



Activity Report 2017

Team MINT2

Méthodes et outils pour l'interaction à gestes

Inria teams are typically groups of researchers working on the definition of a common project, and objectives, with the goal to arrive at the creation of a project-team. Such project-teams may include other partners (universities or research institutions).

RESEARCH CENTER
Lille - Nord Europe

THEME
Interaction and visualization

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Team MINT2

Creation of the Team: 2017 January 01, end of the Team: 2017 December 31

Keywords:

Computer Science and Digital Science:

- A5. - Interaction, multimedia and robotics
- A5.1. - Human-Computer Interaction
- A5.1.1. - Engineering of interactive systems
- A5.1.2. - Evaluation of interactive systems
- A5.1.3. - Haptic interfaces
- A5.1.5. - Body-based interfaces
- A5.1.6. - Tangible interfaces
- A5.1.8. - 3D User Interfaces
- A5.6. - Virtual reality, augmented reality

Other Research Topics and Application Domains:

- B2.5. - Handicap and personal assistances
- B9.1. - Education
- B9.2. - Art
- B9.5. - Humanities

1. Personnel

Faculty Members

- Laurent Grisoni [Team leader, Univ des sciences et technologies de Lille, Professor, HDR]
- Michel Amberg [Univ des sciences et technologies de Lille, Professor]
- Florent Berthaut [Univ Lille SHS, Associate Professor]
- Frederic Giraud [Univ des sciences et technologies de Lille, Associate Professor, HDR]
- Betty Semail [Univ des sciences et technologies de Lille, Professor, HDR]

Post-Doctoral Fellow

- Yosra Rezik [Univ des sciences et technologies de Lille]

PhD Students

- Cagan Arslan [Univ des sciences et technologies de Lille]
- Olivier Capra [Univ des sciences et technologies de Lille]
- Ehsan Enferad [Univ des sciences et technologies de Lille]
- Vincent Gouzou [ANMA, CIFRE contract with LACTH, Univ. Lille SHS]
- Farzan Kalantari [Univ des sciences et technologies de Lille]
- Charlotte Planckeel [Univ Charles de Gaulle]

External Collaborators

- Fabrice Aubert [Univ des sciences et technologies de Lille]
- Patricia Plenacoste [Univ des sciences et technologies de Lille]

2. Overall Objectives

2.1. Overall Objectives

The Mint team focuses on *gestural interaction*, i.e. the use of gesture for human-computer interaction (HCI). The New Oxford American Dictionary defines *gesture* as *a movement of part of the body, especially a hand or the head, to express an idea or meaning*. In the particular context of HCI, we are more specifically interested in movements that a computing system can sense and respond to. A gesture can thus be seen as a function of time into a set of sensed dimensions that might include but are not limited to positional information (the pressure exerted on a contact surface being an example of non-positional dimension).

Simple pointing gestures have long been supported by interactive graphics systems and the advent of robust and affordable sensing technologies has somewhat broadened their use of gestures. Swiping, rotating and pinching gestures are now commonly supported on touch-sensitive devices, for example. Yet the expressive power of the available gestures remains limited. The increasing diversity and complexity of computer-supported activities calls for more powerful gestural interactions. Our goal is to foster the emergence of these new interactions, to further broaden the use of gesture by supporting more complex operations. We are developing the scientific and technical foundations required to facilitate the design, implementation and evaluation of these interactions. Our interests include:

- gestures captured using held, worn or touched objects or contactless perceptual technologies;
- transfer functions possibly used during the capture process;
- computational representations of the captured gestures;
- methods for characterising and recognising them;
- feedback mechanisms, and more particularly haptic ones;
- tools to facilitate the design and implementation of tactile and gestural interaction techniques;
- evaluation methods to assess the usability of these techniques.

3. Research Program

3.1. Human-Computer Interaction

The scientific approach that we follow considers user interfaces as means, not an end: our focus is not on interfaces, but on interaction considered as a phenomenon between a person and a computing system [11]. We *observe* this phenomenon in order to understand it, i.e. *describe* it and possibly *explain* it, and we look for ways to significantly *improve* it. HCI borrows its methods from various disciplines, including Computer Science, Psychology, Ethnography and Design. Participatory design methods can help determine users' problems and needs and generate new ideas, for example [15]. Rapid and iterative prototyping techniques allow to decide between alternative solutions [12]. Controlled studies based on experimental or quasi-experimental designs can then be used to evaluate the chosen solutions [17]. One of the main difficulties of HCI research is the doubly changing nature of the studied phenomenon: people can both adapt to the system and at the same time adapt it for their own specific purposes [14]. As these purposes are usually difficult to anticipate, we regularly *create* new versions of the systems we develop to take into account new theoretical and empirical knowledge. We also seek to *integrate* this knowledge in theoretical frameworks and software tools to disseminate it.

3.2. Numerical and algorithmic real-time gesture analysis

Whatever is the interface, user provides some curves, defined over time, to the application. The curves constitute a gesture (positional information, yet may also include pressure). Depending on the hardware input, such a gesture may be either continuous (e.g. data-glove), or not (e.g. multi-touch screens). User gesture can be multi-variate (several fingers captured at the same time, combined into a single gesture, possibly involving two hands, maybe more in the context of co-located collaboration), that we would like, at higher-level, to be structured in time from simple elements in order to create specific command combinations. One of the scientific foundations of the research project is an algorithmic and numerical study of gesture, which we classify into three points:

- *clustering*, that takes into account intrinsic structure of gesture (multi-finger/multi-hand/multi-user aspects), as a lower-level treatment for further use of gesture by application;
- *recognition*, that identifies some semantic from gesture, that can be further used for application control (as command input). We consider in this topic multi-finger gestures, two-handed gestures, gesture for collaboration, on which very few has been done so far to our knowledge. On the contrary, in the case of single gesture case (i.e. one single point moving over time in a continuous manner), numerous studies have been proposed in the current literature, and interestingly, are of interest in several communities: HMM [18], Dynamic Time Warping [20] are well-known methods for computer-vision community, and hand-writing recognition. In the computer graphics community, statistical classification using geometric descriptors has previously been used [16]; in the Human-Computer interaction community, some simple (and easy to implement) methods have been proposed, that provide a very good compromise between technical complexity and practical efficiency [19].
- *mapping to application*, that studies how to link gesture inputs to application. This ranges from transfer function that is classically involved in pointing tasks [13], to the question to know how to link gesture analysis and recognition to the algorithmic of application content, with specific reference examples.

We ground our activity on the topic of numerical algorithm, expertise that has been previously achieved by team members in the physical simulation community (within which we think that aspects such as elastic deformation energies evaluation, simulation of rigid bodies composed of unstructured particles, constraint-based animation... will bring up interesting and novel insights within HCI community).

3.3. Design and control of haptic devices

Our scientific approach in the design and control of haptic devices is focused on the interaction forces between the user and the device. We search of controlling them, as precisely as possible. This leads to different designs compared to other systems which control the deformation instead. The research is carried out in three steps:

- *identification*: we measure the forces which occur during the exploration of a real object, for example a surface for tactile purposes. We then analyse the record to deduce the key components – *on user's point of view* – of the interaction forces.
- *design*: we propose new designs of haptic devices, based on our knowledge of the key components of the interaction forces. For example, coupling tactile and kinesthetic feedback is a promising design to achieve a good simulation of actual surfaces. Our goal is to find designs which lead to compact systems, and which can stand close to a computer in a desktop environment.
- *control*: we have to supply the device with the good electrical signals to accurately output the good forces.

4. Application Domains

4.1. Domain

MINT team currently devotes application to domains such as cultural heritage, retail, and health.

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. *Evita*

EVITA is a tactile feedback tablet, produced by Hap2U SME company, based in Grenoble. It has been presented at CES in January 2017, the SME has been awarded a CES innovation award. This device is issued from a strong collaboration with MINT group. EVITA is a very generic interaction device, and several projects are currently being discussed for understanding the fields of applications of this device. It is also, in particular, the hardware support for our haptic book for children, described below, that is our second highlight for this Raweb. XploreTouch tablet (the product sold by Hap2U) will be integrated in 2018 in "Palais de la Découverte" permanent exposure (La Villette, Paris).

5.1.2. *Haptic book*

The first digital book augmented with a high fidelity feedback was released in October 2016. Based on a scenario and illustrations made by Dominique Maes - an artist from Belgium - this haptic book was presented for the first time during "La nuit des bibliothèques" in Lille. This project had nice society visibility in 2017, with several expositions (3 exhibitions in the region in 2017, about 14 weeks of availability hired by city of Valenciennes in 2018).

5.1.3. *GoTouchVR spinoff*

Eric Vezzoli and Thomas Sednaoui (two former PhD students of the team) founded GoTouchVR company, that designs a lightweight device (the VRTouch device) for tactile feedback for VR systems. The company was present at CES 2017 and will be also present at CES 2018. An Inria Tech contract was devoted to the VRTouch SDK, taking benefit of MINT knowledge on gesture recognition and interaction design.

5.1.3.1. *Awards*

- SME Hap2U received a "CES innovation award", based on the collaboration that MINT group has with them (E-vita tactile feedback tablet) at CES (January 2017).

6. New Results

6.1. Localized Haptic Texture: A Rendering Technique Based on Taxels for High Density Tactile Feedback

Participants: Yosra Rekik, Eric Vezzoli, Laurent Grisoni, Frederic Giraud.

We investigate the relevance of surface haptic rendering techniques for tactile devices. We focus on the two major existing techniques and show that they have complementary benefits. The first one, called Surface Haptic Object (SHO), which is based on finger position, is shown to be more suitable to render sparse textures; while the second one, called Surface Haptic Texture (SHT), which is based on finger velocity, is shown to be more suitable for dense textures and fast finger movements. We hence propose a new rendering technique, called Localized Haptic Texture (LHT), which is based on the concept of *taxel* considered as an elementary tactile information that is rendered on the screen. By using a grid of taxels to encode a texture, LHT is shown to provide a consistent tactile rendering across different velocities for high density textures, and is found to reduce user error rate by up to 77.68% compared to SHO. Available at <https://hal.inria.fr/hal-01444099>.

6.2. Revgest: Augmenting Gestural Musical Instruments with Revealed Virtual Objects

Participants: Florent Berthaut, Cagan Arslan, Laurent Grisoni.

Gestural interfaces, which make use of physiological signals, hand / body postures or movements, have become widespread for musical expression. While they may increase the transparency and expressiveness of instruments, they may also result in limited agency, for musicians as well as for spectators. This problem becomes especially true when the implemented mappings between gesture and music are subtle or complex. These instruments may also restrict the appropriation possibilities of controls, by comparison to physical interfaces. Most existing solutions to these issues are based on distant and/or limited visual feedback (LEDs, small screens). Our approach is to augment the gestures themselves with revealed virtual objects. Our contributions are, first a novel approach of visual feedback that allow for additional expressiveness, second a software pipeline for pixel-level feedback and control that ensures tight coupling between sound and visuals, and third, a design space for extending gestural control using revealed interfaces. We also demonstrate and evaluate our approach with the augmentation of three existing gestural musical instruments. Available at URL <https://hal.archives-ouvertes.fr/hal-01518579>

6.3. Spontaneous Gesture Production Patterns on Multi-Touch Interactive Surfaces

Participants: Yosra Rekik, Radu-Daniel Vatavu, Laurent Grisoni.

Expressivity of hand movements is much greater than what current interaction techniques enable in touch-screen input. Especially for collaboration, hands are used to interact but also to express intentions, point to the physical space in which collaboration takes place, and communicate meaningful actions to collaborators. Various types of interaction are enabled by multi-touch surfaces (single and both hands, single and multiple fingers, etc), and standard approaches to tactile interactive systems usually fail in handling such complexity of expression. The diversity of multi-touch input also makes designing multi-touch gestures a difficult task. We believe that one cause for this design challenge is our limited understanding of variability in multi-touch gesture articulation, which affects users' opportunities to use gestures effectively in current multi-touch interfaces. A better understanding of multi-touch gesture variability can also lead to more robust design to support different users' gesture preferences. In this work we present our results on multi-touch gesture variability. We are mainly concerned with understanding variability in multi-touch gestures articulation from a pure user-centric perspective. We present a comprehensive investigation on how users vary their gestures in multi-touch gestures even under unconstrained articulation conditions. We conducted two experiments from which we collected 6669 multi-touch gestures from 46 participants. We performed a qualitative analysis of user gesture variability to derive a taxonomy for users' multi-touch gestures that complements other existing taxonomies. We also provide a comprehensive analysis on the strategies employed by users to create different gesture articulation variations for the same gesture type. Available at URL <https://hal.inria.fr/hal-01444113>

6.4. Control and evaluation of a 2-D Multimodal Controlled-Friction Display

Participants: Sofiane Ghenna, Christophe Giraud-Audine, Frédéric Giraud, Michel Amberg, Betty Lemaire-Semail.

The multimodal control of a 2D controlled-Friction Device is presented. We use the Vector control method because the phase and amplitude of two vibration modes at a same frequency can be precisely set. The closed loop response time of 10 ms is achieved. The device is then associated with a finger position sensor. The algorithm of the multimodal approach is then tested. In spite of the inevitable limitations of the system-saturation of amplifiers, low sampling frequency of the sensor-low friction could be imposed under a finger while a high friction was imposed on a predetermined position. This confirms the validity of the modal approach to create multi touch interactions. Available at URL <https://hal.inria.fr/hal-01538340>

6.5. Enriching Musical Interaction on Tactile Feedback Surfaces with Programmable Friction

Participants: Farzan Kalantari, Florent Berthaut, Laurent Grisoni.

In the recent years, a great interest has emerged to utilise tactile interfaces for musical interactions. These interfaces can be enhanced with tactile feedback on the user's fingertip through various technologies, including programmable friction techniques. In this study, we have used a qualitative approach to investigate the potential influence of these tactile feedback interfaces on user's musical interaction. We have experimented three different mappings between the sound parameters and the tactile feedback in order to study the users' experiences of a given task. Our preliminary findings suggest that friction-based tactile feedback is a useful tool to enrich musical interactions and learning. Available at URL <https://hal.inria.fr/hal-01580750>

6.6. bf-pd: Enabling Mediated Communication and Cooperation in Improvised Digital Orchestras

Participants: Luke Dahl, Florent Berthaut, Antoine Nau, Patricia Plenacoste.

Digital musical instruments enable new musical collaboration possibilities, extending those of acoustic ensembles. However, the use of these new possibilities remains constrained due to a lack of a common terminology and technical framework for implementing them. Bf-pd is a new software library built in the PureData (Pd) language which enables communication and cooperation between digital instruments. Its design is based on the BOEUF conceptual framework which consists of a classification of modes of collaboration used in collective music performance, and a set of components which affords them. Bf-pd can be integrated into any digital instrument built in Pd, and provides a "collaboration window" from which musicians can easily view each others' activity and share control of instrument parameters and other musical data. We evaluate the implementation and design of bf-pd through workshops and a preliminary study and discuss its impact on collaboration within improvised ensembles of digital instruments. Available at URL <https://hal.archives-ouvertes.fr/hal-01577942>

6.7. Toward Augmented Familiarity of the Audience with Digital Musical Instruments

Participants: Olivier Capra, Florent Berthaut, Laurent Grisoni.

The diversity and complexity of Digital Musical Instruments often lead to a reduced appreciation of live performances by the audience. This can be linked to the lack of familiarity they have with the instruments. We propose to increase this familiarity thanks to a trans-disciplinary approach in which signals from both the musician and the audience are extracted, familiarity analysed, and augmentations dynamically added to the instruments. We introduce a new decomposition of familiarity and the concept of correspondences between musical gestures and results. This study is both a review of research that paves the way for the realisation of a pipeline for augmented familiarity, and a call for future research on the identified challenges that remain before it can be implemented. Available at URL <https://hal.archives-ouvertes.fr/hal-01577953>

6.8. Understanding Gesture Articulations Variability

Participants: Orlando Erazo, Yosra Rekik, Laurent Grisoni, José Pino.

Interfaces based on mid-air gestures often use a one-to-one mapping between gestures and commands, but most remain very basic. Actually, people exhibit inherent intrinsic variations for their gesture articulations because gestures carry dependency with both the person producing them and the specific context, social or cultural, in which they are being produced. We advocate that allowing applications to map many gestures to one command is a key step to give more flexibility, avoid penalisations, and lead to better user interaction experiences. Accordingly, this study presents our results on mid-air gesture variability. We are mainly concerned with understanding variability in mid-air gesture articulations from a pure user-centric perspective. We describe a comprehensive investigation on how users vary the production of gestures under un-constrained articulation conditions. The conducted user study consisted in two tasks. The first one provides a model of user conception and production of gestures; from this study we also derive an embodied taxonomy of gestures. This taxonomy is used as a basis for the second experiment, in which we perform a fine grain quantitative analysis of gesture articulation variability. Based on these results, we discuss implications for gesture interface designs. Available at URL <https://hal.inria.fr/hal-01578738>

6.9. Understanding Users' Perception of Simultaneous Tactile Textures

Participants: Yosra Rekik, Eric Vezzoli, Laurent Grisoni.

We study users' perception of simultaneous tactile textures in ultrasonic devices. We investigate how relevant is providing the user with different complementary and simultaneous textures with respect to the different fingers that can be used to touch the surface. We show through a controlled experiment that users are able to distinguish the number of different textures independently of using fingers from one or two hands. However, our findings indicate that users are not able to differentiate between two different textures, that is to correctly identify each of them, when using fingers from the same hand. Based on our findings, we are then able to outline three relevant guidelines to assist multi-finger tactile feedback ergonomic and devices design. Available at URL <https://hal.inria.fr/hal-01578729>

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

- Hap2U SME is licensed two patents of MINT team.
- An InriaTech contract has been made with GoTouchVR SME for contributing to the company SDK.

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. *StimTac, 2015-2017*

Participants: Frédéric Giraud [correspondant], Patricia Plénacoste, Laurent Grisoni, Michel Amberg, Nicolas Bremmard.

The aim of this project is to create the first digital book, enhanced with haptic feedback, in order to anticipate the integration of this technology into everyday products. This project addresses technological issues, like programming haptic content in a multimedia software, and design issues to understand how the haptic feedback is perceived by the users.

Stimtac is a book, and could thus be presented to non-specialists users and to a wide public during presentations, demos and forums. The scenario and the illustrations were made by Dominique Maes, a Belgium artist, who did the digital book "Bleu de toi" among other things. The Public Library of Lille is a partner of this project and allows us to meet the public.

This project has been granted 8Keuros from IRCICA.

8.1.2. *MATRICE (sept 2015-sept. 2017)*

Participant: Laurent Grisoni [correspondant].

This regional project, funded by ERDF, led by Lille School of Architecture, aims at understanding in which way 3D printing may be interesting for the building economy. partners: Ecole d'architecture de Lille, Inria, Ecole Centrale de Lille, Télécom Lille 1, Ecole des Mines de Douai.

8.2. National Initiatives

8.2.1. *Equipex IRDIVE (ANR project 2012-2020)*

3 Meuros project, co-funded by ERDF for the development of a pluri-disciplinary project on ICT-based tools for understanding human perception of visual contents. Laurent Grisoni is member of the lead group of this project, and animates an axis devoted to art-sciences and technologies collaborations.



(a)



(b)

Figure 1. Demo session at "La nuit des Bibliothèques (Lille, October 2016), and a page of Stimtac; the ellipse highlights the tactile feedback on E-Vita.

8.2.2. MAUVE CPER ("Contrat de Plan État-Région") 2016-2020 project

Funds: 4 Meuros (validated at national level, funded by Region), and 1 Meuro additional funding provided by ERDF.

Subject: ICT tools for mediation and access to knowledge.

Lead: University of Lille, University of Artois. Laurent Grisoni is co-lead of this project.

8.2.3. InriaRT

Participants: Laurent Grisoni [correspondant], Samuel Degrande, Francesco de Comit .

Art/science Inria internal network gathering projects interested in collaborating with artists.

Inria teams involved: MuTANT (Paris), Imagine (Grenoble), Flowers, Potioc (Bordeaux), Hybrid, MimeTic (Rennes). This initiative will take advantage of an agreement between Inria and French Ministry of Culture, signed early December 2016.

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

MINT participates to the VR4REHAB (2018-2020) project, funded by ENO Interreg. This project gathers rehabilitation structures and provides animation of hackathons for prototyping VR systems for rehabilitation. MINT role is to provide technical support and help mature relevant approaches for getting closer to using VR for personal, lightweight rehabilitation systems. Funds for the team: 430 Keuros. Contact for the team: Laurent Grisoni.

8.3.2. Collaborations with Major European Organizations

we collaborate with INESC-ID (through exchange of students, joint publications).

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific Events Selection

9.1.1.1. Member of the Conference Program Committees

Laurent Grisoni : PC for VISIGRAPP (IEEE InfoViz Art Track), Computer Graphics International (CGI, computer graphics), MOCO (international workshop on gesture), ISEA (art-science), GRAPP (computer graphics)

9.1.1.2. Reviewer

Florent Berthaut: Reviewer for ACM CHI Conference and NIME conference
Laurent Grisoni: Eurohaptics, ACM UIST, ACM CHI

9.1.2. Journal

9.1.2.1. Member of the Editorial Boards

Frédéric Giraud is Associate Editor of IEEE Transactions on Haptics

9.1.2.2. Reviewer - Reviewing Activities

Florent Berthaut: Reviewer for IEEE Multimedia
Laurent Grisoni: Computer & Graphics

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

- Licence: Florent Berthaut, Spreadsheets et VBA programming, LEA L3 TCI (22h), Web programming, LEA L3, Université Lille 3, France
- Licence: Frédéric Giraud, Physique pour le génie électrique (30h), Université Lille 1
- Master: Christophe Giraud-Audine, Control of electrical machines (30h), Power Electronics (30h), signal processing (30h), niveau M1, ENSAM, France
- Master: Florent Berthaut, Web programming, LEA M1 TSM (16,5h) and LEA M1 RIC1 (48h), Database, LEA M1 ANI (22h), Université Lille 3, France
- Master: Frédéric Giraud, Control of electrical machines (30h), Power Electronics (40h) niveau M1, Université Lille1, France
- Master: Laurent Grisoni, NIHM : nouvelles Interactions Homme-Machine, (6h), niveau M2, Université Lille 1, France
- Master: Laurent Grisoni, Représentation et compression de données (24h), introduction à la programmation (38h), cryptographie (8h), Ecole Polytech'lille (dept IMA)
- Master: Laurent Grisoni: Gestion de projet en Co-design interdisciplinaire, Master Sciences et Culture du Visuel, Université de Lille Sciences Humaines et Sociales, Master Sciences et Cultures du Visuel (12h)
- Master: Laurent Grisoni, IHM et interface à gestes, (24h), niveau M2 (IMA5), Polytech Lille, France

9.2.2. Supervision

- PhD in progress: Ehsan Enferad, Modélisation et commande d'une interface tactile à stimulation hybride par modulation de friction et retournement temporel, Nov. 2015, F. Giraud, C. Giraud-Audine
- PhD in progress: Cagan Arslan, Fusion de données pour l'interaction homme-machine, Oct. 2015, L. Grisoni/J. Martinet
- PhD in progress: Farzan Kalantari, Interaction sur dispositif à retour tactile et kinesthésique, Oct. 2014, L. Grisoni, F. Giraud
- PhD: Hanae Rateau, Exploring Interactive Sub-Spaces for Gestural Midair Interaction, Université de Lille Sciences et Technologies, 17 May 2017, L. Grisoni
- PhD in progress: Vincent Gouezou: L'architecte et ses outils, au travers de l'histoire et dans sa relation actuelle au numérique, Oct. 2014, L. Grisoni 25% (with F. Vermandel, architect, Lille School of Architecture)
- PhD in progress: Charlotte Planckeel, Le sens de la lacunae en archéologie de l'âge du bronze, archéologie et outils numériques, L. Grisoni (25%, with A. Lehoerff, Lille 3, archeologist)

- PhD in progress: Olivier Capra, Interaction de présentation, Oct. 2016, L. Grisoni, F. Berthaut

10. Bibliography

Publications of the year

Articles in International Peer-Reviewed Journals

- [1] E. VEZZOLI, Z. VIDRIH, V. GIAMUNDO, B. LEMAIRE-SEMAIL, F. GIRAUD, T. RODIC, D. PERIC, M. ADAMS. *Friction Reduction through Ultrasonic Vibration Part 1: Modelling Intermittent Contact*, in "IEEE Transactions on Haptics (ToH)", 2017, vol. 10, n^o 2, pp. 196 - 207 [DOI : 10.1109/TOH.2017.2671432], <https://hal.inria.fr/hal-01629239>

International Conferences with Proceedings

- [2] S. GHENNA, C. GIRAUD-AUDINE, F. GIRAUD, M. AMBERG, B. LEMAIRE-SEMAIL. *Control and evaluation of a 2-D Multimodal Controlled-Friction Display*, in "IEEE World Haptics 2017", Fürstfeldbruck (Munich), Germany, June 2017, <https://hal.inria.fr/hal-01538340>
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