Wearable Haptic Solutions to Deal With COVID-19 Pandemic

Tommaso Lisini Baldi[1], Nicole D'Aurizio[1,2], Gianluca Paolocci[1,2], Sara Marullo[1,2], and Domenico Prattichizzo[1,2]

[1]Dipartimento di Ingegneria dell'Informazione e Scienze Matematiche, Università di Siena, Siena, Italy
[2]Department of Advanced Robotics, Istituto Italiano di Tecnologia, Genova, Italy

***Abstract*—The COVID-19 pandemic induced drastic changes to the social life of millions of people. The feeling of loneliness experienced by many due to national lockdowns emphasised how important is connection and sociality to humans, confirming the fundamental role of technology as a means to bridge distance. In this context, we believe that haptics may provide a substantial contribution as the only technology able to provide compelling sensations and information exploiting an underutilized sense, i.e. the sense of touch. Differently from the auditory feedback, tactile perception directly engages our motor learning system with extraordinary sensitivity and speed. Moreover, tactile communication can be used in situations where visual or auditory stimuli are distracting, impractical or unsafe.**

We report three approaches showing the capability of wearable haptics interfaces to cope with disease prevention, social isolation and physical wellness maintenance.

I. INTRODUCTION

Despite the advancements in technology and medicine, pandemics are still an open issue causing millions of deaths even in the XXI century. A paradigmatic example is the current epidemic of SARS-CoV-2 that caused over 49.7 million COVID-19 infections and more than 1.2 million deaths by 8th of November 2020 [1]. Worldwide governments and public institutions are fighting against the outbreak, with a great effort in developing vaccines, effective treatments, and policies for limiting the diffusion. In response to a pandemic situation, we believe that anyone could make some contributions by proposing suitable solutions adoptable on a large scale. Specifically, technological solutions arising from the wearable haptic research field can have a great impact in coping with social isolation and observance of preventive behaviour. Wearable devices exploiting haptic technology enable researchers to provide compelling touch sensations as well as to convey information in everyday environments, where visual and auditory modalities might be busy to effectively accomplish a task (e.g., vision occupied in finding objects), impaired due to personal protective equipment (e.g., worker wearing headphones), or inappropriate (e.g., student attending lecture, spectator during a public show).

Within this work, we describe three approaches dealing with three aspects of the ongoing pandemic, i.e. *i)* disease prevention, *ii)* social interaction, and *iii)* physical wellness maintenance. These approaches concern people's mental and physical well-being, believing that strengthening both aspects will contribute to a less stressful daily life.

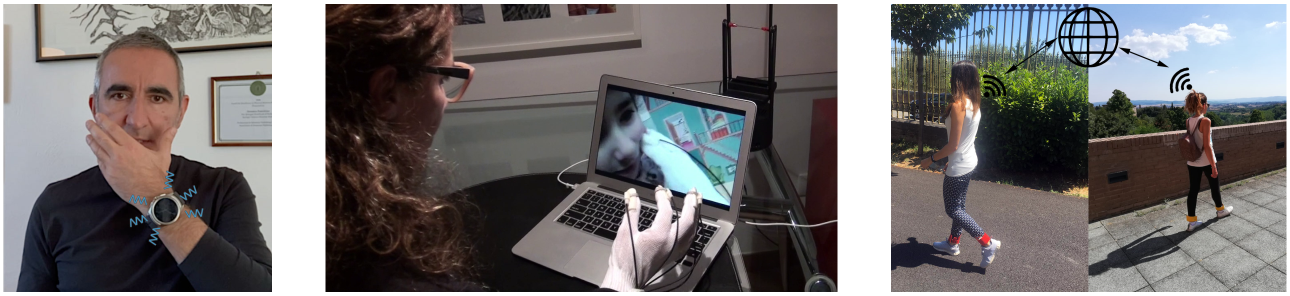
II. NO FACE-TOUCH

The alarming morbidity of COVID-19 has drawn the attention to the social impact of hygiene rules, with particular focus on the importance of limiting face-touch occurrences. During the day, episodes of such bad habits are often "automatic" and occur with little awareness. This aspect is further supported by a behavioural observation study undertaken in [2], where on average the 26 subjects touched their face 23 times per hour. In addition, the act of touching the face is often a cultural and unconscious way to express an emotional state, such as fear, stress, surprise and focus of attention. These observations become even more serious considering that, as regards SARS-CoV-2, if the virus is transferred to eyes, nose or mouth, it can enter the body and infect the subject [3]. Hence, avoiding face-touches has to become a novel habit to acquire.

To deal with this aspect, we developed No Face-Touch [4], a system able to estimate hand proximity to face and notify the user with an haptic signal whenever a face-touch movement is detected. In its complete setup, No Face-Touch is composed of three elements: *i)* a smartwatch worn by the user featuring an accelerometer and a magnetometer; *ii)* an application running on the smartwatch or on the companion smartphone; *iii)* a wearable accessory worn close to the face (like a necklace, a pair of earrings or a pair of glasses) embedding magnets to generate a detectable magnetic field (Figure 1a). Its ease of implementation allows this solution to be ready-to- use and large-scale deployable. In an alternative version of the algorithm, sets of wrist-angles compatible with face touches have been defined and acceleration data are used to feed a recurrent neural network trained for detecting face-touch occurrences. Experimental results revealed the effectiveness of the proposed system, demonstrating its impact in reducing the number of face-touches and their duration.

III. REMOTOUCH

The social isolation to which we have been subjected in the last period has made video-conferencing systems common for everyone, either for social reunion or meeting with colleagues. In this context, being able to provide effective haptic stimuli through lightweight, inexpensive, and unobtrusive devices can significantly increase the immersiveness of remote interactions. An example of this kind of technology is RemoTouch [5], a system consisting of a human avatar equipped with an instrumented glove and a user wearing tactile displays allowing to feel the remote tactile interaction (Figure 1b). The glove is equipped with force sensors, one per finger, and the measured contact force at the remote interaction is fed back to the user through simple and wearable tactile displays, one per finger. The tactile display consists of two motors and a belt able to deform the fingertip according to the contact force measured



(a) (b) (c)

Fig. 1: (a) The application No Face-Touch runs on the smartwatch. It estimates hand proximity to face and notifies the user with a vibration whenever a face-touch movement is detected. (b) An experience of remote touch. The teacher remotely touches the child and transmits the tactile interaction to the mother who is able to perceive the remote touch experience. (c) A representative trial of 'remote social walking'. The participants were tasked to tune their own gait cadence with the partner's rhythm, displayed by the anklets.

by the remote instrumented glove. An enhanced version of the system, presented in [6], is able to recreate the sensations of touching objects made of different materials, providing pressure and texture rendering through a moving platform and a vibrotactile motor, respectively. Indeed, the human sense of touch is capable of gathering valuable information about the features of an object one is in contact with through high-frequency vibrations. Such devices could be coupled with the sensing counterpart or used standalone to interact with the VR environment. RemoTouch is not only a real-time communication system but it can be also exploited as a system to record the many visual-tactile experiences to be played back at a different time. These experiences can be shared with other people as it usually happens for images or music in social networks.

IV. Social Walking

Due to the increase of infections in the autumn, many shared spaces that promote physical activity, e.g. gyms and swimming pools, were closed or limited. One of the negative effects of this limitation is that many people quit performing physical exercise, or devote less time to healthy habits. Haptic technology can provide these persons with the possibility of feeling close to their workout or jogging partners in a safe way by creating a communication mediated by touch. We recently developed a system capable of recording in real-time the walking cadence of a user, which is then displayed to one or multiple partners through a pattern of vibrations provided at the ankles [7]. The system records the stride duration using an Arduino connected to a pressure sensor under the right heel (inside the shoe), then forwards the time information to the smartphone using Bluetooth communication, and leverages the internet connection to reach the smartphones of the other partners passing though a remote server. The server stores the time data, together with other relevant parameters of the individual walk, used for post processing analysis. Thanks to this implementation, the system enables the possibility of performing a 'remote social walking' (Figure 1c). We believe that walking together from remote can be beneficial in a two-fold manner: it can motivate sedentary people to go for a walk by leveraging the emotional aspect (think about a grandparent feeling the steps the grandchild living in a different place), or the partner's rhythm can provide the user with a challenging opportuinity to perform better the physical exercise, e.g. by maintaining a quick step cadence. Although we did not extensively study the effects of the emotional involvement in promoting healthy habits, the experimental campaign revealed the effectiveness of the haptic system in enabling the remote synchronization of the user's step cadence to the partners. In case the formation is composed by two people, each participant is provided with haptic cues that describe the partner's walking cadence. If three or more people are in the remote group, each participant perceives the average walking cadence of the other partners (excluded itself), updated to the last stride duration received by the server. This approach could be easily extended to many different scenarios involving cyclic tasks, e.g. cycling, rowing, sharing the rhythm while performing high intensity training (push-ups, squats), or activities that require synchronization of motions, by using different sensors and actuators on the same communication infrastructure.

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