Lecture Notes in Networks and Systems 1041

Marcelo Zambrano Vizuete · Miguel Botto-Tobar · Sonia Casillas · Carina Gonzalez · Carlos Sánchez · Gabriel Gomes · Benjamin Durakovic *Editors*

Innovation and Research – Smart Technologies & Systems

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Preface

The 4th edition of the International Research and Innovation Congress – Smart Technologies and Systems, CI3 2023, took place from August 30 to September 1, 2023, at the facilities of the Instituto Tecnológico Universitario Rumiñahui, located in the city of SangolquÍ, Pichincha, Ecuador.

The conference was organized by the Red de Investigación, Innovación y Transferencia de Tecnología RIT2, made up of the most relevant university institutes in Ecuador, among which are ITCA, BOLIVARIANO, ARGOS, VIDA NUEVA, ESPÍRITU SANTO, SUDAMERICANO, ISMAC, SAN ISIDRO, ARTES GRÁFICAS, ORIENTE, HUMANE, SUCRE, CENTRAL TÉCNICO, POLICÍA NACIONAL and RUMIÑAHUI.

Additionally, the event is sponsored by the Secretaría de Educación Superior, Ciencia, Tecnología e Innovación SENESCYT, Labortorio de Comunicación Visual de la Universidad Estatal de Campinas—Brazil, Universidad Ana G. Méndez—Puerto Rico, Centro de Investigaciones Psicopedagógicas y Sociológicas—Cuba, Instituto Superior de Diseño de la Universidad de La Habana—Cuba, GDEON and the Corporación Ecuatoriana para el Desarrollo de la Investigación y la Academia—CEDIA.

The main objective of CI3 2023 is to generate a space for dissemination and collaboration, where academia, industry and government can share their ideas, experiences and results of their projects and research.

"Research as a pillar of higher education and business improvement" is the motto of the Conference and suggests how research, innovation and academia must coincide with the productive sector to leverage social and economic development.

CI3 2023 had 145 papers submitted, of which 52 were accepted for publication and presentation. To guarantee the quality of the publications, the event has a staff of more than 70 experts, from different countries such as Spain, Argentina, Chile, Mexico, Peru, Brazil, Ecuador, among others, who carry out an exhaustive review of each proposal sent.

Likewise, during the event a series of keynote conferences were held, given by both national and international experts, allowing attendees to get in touch with the latest trends and technological advances around the world. Keynote speakers included: Ph.D. Carina González, University of La Laguna, Spain; Ph.D. Gabriel Gómez, State University of Campinas, Brazil; Ph.D. Carlos Sanchez, University of Zaragoza, Spain; Ph.D. Juan Minango, Instituto Tecnológico Superior Rumiñahui; Dr. Iván Cherrez, Universidad Espíritu Santo, Ecuador; and Ph.D. Nela Paustizaca, Escuela Politécnica del Litoral, Ecuador.

The content of this proceeding is related to the following topics:

- Smart Cities
- Innovation and Development
- Applied Technologies
- Economics and Management
- ICT for Educations.

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Applied Technologies

Applied Technologies

Mechanical Testing and Durability Evaluation of 3D Printed Magnetic Closures for Adaptive Fashion

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Abstract. This study focuses on the development and evaluation of 3D printed magnetic fasteners or buttons for adaptive fashion, with the goal of improving the dressing experience for people with disabilities. The research employs stereolithography (SLA), a 3D printing method, to create these fasteners or buttons, and compares their mechanical performance and durability to traditional fasteners. A factorial experimental design was used and samples were prepared with various types of fabric commonly used in adaptive clothing. Mechanical performance was evaluated using a tensile testing machine and custom designed devices to measure magnetic separation force. Durability was evaluated under simulated dry and wet conditions by measuring stitch button strength. The study underestimates the potential of these fasteners to improve the wearability and comfort of adaptable garments. The results of this research will serve as a basis for future innovations in adaptive clothing design and contribute to the continuous improvement of adaptive fashion products.

Keywords: Adaptive fashion · 3D printing · Magnetic closures · Mechanical testing · Durability evaluation

1 Introduction

Adaptive fashion is an emerging field within the fashion industry that focuses on designing and creating clothing specifically tailored to the needs of individuals with disabilities, seniors, or those with limited mobility. The primary goal of adaptive fashion is to provide these individuals with comfortable, stylish, and functional clothing options that are easy to put on and remove [1]. The importance of adaptive fashion cannot be overstated, as it can significantly improve the quality of life for many individuals, enabling them to express their personal style and feel confident in their appearance, while also simplifying the dressing process and fostering independence [2]. One of the key challenges in designing adaptive clothing is the development of innovative fastening solutions that

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cater to the unique needs of the target population. Traditional fastenings such as buttons, zippers, and snaps can be difficult to manipulate for individuals with limited dexterity or fine motor skills and may not provide the necessary ease of use or comfort [3]. Consequently, there is a growing need for novel fastening mechanisms that can be easily used by individuals with diverse abilities and requirements while maintaining durability and aesthetic appeal.

3D printing technology has experienced rapid advancements in recent years and has found applications in a wide range of fields, including fashion [4, 5]. Additive manufacturing techniques, such as Stereolithography (SLA) and Fused Deposition Modeling (FDM), allow for the rapid prototyping and production of custom-designed components, making them particularly well-suited for the development of innovative fastening solutions in adaptive fashion [6]. By harnessing the potential of 3D printing, designers and engineers can develop adaptive fashion solutions that not only meet the functional requirements of users but also reflect contemporary fashion trends and aesthetics [7].

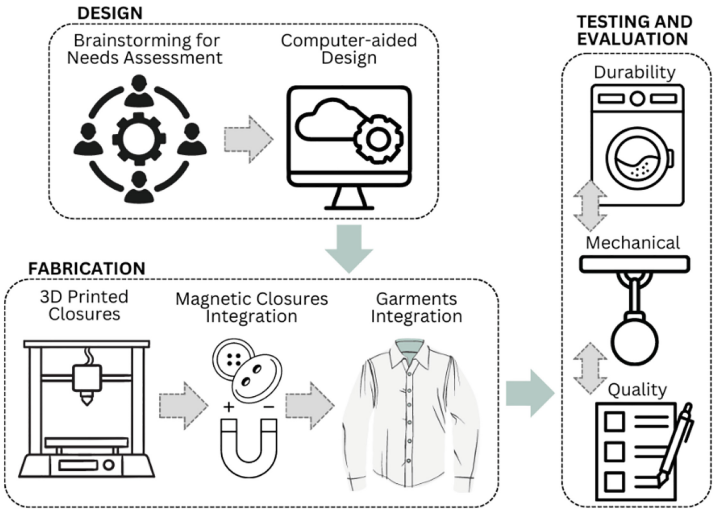

Fig. 1. Roadmap for creating customized clothing for individuals with disabilities through the utilization of 3D printing technology for Adaptive Fashion.

Figure 1 presents a roadmap for the design and fabrication of tailored clothing for people with disabilities using disruptive technologies such as 3D printing. The roadmap can be divided into four main stages: 1) Needs assessment, 2) Design, 3) Fabrication, and 4) Evaluation and feedback.

- Needs assessment: This initial stage involves identifying the specific requirements and preferences of individuals with disabilities. This process may include interviews, focus groups, or surveys to gather information on factors such as comfort, ease of use, and personal style preferences. This stage is crucial for understanding the unique challenges faced by the target population and ensuring that the final product addresses their specific needs [8].

- Design: In this stage, designers use the information gathered during the needs assessment to create clothing prototypes that incorporate innovative fastening solutions, such as 3D printed magnetic closures/buttons. Designers may employ computer-aided design (CAD) tools to create digital models of the garment components, including the fastening mechanisms, and use simulation software to assess their performance [9].
- Fabrication: Once the design has been finalized, the 3D printing process begins. Additive manufacturing techniques, such as Stereolithography (SLA) and Fused Deposition Modeling (FDM), are employed to create the custom-designed fastening components. These components are then integrated into the garments, either during the production process or as a post-production modification [10].
- Evaluation and feedback: After the garments have been produced, they are tested by individuals with disabilities to assess their fit, comfort, and ease of use. Feedback is collected from users to determine the effectiveness of the 3D printed fastening solutions and identify any areas for improvement. This feedback loop allows for continuous refinement of the design and fabrication process, ensuring that the final product meets the needs and preferences of the target population [11].

The objective of this study is to evaluate the mechanical performance and durability of 3D printed magnetic closures/buttons designed for adaptive garments and compare them to traditional fastenings. The study employed a factorial experimental design to assess the mechanical performance of samples using a tensile testing machine and custom-designed fixtures, measuring the magnetic separation force. Durability was evaluated through simulated dry and moist conditions, measuring the stitch button force. The study emphasized the potential of these closures to enhance the ease of use and comfort of clothing for individuals with disabilities. By assessing the performance of these closures under various conditions of materials and assembly used in adaptive clothing, and by measuring the magnetic separation force, we obtained valuable insights that will inform future innovations in adaptive clothing design.

2 Methodology

2.1 Conceptual Design of Magnetic Buttons

The design phase is crucial in applications about adaptive fashion. A key consideration is the target demographic for these magnetic buttons – adults with disabilities, which according to the World Health Organization, represent about 15% of the world's population [5]. As the prevalence of disability is expected to increase due to population ageing, chronic diseases, and improvements in disability measurement methodologies, the design of accessible, user-friendly buttons as closures becomes even more significant (Fig. 1).

3 3D Printing and Assembly of Magnetic Buttons

During the detailed design stage, we employed a design-for-3D-printing methodology using Tinkercad, a user-friendly and versatile free CAD software (Fig. 2). This critical design phase took into account several key factors, including size, shape, magnet

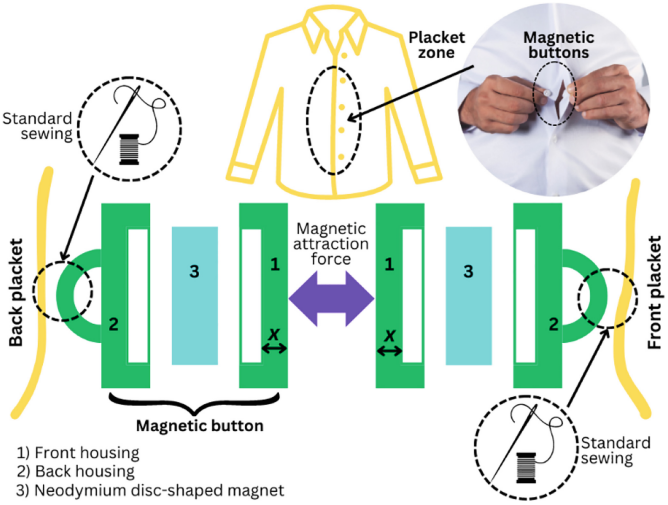

Fig. 2. The conceptual design of the magnetic closure, which is the initial stage in the design process. Magnetic buttons have been chosen for the closure mechanism. The variable 'x' denotes the thickness, which serves as a factor in the experimental design.

incorporation, compatibility with various garments, and the durability of the closure. The housings were manufactured using an FORM 3 (Formlabs, Boston MA), a 3D printing that utilizes SLA photocuring technology. The material used was the standard photoresin of Formlabs. The layer thickness for printing was set at 50 μm (μm). Following the printing of the housings, post-processing was carried out. This involved cleaning with isopropyl alcohol, drying with compressed air, and post-curing for 20 min using UV light. After these steps, the material support from the printing was removed. Finally, a N35 neodymium disc-shaped magnet with a diameter of 10 mm was enclosed between the front and back housings to complete the magnetic buttons (Fig. 3).

4 Magnetic Separation Force Experimental Procedure

Understanding the force required to separate magnetic buttons is crucial, particularly for individuals with disabilities. This force directly impacts the ease with which these individuals can remove their clothing. In this experiment, we measured this force and compared it with the force required to remove typical metal press buttons fasteners used in clothing (Fig. 4b).

A comprehensive experimental design was conducted using a full factorial design with two factors, each having three levels, and three replicates. The factors under consideration were the Front Housing Thickness (FHT) and Button Diameter (BD). The levels for FHT were set at 2 mm, 3 mm, and 4 mm, while for BD, the levels were 10 mm, 12 mm, and 15 mm. The response variable in this experiment was the Separation Force (SF) between the magnetic buttons (Table 1).

The system used to measure the SF was a mechatronic system, composed of a linear actuator and a force sensor with a load capacity of 100 N (FG-3006 Nidec-Shimpo)

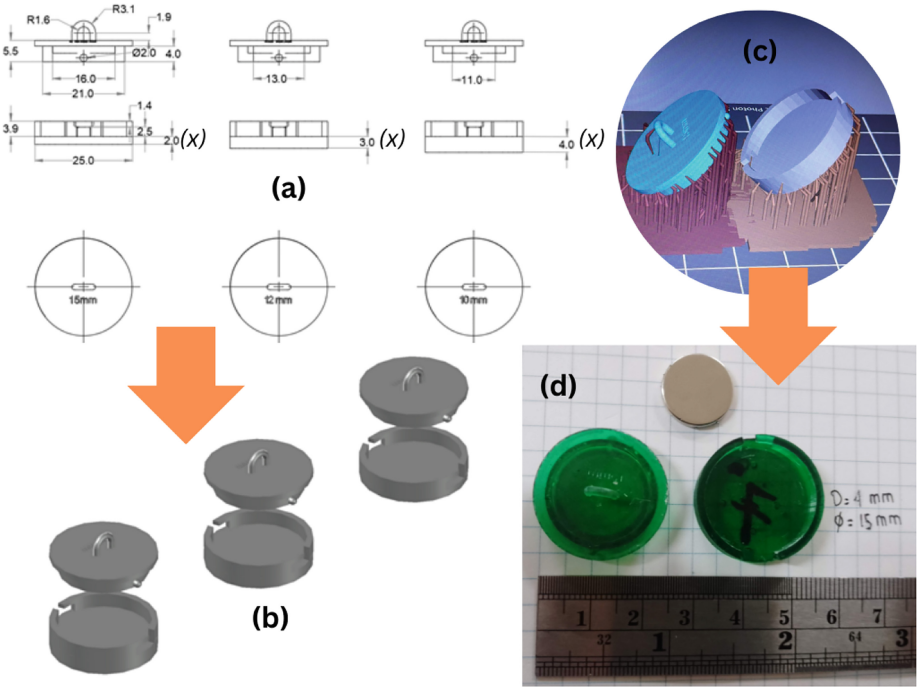

Fig. 3. (a) 2D CAD design of housings for magnetic buttons, (b) 3D models of housings, (c) Study of printability, and (d) 3D printed housings and preliminary assembly of magnetic buttons for closures.

(Fig. 4a). The testing speed was set at 5 mm/min, and all tests were conducted at a consistent temperature of 20 °C. This design allowed for a thorough investigation of the impact of FHT and BD on the SF of the magnetic buttons, providing valuable insights for further development and refinement of the product.

Table 1. Factors used to evaluate the proof of concept.

Factors	Symbol	Units	Levels
Front housing thickness	FHT	mm	2,3, 4
Button diameter	BD	mm	10, 12, 15

5 Button Stitch Separation Force Experimental Procedure

Comprehension of the force required to separate buttons stitched onto clothing is equally crucial, especially for individuals with disabilities. This force directly impacts the ease with which these individuals can remove their clothing. Moreover, an excessive force

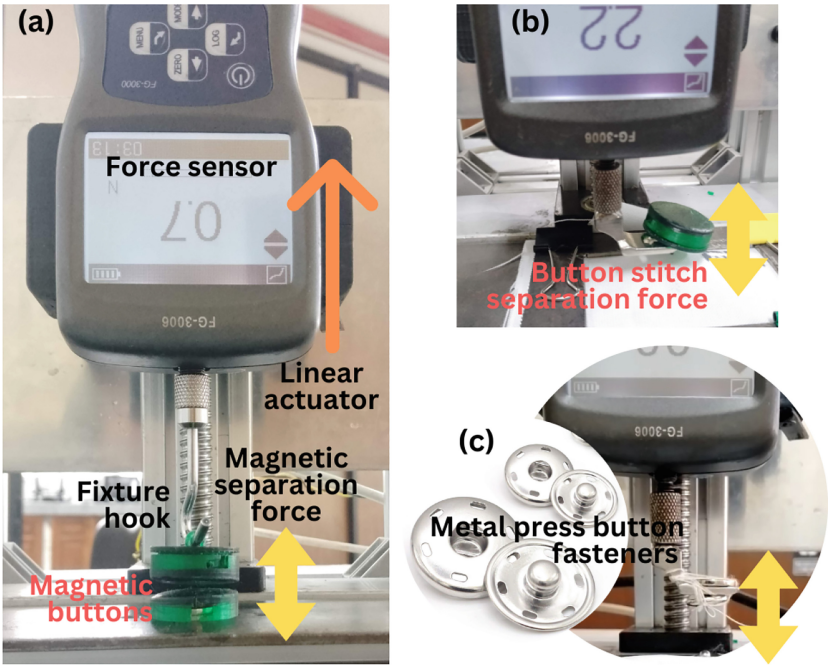

Fig. 4. Experimental procedure to measure (a) the magnetic separation force, (b) button stitch separation force, and (c) separation force of metal press button fasteners in the control system.

applied to separate the magnetic buttons could provoke the failure of the button stitch, further complicating the process of removing clothing. In this experiment, we measured this force using a cotton thread for the stitch, under both dry and moist conditions to simulate washing conditions.

The experimental design was similar to the one used for measuring the Separation Force (SF) of magnetic buttons. The factors under consideration were the Front Housing Thickness (FHT) and Button Diameter (BD). The levels for FHT were set at 2 mm, 3 mm, and 4 mm, while for BD, the levels were 10 mm, 12 mm, and 15 mm. The response variable in this experiment was the Separation Force (SF) between the buttons stitched with cotton thread (Fig. 4c). In this procedure, we did not use replicates, focusing instead on the effect of the cotton thread's condition (dry and moist) on the SF. Initially, we used dry cotton for the stitch. Then, we moistened the cotton thread with water to simulate washing conditions. This design allowed for a thorough investigation of the impact of the thread's condition on the SF of the stitched buttons, providing valuable insights for further development and refinement of the product.

6 Results and Discussion

7 3D Printing and Assembly of Magnetic Buttons

The detailed design stage was essential in the successful fabrication of the 3D printed magnetic buttons. The design process was meticulous, with a strong emphasis on several key factors, including size, shape, magnet incorporation, compatibility with various garments, and the durability of the closure. The use of SLA photocuring technology, was helpful in achieving our objectives. This technology allowed us to manufacture the housings with precision and consistency, which would have been challenging with other types of additive manufacturing technologies. The importance of using SLA 3D enabled us to create customized shapes of buttons, which is crucial for the functionality and aesthetic appeal of the magnetic closures. Other additive manufacturing technologies might struggle to achieve the same level of customization and precision.

However, the assembly process presented a significant challenge due to the properties of the N35 neodymium magnets. Despite their strength, these magnets are notably fragile, necessitating careful handling during assembly to prevent damage. Despite this, the magnets were successfully enclosed between the front and back housings, completing the magnetic buttons.

Creating a straightforward mathematical model to depict the relationship between the magnetic force and the properties of the 3D printed material was a complex endeavor, but necessary in the production of garment accessories. The behavior of the 3D printed photopolymer under different conditions, and its interaction with the magnetic force, is not easily predictable and warrants further investigation. Looking ahead, future studies could explore the use of different types of resins and their impact on the performance of the magnetic buttons. Additionally, refining the design and assembly process to minimize potential damage to the neodymium magnets could be a focus of future research. The development of a more accurate mathematical model to predict the behavior of the magnetic buttons under various conditions would also be a valuable contribution to this field of study. This study serves as a foundation for future investigations and advancements in the field of adaptive fashion. It opens up possibilities for greatly improving the way individuals with disabilities interact with their clothing.

The force necessary to remove typical metal press button fasteners used in clothing was measured three times, yielding an average of 13.5 N with a standard deviation of 0.87 N. This finding indicates that a considerable amount of force is required to manipulate these fasteners, which could pose a significant challenge for individuals with disabilities. Furthermore, it's important to note that many individuals with disabilities may not have the ability to use both hands to manage the closures on their clothing. This underscores the need for more accessible and user-friendly fastening solutions in the field of adaptive fashion.

8 Magnetic Separation Force Experimental Procedure

The force required to separate magnetic buttons is a critical factor, particularly for individuals with disabilities. This force directly influences the ease with which these individuals can remove the closures of their clothing. In this experiment, we measured this

force and compared it with the force required to remove typical metal press buttons fasteners used in clothing. The results of the factorial analysis, as shown in Fig. 5, revealed significant understandings. According to the Pareto Chart of standardized effects, simple factors BD, SF, and the interaction BD*SF are significant. The range of the separation force for the magnetic closure varied between 0.8 and 2 N. This range provides valuable information for clothing designers working on adaptive fashion for people with disabilities, allowing them to design adequate closures depending on the type of clothing and the age of the individuals.

The interaction between BD and SF shows a relationship between the shape and dimensions of the housings, which could be studied with more advanced statistical models. This interaction suggests that both the size and shape of the button, as well as the force applied, play a significant role in the ease of separation. The residual plots were also analyzed to verify the assumptions of normality, independence, and equal variance. These plots further validate the reliability of our results and the robustness of our experimental design.

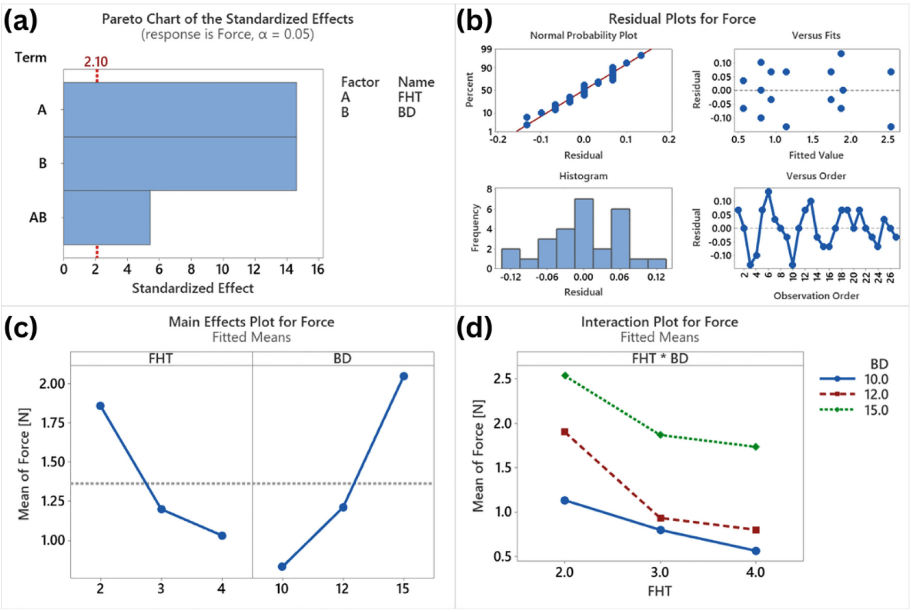

Fig. 5. Factorial analysis of magnetic separation force. (a) Pareto chart for significant effects, (b) Residual plots, (c) Factorial plots for Front Housing Thickness (FHT) and Button Diameter (BD), and (d) Interaction of FHT and BD.

9 Button Stitch Separation Force Experimental Procedure

The force required to separate buttons stitched onto clothing directly impacts the ease with which these individuals can remove their clothing. Moreover, an excessive force applied to separate the magnetic buttons could provoke the failure of the button stitch,

further complicating the process of removing clothing. In this experiment, we measured this force using a cotton thread for the stitch, under both dry and moist conditions to simulate washing conditions. Our results showed that the force to break the button stitch for dry conditions varied between 7.6 and 14.6 N, and for moist or humid conditions, it varied between 9.4 and 19.8 N. These results indicate that the magnetic separation force is less than the force to break the stitch in dry conditions, which is a positive outcome for the usability of these magnetic closures.

However, the results under moist conditions suggest that further investigation is needed, especially under washing conditions. The increase in separation force under moist conditions could potentially pose challenges for individuals with disabilities in removing their clothing after washing. Future studies could explore this aspect in more depth, considering other experimental factors that could influence the separation force under washing conditions (Fig. 6).

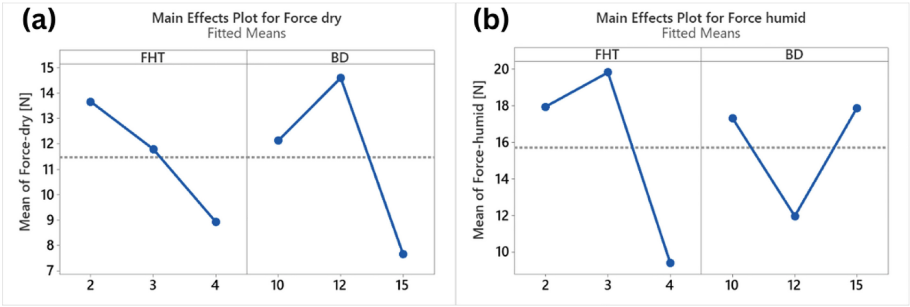

Fig. 6. Factorial analysis of the stitch button separation force under (a) dry conditions and (b) moist conditions.

10 General Discussion

The advent of 3D printing technology in the fashion industry has ushered in a new era of innovation, customization, and sustainability. As highlighted by Wu et al., 3D printing is not just a tool but a transformative force, especially in the realm of smart clothing, where it offers unparalleled opportunities for embedding sensors and electronics seamlessly into garments [12]. This convergence of technology and fashion not only enhances the functionality of clothing but also introduces a new dimension of interactivity and adaptability. The use of 3D printed magnetic buttons, as explored in this study, exemplifies the potential of this technology. Traditional fastenings, such as buttons and zippers, have long been a challenge for individuals with disabilities. The development of 3D printed magnetic closures offers a solution that is not only functional but also aesthetically pleasing and easy to use. This innovation, when viewed in the context of adaptive fashion, underscores the importance of 3D printing in creating garments that are tailored to the unique needs of every individual.

Chakraborty and Biswas delved deeper into the potential of 3D printing in the textile and fashion industry, emphasizing the use of polymer-fiber composites [13]. These

materials, when 3D printed, can achieve unique textures and properties, allowing for the creation of garments that are both functional and fashionable. The ability to produce such innovative materials and structures is particularly relevant when considering the design and functionality of magnetic buttons, offering a level of customization and performance that is hard to achieve through traditional methods. Khajavi's exploration of additive manufacturing's role in promoting sustainable business models in the clothing industry is particularly pertinent [14]. The use of 3D printed magnetic closures, for instance, can reduce waste by ensuring precise production, eliminating the need for excess materials. Moreover, the on-demand nature of 3D printing means that garments can be produced as and when needed, reducing overproduction and inventory costs.

However, the broader adoption of 3D printing and its innovations, like magnetic closures, requires a shift in the fashion industry's mindset. Palomo-Lovinski and Hahn's study revealed a spectrum of attitudes towards sustainable practices in the fashion design industry [15]. While the potential benefits of 3D printing and sustainable practices are evident, there remains a need for education and collaboration to ensure widespread adoption. In summary, 3D printing technology, especially in the context of innovations like magnetic closures, holds immense promise for the fashion industry. It offers a unique blend of customization, functionality, and sustainability, paving the way for a future where fashion is not just about aesthetics but also about inclusivity and environmental responsibility.

11 Conclusion

This research has made significant progress in the field of adaptive fashion, particularly in the development and evaluation of 3D printed magnetic closures for adaptive garments. The study underscores the potential of these closures to enhance the ease of use and comfort of clothing for individuals with disabilities. By assessing the performance of these closures with various conditions of materials and assembly used in adaptive clothing and measuring the magnetic separation force, we have obtained valuable insights that will inform future innovations in adaptive clothing design.

The integration of 3D printing technology in the fashion industry, as highlighted in our general discussion, is not just a novel approach but a transformative one. It offers a unique blend of customization, functionality, and sustainability, which is pivotal in the realm of adaptive fashion. The use of magnetic closures, in particular, exemplifies the innovative solutions that 3D printing can bring to address long-standing challenges in the fashion industry.

Furthermore, this research offers a comprehensive understanding of how stitched magnetic buttons function under different conditions. This knowledge is crucial for the ongoing improvement of adaptive fashion products, with the aim of enhancing the clothing experience for individuals with disabilities. The insights gained from this study serve as a foundation for future investigations and advancements in the field of adaptive fashion.

Future Work: As we move forward, our research will expand to evaluate other types of garments, including outerwear, formal wear, and sportswear, to understand how 3D printed magnetic closures can be integrated across a broader spectrum of clothing. Additionally, we plan to explore new experimental configurations of 3D printing, delving

into different materials, printing techniques, and post-processing methods to optimize the performance and aesthetics of the closures. There's also potential in collaborating with designers and individuals with disabilities to co-design garments that truly cater to their needs. By doing so, we aim to push the boundaries of what's possible in adaptive fashion, ensuring that clothing is not just functional but also a reflection of one's personal style and identity.

References

1. Kabel, A., Dimka, J., McBee-Black, K.: Clothing-related barriers experienced by people with mobility disabilities and impairments. Appl. Ergon. **59**, 165–169 (2017). https://doi.org/10.1016/j.apergo.2016.08.036
2. Chang, W.-M., Zhao, Y.-X., Guo, R.-P., Wang, Q., Gu, X.-D.: Design and study of clothing structure for people with limb disabilities. J. Fiber Bioeng. Inform. **2**(1), 62–67 (2009). https://doi.org/10.3993/jfbi06200910
3. "Anthony" Chen, X., Kim, J., Mankoff, J., Grossman, T., Coros, S., Hudson, S.E.: Reprise: a design tool for specifying, generating, and customizing 3D printable adaptations on everyday objects. In: Proceedings of the 29th Annual Symposium on User Interface Software and Technology, pp. 29–39. ACM, Tokyo Japan (2016). https://doi.org/10.1145/2984511.2984512
4. Gibson, I., Rosen, D., Stucker, B., Khorasani, M.: Additive Manufacturing Technologies, 3rd edn. Springer, Cham, Switzerland (2021)
5. World Health Organization and World Bank. World report on disability 2011.. https://apps.who.int/iris/handle/10665/44575 (2011). Accessed 05 Jun 2023
6. Ahmad, S., Miskon, S., Alabdan, R., Tlili, I.: Towards sustainable textile and apparel industry: exploring the role of business intelligence systems in the era of industry 4.0. Sustainability **12**(7), 2632 (2020). https://doi.org/10.3390/su12072632
7. Cumming, D.: A case study engaging design for textile upcycling. J. Text. Des. Res. Pract. **4**(2), 113–128 (2017). https://doi.org/10.1080/20511787.2016.1272797
8. Ghoreishi, M., Happonen, A.: The case of fabric and textile industry: the emerging role of digitalization, internet-of-things and industry 4.0 for circularity. In: Yang, X.-S., Sherratt, S., Dey, N., Joshi, A. (eds.) Proceedings of Sixth International Congress on Information and Communication Technology: ICICT 2021, London, Volume 3, pp. 189–200. Springer, Singapore (2022). https://doi.org/10.1007/978-981-16-1781-2_18
9. Jevšnik, S.: 3D virtual prototyping of garments: approaches, developments and challenges. J. Fiber Bioeng. Inform. **10**(1), 51–63 (2017). https://doi.org/10.3993/jfbim00253
10. Rathore, B.: Textile industry 4.0 transformation for sustainable development: prediction in manufacturing & proposed hybrid sustainable practices. Eduzone: Int. Peer Reviewed/Refereed Acad. Multi. J. **11**(01), 223–241, (2022). https://doi.org/10.56614/eiprmj.v11i1.229
11. Wilson, J.: Handbook of Textile Design: Principles, Processes and Practice, Repr. Woodhead, Cambridge (2004)
12. Wu, S., et al.: 3D printing technology for smart clothing: a topic review. Materials **15**(20), 7391 (2022). https://doi.org/10.3390/ma15207391
13. Chakraborty, S., Biswas, M.C.: 3D printing technology of polymer-fiber composites in textile and fashion industry: a potential roadmap of concept to consumer. Compos. Struct. **248**, 112562 (2020). https://doi.org/10.1016/j.compstruct.2020.112562
14. Khajavi, S.H.: Additive manufacturing in the clothing industry: towards sustainable new business models. Appl. Sci. **11**(19), 8994 (2021). https://doi.org/10.3390/app11198994

15. Palomo-Lovinski, N., Hahn, K.: Fashion design industry impressions of current sustainable practices. Fashion Pract. **6**(1), 87–106 (2015). https://doi.org/10.2752/175693814X13916967094911

Study on the Need for Pre-hospital Personnel Within the Office of Sis-Ecu911 to Mitigate the Emergency

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Abstract. The presence of prehospital personnel within the emergency system office is essential to ensure an efficient and coordinated response to emergency situations. Their training, experience and communication skills play a crucial role in assessing emergencies, allocating resources, and making informed decisions, helping to save lives and provide appropriate care to those in need. The objective of this work is to determine the need for prehospital personnel within the SIS-ECU911 office through the design of the operator profile to mitigate the emergency. The methodology has a quantitative descriptive approach, with a convenience sample of 20 Cañar Canton Firefighters, the collection instrument is through a questionnaire on the importance of a paramedic, Excel tabulation to determine the frequency of responses that tend to the importance of prehospital personnel. As a result, it is observed that 81% mention that the paramedic in the office acts as a crucial link between the callers, the emergency services in the territory, and other support services, such as the police, fire brigades, among others. Your ability to communicate clearly and accurately is essential to ensure a coordinated response and appropriate care. In addition, a professional that the radio operator must comply with and that he must have to implement a priori in the SIS-ECU 911 is designed as a proposal. Additionally, a Professional is proposed that details the basic aspects that the radio operator must comply with to provide a service effectively.

Keywords: Radio operator · Paramedic · Pre-hospital

1 Introduction

Pre-hospital personnel play a crucial role within the emergency system, due to their presence in the office or emergency coordination center it is essential to guarantee a rapid and efficient response to emergency situations.

At the Ecuadorian level, the emergency system is the Integrated Security Service Ecu 911, the institutions that solve the emergency responses of the population and are

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articulated to this system are: Traffic and Mobility Management, Municipal Services, Military Services and Armed Forces, Citizen Security and National Police of Ecuador, Sanitary Management and Ministry of Health, Red Cross, IESS, Accident Management and Fire Brigades and Risk Management [1].

In some emergency systems, specific roles are assigned to different professionals based on their training and experience. Dispatchers are typically responsible for receiving and triaging emergency calls, while paramedics provide direct medical care on the ground. This division of duties may be based on considerations of efficiency and specialization.

The lack of paramedical dispatchers could be related to the availability of trained personnel in the area, and it is possible that the number of qualified paramedics to work as dispatchers in the SIS ECU 911 is not sufficient to cover all the operational needs of the system [1].

Emergency systems often have limited resources and must establish priorities based on the needs and demand of the population. It is possible that, in the case of ECU 911, resources may have been directed primarily towards recruiting and training medical and paramedical personnel to provide direct care in the field, rather than focusing on paramedical dispatchers. Due to the aforementioned, the following question arises: Why is it important to incorporate paramedical personnel into the SIS-ECU 911 office?

The importance of this project focuses on the contribution to the correct management of the information that enters the emergency rooms to reach the reduction of the mortality rate of the victims and patients.

By having a professional with a paramedic profile in the SIS-ECU 911 dispatch rooms, their knowledge and experience will allow them to adequately assess the situation and allocate the necessary resources efficiently, optimizing the response time to emergencies. In addition, you can provide basic first aid instructions and basic life support over the phone, which can make all the difference in the survival and well-being of patients [2].

Emergency Communication. It refers to the process of exchanging critical and relevant information during emergency or disaster situations. It is used to coordinate and aid, make informed decisions, and alert the public to events that pose an imminent risk to safety or well-being. Its main objective is to guarantee the safety of people and minimize damage in crisis situations. It may involve disseminating warnings, instructions, and advice on how to act in an emergency, as well as coordinating rescue and response efforts [3].

A good emergency radio operator requires practice, training, exercise, and a fundamental attitude, the same that is necessary to understand how knowledge should be applied. This is not just a radio amateur connecting a set and an antenna and transmitting. It is important to know the most efficient way to communicate a message adequately and effectively, how to operate in an emergency network, how to behave in critical or delicate situations, and how to handle sensitive information. Radio operators must know and accept their own limitations, as well as take advantage of their abilities [3].

Emergency Console Operator. There is a professional in charge of managing radio communications in an emergency control center. His main function is to receive, transmit and coordinate information related to emergencies and incidents that are taking place.