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Tutorial in “Frontiers in Haptic Technology and Interaction Design: the Challenges, the Technology, the Perspectives”

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Technological advancement provides an increasing number and variety of solutions to interact with digital content. However, the complexity of the devices we use to interact with such content grows according to the users’ needs as well as the complexity of the target interactions. This also includes all those tools designed to mediate touch interactions with virtual and/or remote environments, i.e., haptic interfaces and rendering techniques. We propose three hours of tutorials to discuss the technology, challenges, and perspective of haptic systems and rendering techniques for immersive human-computer interaction.

CCS Concepts: • **Human-centered computing** → **Haptic devices**.

Additional Key Words and Phrases: Human-Computer-Interaction, Haptics, Wearable Devices, Human-Robot-Interaction

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1 INTRODUCTION

We face an era in which digital contents and virtual reality applications are growing in terms of complexity and market distribution [21]. From computer screens to smartphones, from tablets to wearables, user interaction with virtual and augmented reality environments provides a rich and immersive experience to interact with digital contents. In this respect, touch actuation and sensing technologies are analogous to video cameras and display screens, which register moving images and feed them to our eyes, or microphones and speakers, which register sounds and play them to our ears, respectively [12, 19]. In the scenario of interaction with immersive environments, the sense of touch provided by haptic devices can influence the user experience, ergonomics, and learning ability. In this tutorial, where participation is physical, target audience will involve ICT/HCI professionals, students, and researchers interested in exploring more about haptics in computer and immersive interaction. (Link to the tutorial <https://sites.google.com/view/xrr-nordichi22/home>).

2 HAPTICS AND WEARABLE SOLUTIONS

In this scenario, haptic research contributes with novel and advanced solutions designed to meet interactivity requirements and the simplicity of feedback interpretation for the interaction. Novel devices and engineering solutions involving wearable, portable, grounded, and mid-air haptics proposes several possible interaction directions [19]. The relevance of the contact interaction passes through the need to touch virtual objects to enhance the interaction dynamics

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53 to the necessity of providing better control of specific interfaces. This can involve scenarios where haptic feedback, for
54 example, plays a crucial role in assembly [10], for the simulation and training of stitching procedures [8], palpation [11],
55 various dental procedures [23, 24], as well as endoscopy [5], laparoscopy [20], and biopsy [15] procedures.
56

57 The learning goal of this part of the tutorial deals with providing an overview of haptic technologies and rendering
58 techniques for interaction with virtual and distant environments, specifically focusing on wearable and tactile solutions.
59 The audience will be introduced to the methods, technologies and challenges for providing haptic feedback to the users.
60

61 **3 HUMAN-COMPUTER INTERACTION DESIGN AND NEW HAPTIC TECHNOLOGIES**

62 Haptic feedback is essential to guarantee a comprehensive experience using digital interfaces. This interests immersive
63 virtual reality users, whose interaction with the virtual environment is counterbalanced by the presence of a wearable
64 headset that limits the external world view. In this part of the tutorial, the presentation and the demonstration will
65 guide the audience toward the latest research results connecting human-computer interaction design and the sense of
66 touch. Furthermore, this session will describe various stimuli provided by robotic and cutaneous technologies. Finally,
67 a demonstration of possible applications related to the possibility, for the users, of bridging the gap between Virtual
68 Reality and haptic stimuli will be presented [13]. The learning goal in this part is to provide a picture of how common
69 graphical environments, including, for example, immersive virtual reality scenarios, can be enriched by the haptic
70 interaction derived from cutaneous and kinesthetic feedback.
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75 **4 THE ROLE OF HAPTICS IN VIRTUAL AND PHYSICAL INTERACTION IN INDUSTRY**

76 Regardless of the variety of studies and solutions that enable haptic feedback, the touch sense also plays a crucial
77 role in robotics. Several works are oriented to improve training performance in robotic surgical scenarios [6] and,
78 in general, robotic teleoperation. Indeed, research shows that haptic feedback plays an important role in improving
79 robotic teleoperation at large. It has been proven to enhance operators' performance in a large range of robotic
80 applications, including micro-robotics [4, 18], needle and catheter insertion [1, 16, 22], surgical knot tying [3, 14], waste
81 management [2]. The benefits of haptic feedback in such scenarios include increased manipulation and perception
82 accuracy, decreased completion time, and decreased the peak and mean force applied to the remote environment. The
83 inclusion of haptic feedback is also usually supported by the majority of users, both experts and novices [9, 17]. A
84 growing interest is also provided by the possibility of using industrial robots arms in ergonomic tasks connected to
85 human manufacturing operations [7]. It is the case, for example, of the possibility to control a set of robots to provide
86 force feedback to the users' arms. With that said, it is essential to create a scenario where the users can integrate the
87 beneficial aspects connecting the force feedback in robotic tasks for the industry.
88
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92 In this part, the audience is guided towards a preliminary explanation on how haptics can be used in research studies
93 involving safety and ergonomics, with special attention to human-robot interaction applications.
94
95

96 **5 CONCLUSION AND EXPECTED OUTCOME**

97 Open to all attendees, connected to industry, academia, and enthusiasts, the proposed tutorial focuses on providing
98 the audience with current technological challenges and research methods in haptics. Another expected outcome is to
99 provide an initial picture of the existing solutions and limitations of haptic technology. The tutorial illustrates these
100 aspects with presentations involving the latest results on haptic solutions, human-computer interaction and haptics. In
101 addition, there will be space dedicated to touch and force feedback in industrial scenarios, the latter involving robotics.
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105 During the morning, interactive demonstrations will be presented to the audience, whose physical participation is
106 crucial for the realization of the tutorial.
107

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