor at UNIBO (currently)
- PhD in Mathematics (2022)

Research areas

- Inverse problems
 - Variational models
 - Machine & Deep Learning
- applied to creative industries and bio-medicine

VR*A*i

vision robotics
artificial
intelligence



Ehi, that's me!



VRAI Laboratory



VRAI Team Research is mainly concerned in the following topics:

- Computer Vision
- Computer Graphics
- Machine Learning & Deep Learning
- Mobile Robotics & Mechatronics
- ... and **Extended Reality!**

VARLAB: Virtual and Augmented Reality Lab

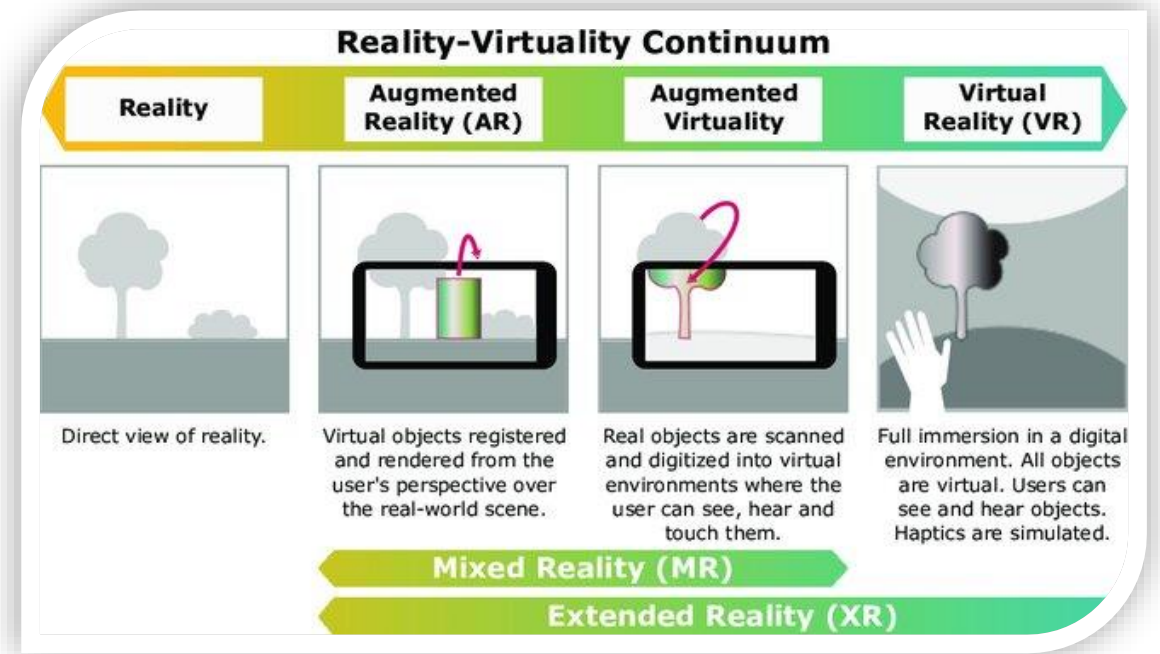


- The **Virtual and Augmented Reality Laboratory** is the result of an ongoing collaboration between the Department for Life Quality Studies, Department of Arts and the Department of Computer Science and Engineering;
- Our main research topics involves the design of immersive XR environments, ranging from AR to VR, often integrating AI models and paradigms;

Metaverse

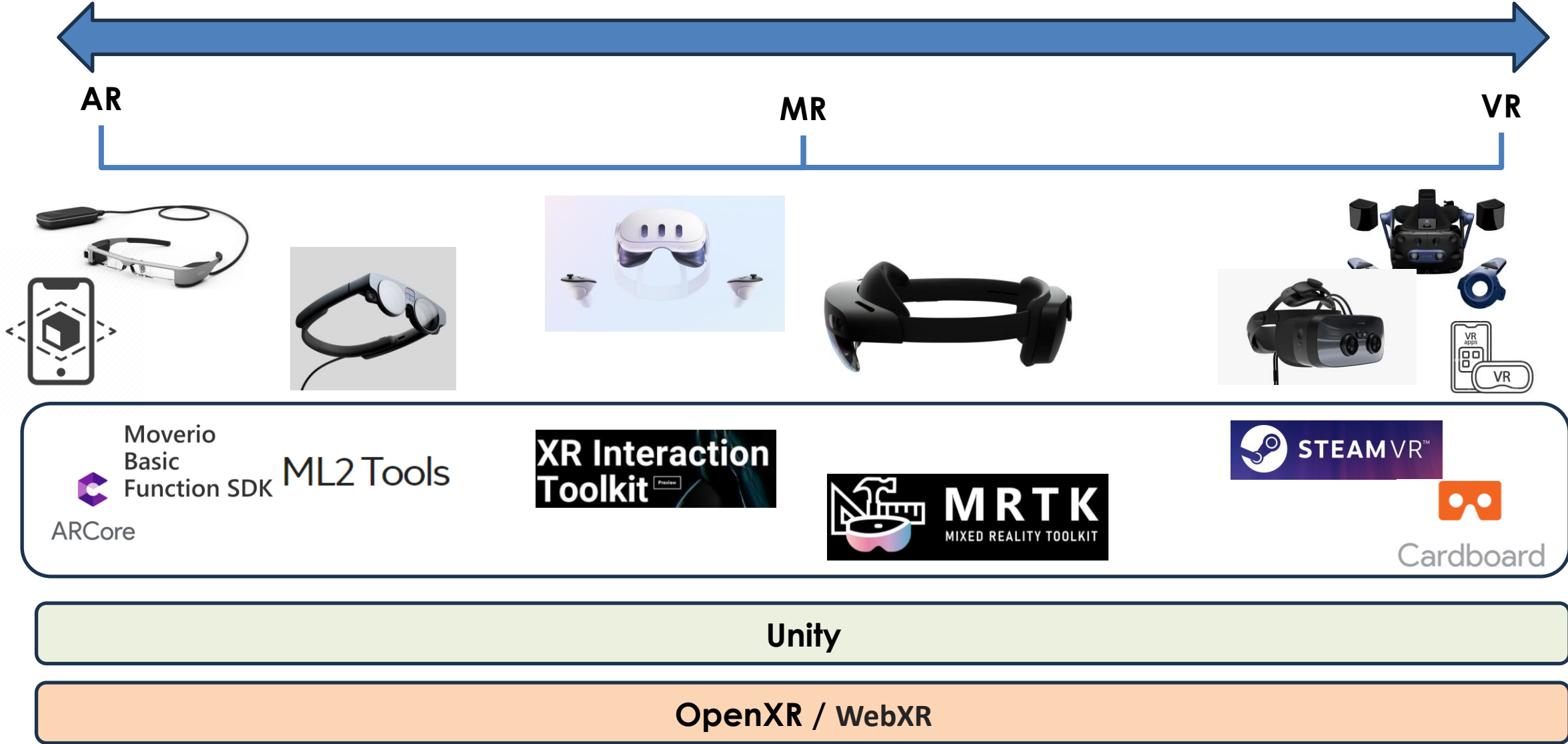
- The term “**metaverse**” is a recent inclusion in scholars' vocabulary but was introduced in 1992 through Neal Stephenson's novel “Snow Crash”;
- A generalization of such a concept was embraced by Mark Zuckerberg when he launched Meta, envisioning the metaverse as a unified and immersive ecosystem in which the divisions between the digital and physical realms are invisible to users;
- Another definition of the Metaverse amounts to “the layer between a subject and reality, a 3D virtual shared world where all activities can be carried out with the help of **eXtended Reality (XR)** paradigms” [2].

XR is an umbrella term, where the X is a variable that represent past, current and future spatial computing technologies [2,3];



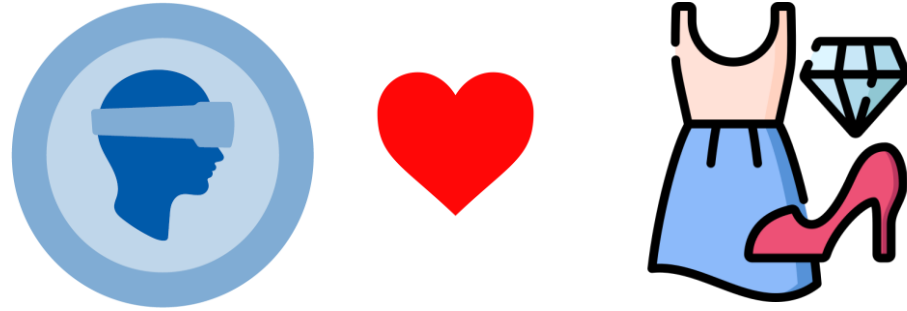
XR on a spectrum of technological stacks

- Based on the target device, different technological stack must be adopted



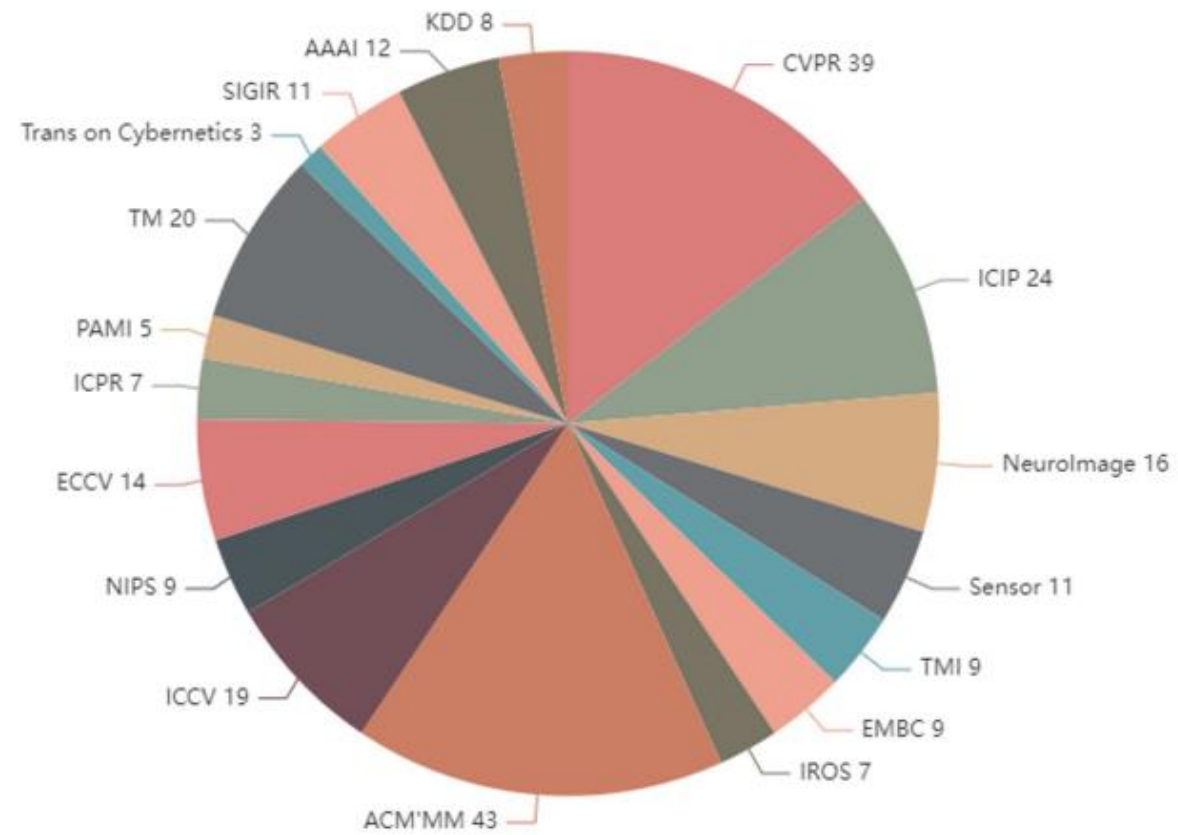
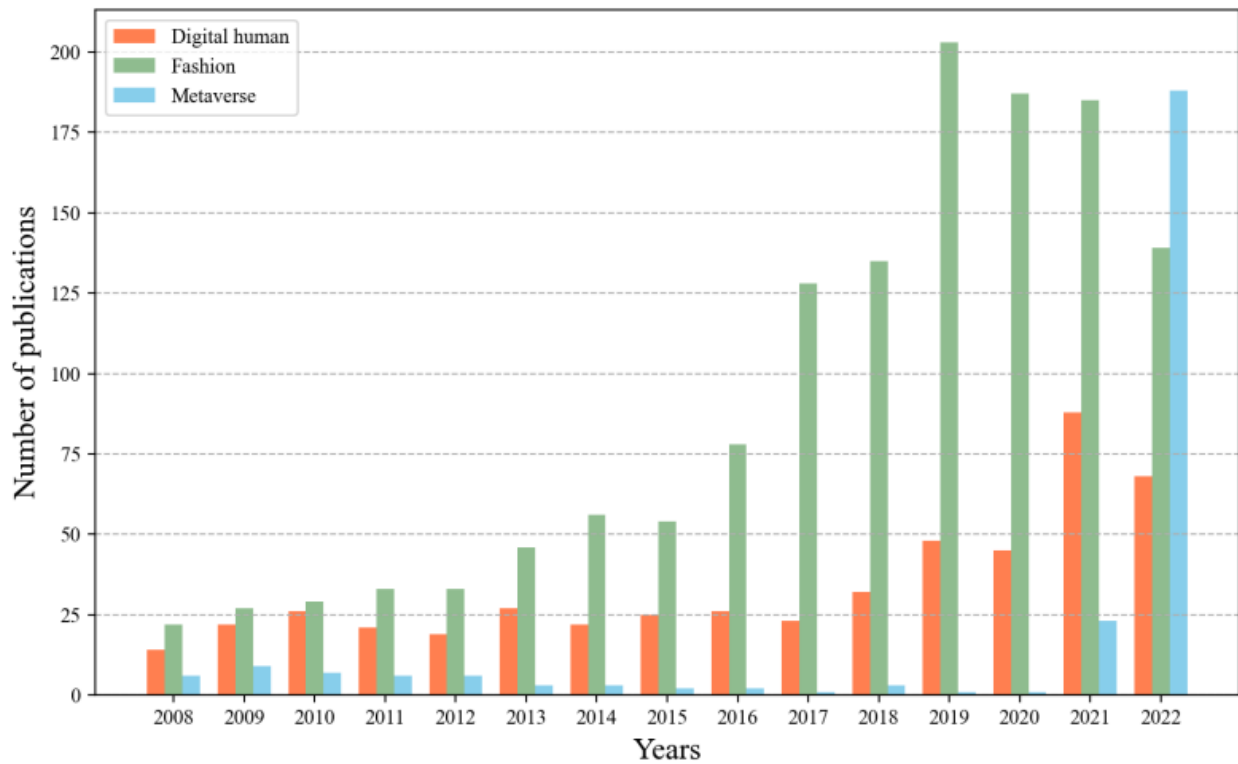
Why building Fashion Metaverses?

Motivations



- [Forbes](#) estimates that the global market for VR and AR in retail will reach USD 1.6 billion by 2025;
- Furthermore, according to [Statista](#), the global XR market hit 28 billion U.S dollars in 2021, and by 2028 is predicted to reach over 250 billion;
- In the report “The State of Fashion Technology” The Business of Fashion and McKinsey & Company experts mention that it is expected that fashion companies increase technology investment between 3 and 3.5 percent by 2030, with a large investment dedicated to XR and AI technologies [1a];
- In fact, **XR can bring several benefits to fashion brands, providing tools for collaborative design and innovative ways to engage with consumers;**
- Immersive visualization of products, natural interactions and virtual-try on, are just examples of technologies that could be employed [1a];

- Following this line, 3D content is predicted to enhance conversion by up to 27.96% on retailer websites [1a];
- Another examples is information fruition for decision making AI helps predicting future scenario and XR helps to visualize and manipulate variables;
- At the same time **x-commerce** scenarios **could be defined, to provide novel and collaborative experience for shopping in the metaverse;**
- **From an academic perspective, [1b] conducted a systematic literature review and found that the first publications on the subject started in 2003, becoming one of the most researched topics in the domain of digital fashion in 2021;**
- In [1c] authors collected and analyzed publications from 2007 to the present and provide a new taxonomy of extant research topics based on these articles. They found out a correlation among years and the number of publications in Fashion for the Metaverse;



Fashion Metaverse enabling technologies

- It is worth noticing that the rapid evolution of XR is also driven by advancements in other research branches, such as Artificial Intelligence (AI), Non-Fungible Token (NFT), networking and wireless technologies (5G), the Internet of Things (IoT) [1,2,3];
- In particular, the synergy between XR and **AI** is advancing several fields of research and industry [1,2,3];
- At the intersection of all these research branches, Digital Twin (DT) is rising as one of the most promising technology for a large amount of field of studies and use cases;

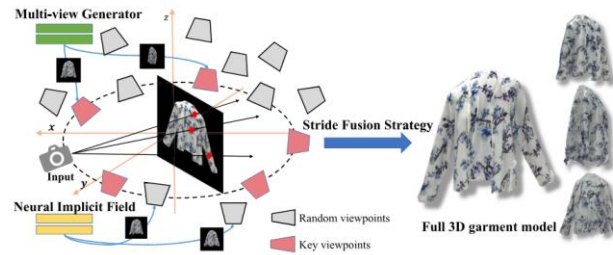
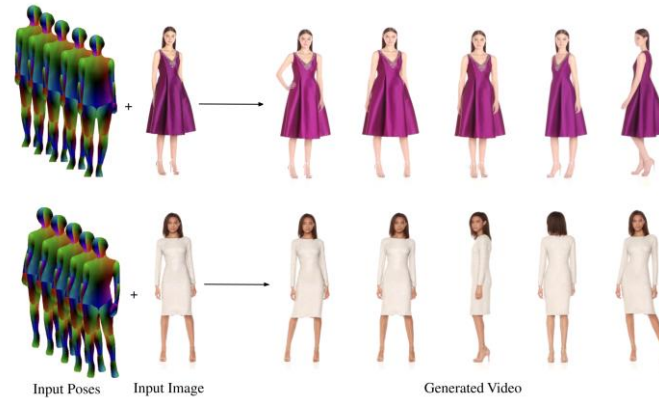
Virtual Reality: x-Commerce and Voice assistants [24]



- New opportunities for e-commerce strategies, giving birth to an XR-based commerce (x-commerce) ecosystem, that could give a more brick-and-mortar store-like experience.
- One interesting and consolidated one amounts to the interactions among customers and shop assistants inside fashion stores;
- For this reason, we designed and implemented an XR-based shopping experience, where vocal dialogues with an Amazon Alexa virtual assistant are supported, to experiment with a more natural and familiar contact with the store environment;
- **We discover that, even if the proposed implementation with Amazon Alexa as a voice assistant has imposed some design limitations, the presence of a voice assistant may improve the perceived immersion.**

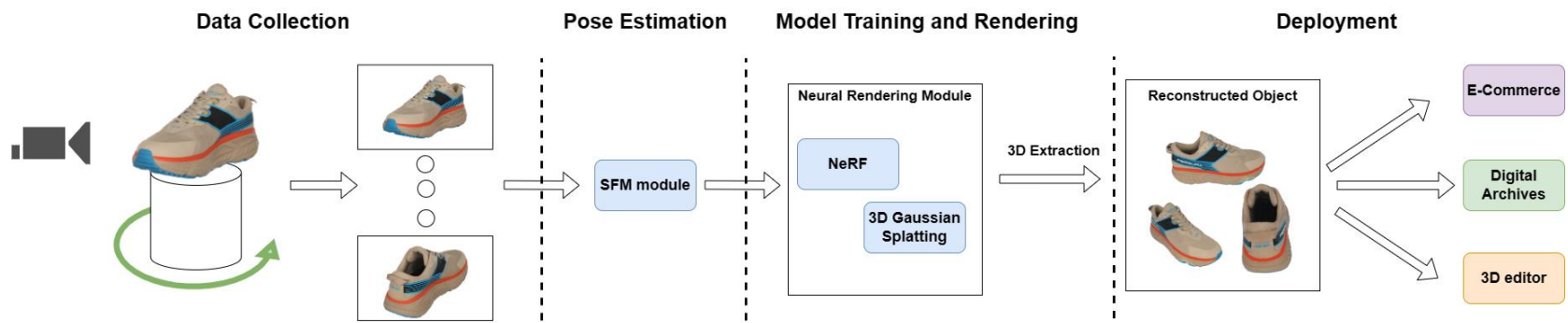
*Morotti, E., **Stacchio, L.**, Donatiello, L., Rocchetti, M., Tarabelli, J., & Marfia, G. (2022). Exploiting fashion x-commerce through the empowerment of voice in the fashion virtual reality arena: Integrating voice assistant and virtual reality technologies for fashion communication. *Virtual Reality*, 1-14.

Build FAME with Generative AI

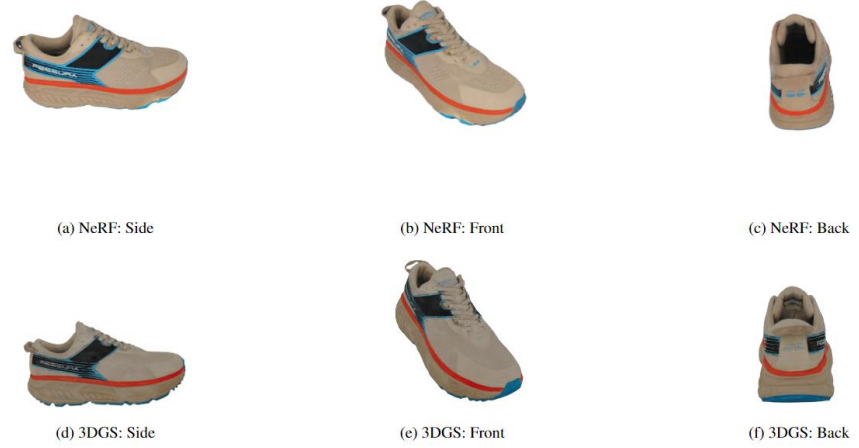


- Diffusion Models for Dress generation and VTON;
- Neural Rendering for 2D to 3D projection;
- Avatar generation (driven by LLMs);
- Automatic Fashion catwalks;

Automated Fashion 2D to 3D conversions



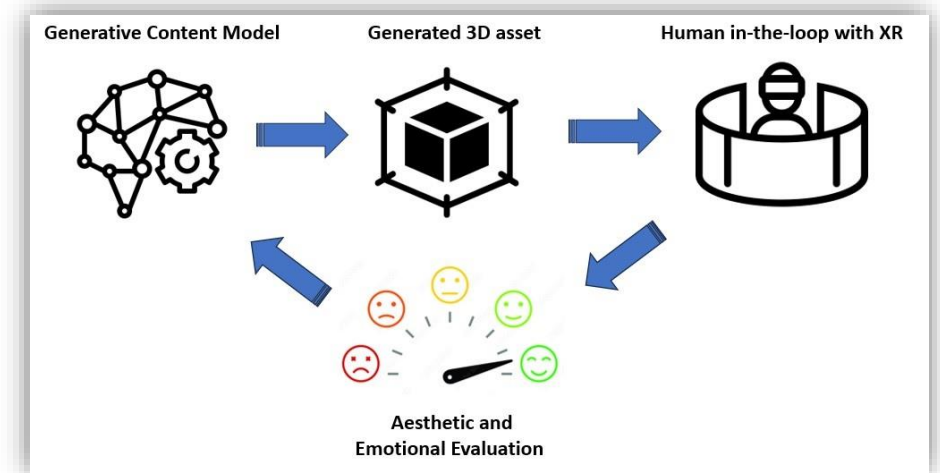
- Development of frameworks for incorporating Neural Rendering techniques into real-world industrial fashion environments, marking a pioneering step in the field;
- Comprehensive evaluation of Neural Radiance Fields (NeRF) and 3D Gaussian Splatting (3DGS) methods specifically for footwear design, including both quantitative and qualitative analyses;
- Establishment of a framework to support the wider application of AI in 3D design, bridging XR applications.



**3D fashion design: advancing the design process for a more sustainable fashion industry through Neural Rendering Methods, under review*

XR as a bridge for effective 3D genAI evaluations

- The goodness of genAI models is usually evaluated with quantitative metrics in the data or latent space;
- Humans' evaluation takes place using simple constructs such as the Mean Opinion Score (MOS), that don't consider components such as the aesthetic and emotional ones [52];
- This components could play a **role in positively controlling the automatic generation of multimedia content while at the same time introducing novel forms of human-in-the-loop**;
- On top of the previous considerations, we discuss a possible framework to inject a new Human-in-the-loop (HITL) evaluation framework, exploiting XR paradigms for immersive content;



* **Stacchio, L.**, Scorolli, C., & Marfia, G. (2022). Evaluating Human Aesthetic and Emotional Aspects of 3D generated content through eXtended Reality.

* Scorolli, C., Grasso, E. N., **Stacchio, L.**, Armandi, V., Matteucci, G., & Marfia, G. (2023). Would you rather come to a tango concert in theater or in VR? Aesthetic emotions & social presence in musical experiences, either live, 2D or 3D. *Computers in Human Behavior*, 149, 107910.

HDT as customer in a fashion shop



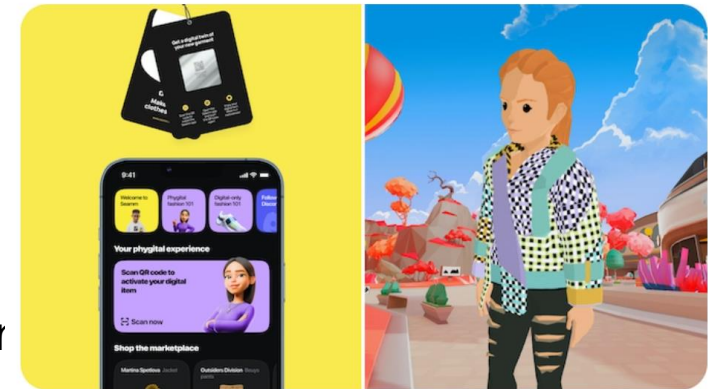
* **Stacchio, L.**, Perlino, M., Vagnoni, U., Sasso, F., Scorolli, C., & Marfia, G. (2022, March). Who will trust my digital twin? maybe a clerk in a brick and mortar fashion shop. In 2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW) (pp. 814-815). IEEE.

Fashion Digital Twins

- Digital Twin (DTs) can be defined as (physical and/or virtual) machines or computer-based models that are simulating, emulating, mirroring, or “twinning” the life of a physical entity, which may be an object, a process, a human, or a human-related feature [29];
- Each **DT is linked to its physical twin through a unique key identifying the physical twin**, and therefore allowing to establish a bijective relationship between the DT and its twin;
- **A DT is more than a simple model or simulation**, is a living, intelligent and evolving model, being the virtual counterpart of a physical entity or process;
- **The twinning process is allowed by the continuous interaction**, communication, and synchronization (closed-loop optimization) between the DT, its physical twin and the external, surrounding environment;



Consumers buy a physical apparel with Seam QR code attached.



Consumers scan the QR code and get digital twin of the apparel that can be worn in Decentraland

Interactive XR - DT Visualization/Annotation Module [30]

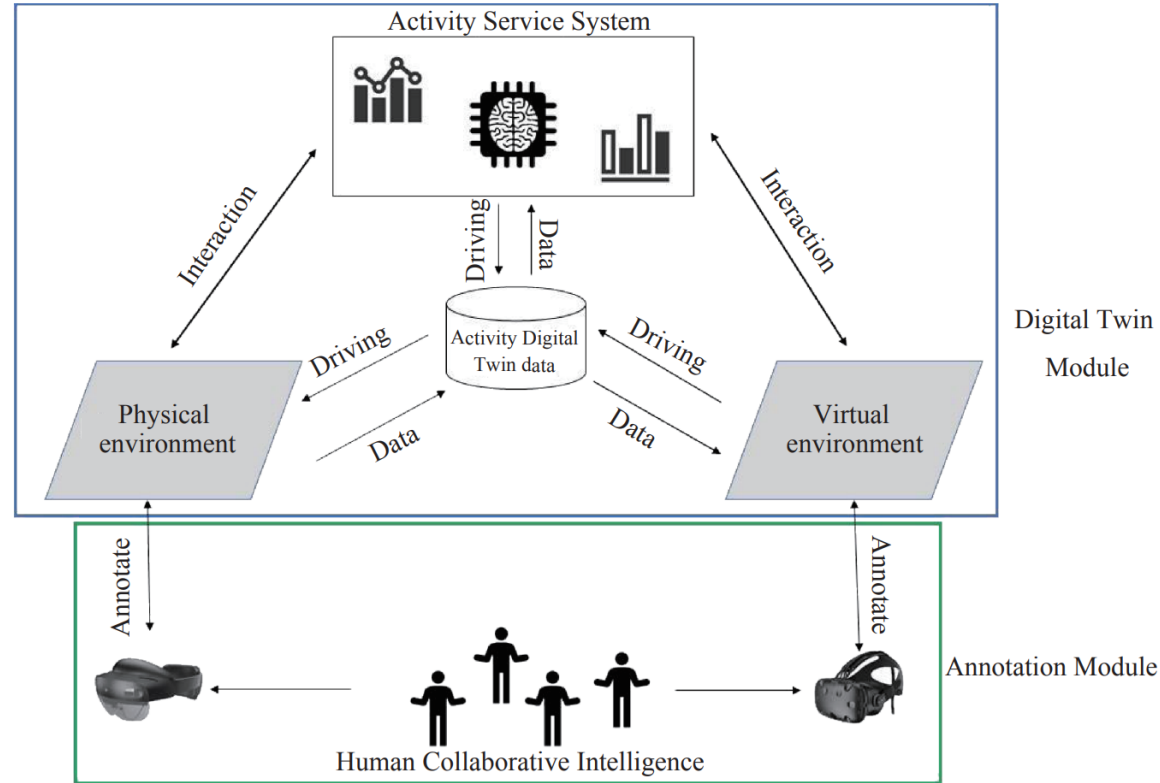


Figure 1 Main components of the HCLINT-DT framework.

* **Stacchio, L., Angeli, A., & Marfia, G. (2022).** Empowering digital twins with extended reality collaborations. *Virtual Reality & Intelligent Hardware*, 4(6), 487-505.

How we can re-use all the huge human heritage and creative outcomes that there is already?

How to understand if XR is a good metaphor of the real fashion world?

FAME Special Sessions Papers: A fashion metaphor through aesthetics, emotion and cultural heritage

1. *Photogrammetry and 360° virtual tours: differences, relevance, and future possibilities, Irene Calvi, Eleonora Stacchiotti, **Pasquale Cascarano***
2. *AI for enhancing and preserving Dance Cultural Heritage: a Case Study on Rudolf Nureyev's Costumes , Silvia Garzarella, Pasquale Cascarano, **Lorenzo Stacchio***

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- [1b] Baek, E., Haines, S., Fares, O. H., Huang, Z., Hong, Y., & Lee, S. H. M. (2022). Defining digital fashion: Reshaping the field via a systematic review. *Computers in Human Behavior*, 107407.
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- [2] Damar, M. (2021). Metaverse shape of your life for future: A bibliometric snapshot. *Journal of Metaverse*, 1(1), 1-8.
- [3] Wang, Y., Su, Z., Zhang, N., Xing, R., Liu, D., Luan, T. H., & Shen, X. (2022). A survey on metaverse: Fundamentals, security, and privacy. *IEEE Communications Surveys & Tutorials*



Fashion for the Metaverse (FAME) - Closing Remarks and Future prospects

AIVR – Special Session Track

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Projection on future challenges



**Human Digital
Twin**



**3D
Collaborative
Design**



x-Commerce



**Human and
Garment
modelling**

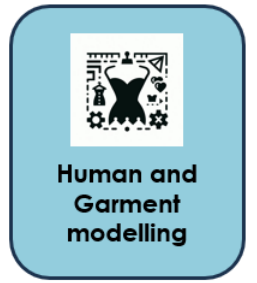


**Meta Fashion
Assistant**



Bridging 2D-3D

Fine Modeling of the Human Body and Fashion Items



- The Metaverse's allure stems from its complete divergence from reality, offering users an immersive experience in a distinctly different life;
- **Achieving this immersion involves intricately modeling numerous objects like fashion items and the human body relies on time-consuming 3D scanning and manual artist-driven technique;**
- Although view-based 3D reconstruction methods enhance efficiency, resulting models often lack accuracy, undermining the immersive experience;
- Therefore, the future focus lies in developing cost-effective methods for finely modeling human figures and fashion items in the Metaverse;
- **Challenge will rely mostly on conversion method from 2D to 3D;**

X-commerce: infinite shopping



- What can we do to improve the already existent XR commerce experience?
- How could we combine discriminative and generative AI?
- What about chatbots?
- What about Human Digital Twins role?
- What if: infinite x-commerce?
- A long road is in front of us, full of opportunities!

Close the 2D-3D gap: the beginning



- Despite a lot of models have been designed in order to project 2D fashion garments to 3D ones, there is still a lot to do;
- Models in the literature, have not been tested with high variance meshes and textures;
- At the same time, is unclear how to integrate XR paradigms in the capture and generation loop;

Define reliable 3D collaborative design tool & physics simulation



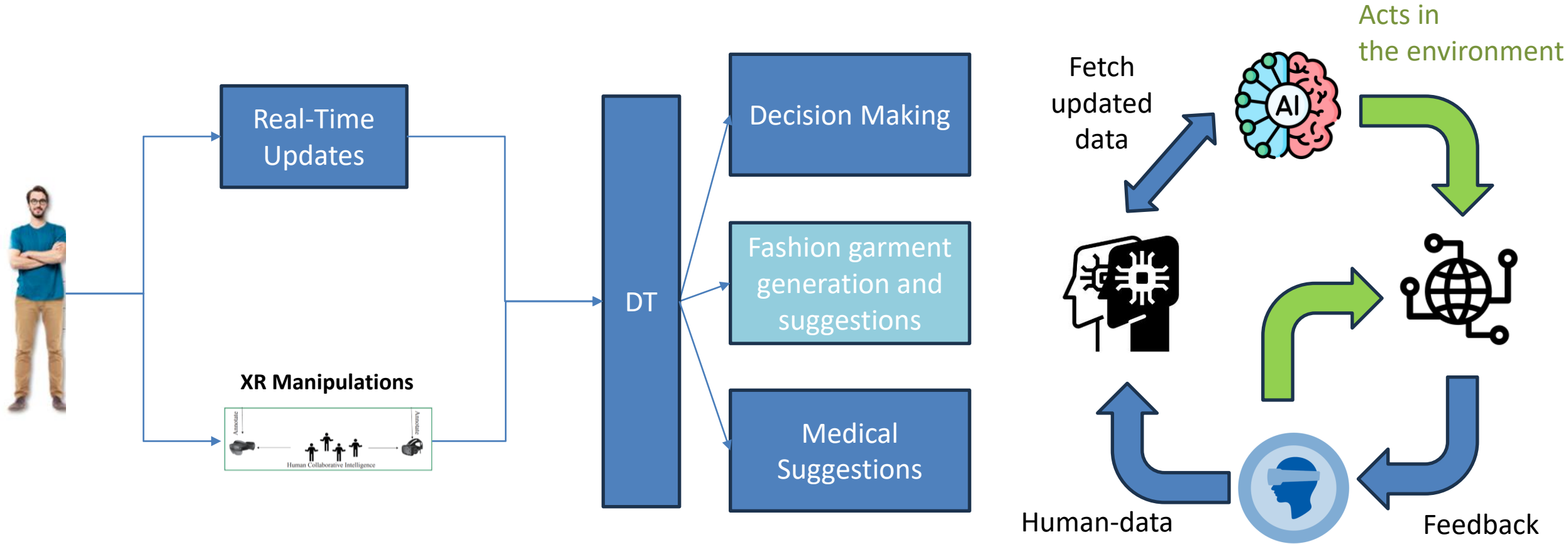
- Fashion design thrives on collaboration and creativity, but faces a critical hurdle;
- **However, there is a lack of Robust 3D Collaborative Design Tools, that employs both AI and XR paradigms;**
- Addressing this gap could unleash the full potential of collaborative design in fashion, fostering innovation and efficiency;
- While designing, the distinct physical properties of fabrics are fundamental;
- Moreover, while much research concentrates on modeling the texture of clothing materials, **the simulation of fabric stiffness is often overlooked;**
- Recently, a company named [CLO3D](#) created a software for design 3D clothes, while at the same time providing a reasonable clothing physics fabrics simulation → **NOT OPEN SOURCE AND NOT XR-INTEGRATED**

Human Digital Twin For Fashion



- It represents the Digital Twin and Human Data, providing a possible infinite cycle to update and guide a human through classical fashion tasks: **outfit generation, recommendation, score**;
- For example, leveraging AR and AI, HDT could provide the best outfit for a certain scenario;
- In case of VR, we could generate and visualize a garment based on our synchronized virtual avatar, dress it and let a company produce it (i.e., massive customization);
- In case of MR, we could merge the both, by experiencing the dresses physics with environmental awareness;
- **Creating holistic and modular framework that could adapt to several contexts is still an open challenge**;

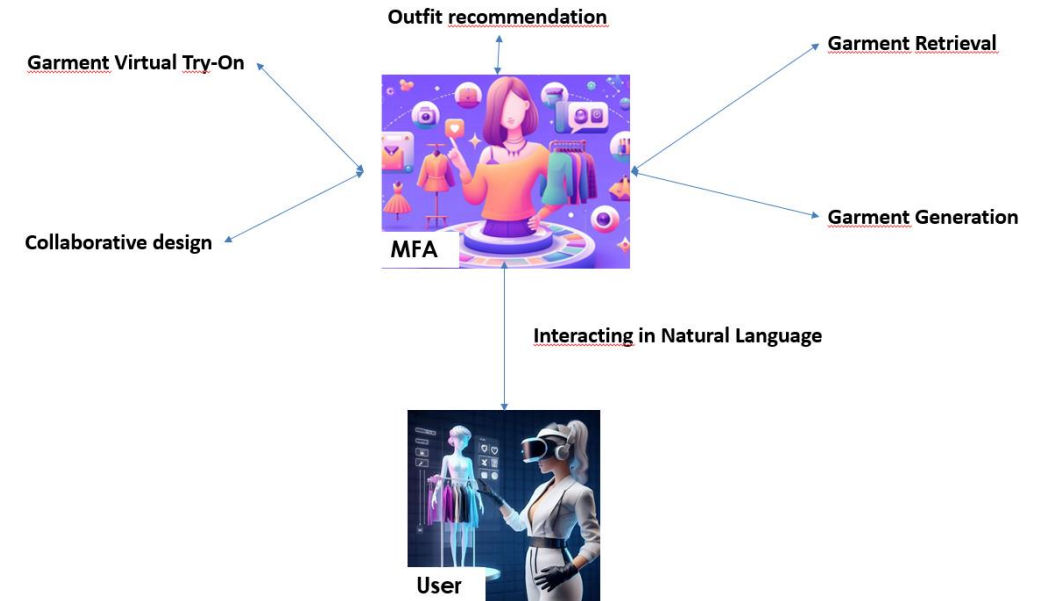
Evolving Human Digital Twins



- Human Digital Twin (HDT) applies DT to human data, to provide enhanced system performance as it combines system models and analyses with real-time measurements;
- HDTs have the potential to change the practice of human system integration employing real-time sensing and feedback to tightly couple measurements of human performance, behavior, and environmental influences throughout a product's life cycle

Meta-Fashion Assistants (MFA)

- The MFA is unique compared to other virtual assistants in that it emphasizes the use of images and natural language more than any other use case in fashion.
- The design of an MFA requires a few key components:
 - **Natural language comprehension and generation;**
 - **Image/3D Model recognition;**
 - **Image/3D Model generation;**
 - **Visual search;**
 - **Outfit recommendation;**
 - **Analytics;**
 - **Access to large fashion garments database;**



Meta-Fashion Assistants (MFA)

