Activity Report 2015

Project-Team MINT

Methods and tools for gestural interactions

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Project-Team MINT

Creation of the Team: 2010 January 01, updated into Project-Team: 2012 January 01

Keywords:

Computer Science and Digital Science:
        5.1.2. - Evaluation of interactive systems
        5.1.3. - Haptic interfaces
        5.1.5. - Body-based interfaces
        5.6. - Virtual reality, augmented reality

Other Research Topics and Application Domains:
        9.1. - Education
        9.2. - Art
        9.5.10. - Digital humanities

1. Members

Faculty Members
    Laurent Grisoni [Team leader, Univ. Lille I, Professor, HdR]
    Florent Berthaut [Univ. Lille III, Associate Professor, associate member]
    Frederic Giraud [Univ. Lille I, Associate Professor, HdR]
    Fabrice Aubert [Univ. Lille I, Associate Professor]
    Francesco de Comité [Univ. Lille I, Associate Professor]
    Betty Semail [Univ. Lille I, Professor, HdR]
    Christophe Giraud-Audine [Arts & Métiers Paris tech, Associate Professor, associate member]

Engineers
    Michel Amberg [Univ. Lille I, Research Engineer]
    Erwan Douaille [Inria]
    Florian Renaut [Univ. Lille I, until Jun 2015]

PhD Students
    Cagan Arslan [Univ. Lille I, from Mar 2015]
    Wael Ben Messaoud [Univ. Lille I]
    Nicolas Bremard [Univ. Lille 1, until Nov 2015]
    Sofiane Ghenna [Univ. Lille I]
    Vincent Gouezou [CIFRE]
    Farzan Kalantari [Univ. Lille I]
    Charlotte Planckeel [Univ. Lille III, from Nov 2015]
    Hanae Rateau [Univ. Lille I]
    Eric Vezzoli [Univ. Lille I]
    Ehsan Enferad [Univ. Lille I]

Post-Doctoral Fellow
    Yosra Rekik [Univ. Lille I, fev.2016-dec. 2018]

Visiting Scientist
    Orlando Erazo [from Nov 2015]

Administrative Assistant
    Karine Lewandowski [Inria]

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 [23]. 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 [27]. Rapid and iterative prototyping techniques allow to decide between alternative solutions [24]. Controlled studies based on experimental or quasi-experimental designs can then be used to evaluate the chosen solutions [29]. 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 [26]. 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 [30], Dynamic Time Warping [32] 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 [28]; 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 [31].

- *mapping to application*, that studies how to link gesture inputs to application. This ranges from transfer function that is classically involved in pointing tasks [25], 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. Highlights of the Year

4.1. Highlights of the Year

4.1.1. Art/Science collaborations

4.1.1.1. Art paper and art show at SIGGRAPH ASIA (Kobe): Tools for digital anamorphoses: using raycasting techniques for creation anamorphoses

Anamorphoses have been know for centuries, as distorted images needing to be seen in a mirror from a special point of view in order to see the non-distorted image. During Renaissance, they have been associated to mathematical techniques for drawing such pictures efficiently, on specific mirror shapes (in the case of cylindrical or conical mirrors). We can expect in the next years a strong interest in such type of images, because of the emergence of various contexts and physical supports for image visualisation (soft or de-formable screens, lightmapping, projection of images on dynamic objects, etc...). Solving the numerical problem of anamorphosis in the general case belongs to the same class of problems as when the trend is to control image deformation as long as image is seen projected on, or reflected by, a non-planar surface, which can be of arbitrary shape. In this work, we show how raycasting technique, well-known in the computer graphics community , can be used to provide an efficient general framework for such rendering. We describe an effective procedure for building general anamorphoses. A generalisation of the method leads to the conception of three-dimensional anamorphic sculptures, usable for 3D printing anamorphic objects. We exhibit , through several artworks, tangible and virtual examples.
http://hal.univ-lille3.fr/hal-01258727v1

4.1.1.2. Presented at VISAP (IEEE InfoViz artTrack): "A main levée" Art Installation

Developed in collaboration with MINT, the "A main levée" art installation by Pauline de Chalendar was presented at VISAP, IEEE Infoviz ArtTrack, in August 2016. This immersive installation allows for free hand drawing using a virtual-reality headset. From this artwork (also presented at Panorama 2015 exposition),

4.1.2. Industrial collaboration: Hap2u

A license agreement has been signed with Hap2u, a new start-up which aims at designing new interaction devices, based on our patent on tactile rendering. Hap2u will industrialise commercial products, based on our patents. The beginning of the commercial activity might start in 2016.

4.1.3. MAuVE project

MAuve is a 4 Meuros project (2016-2020), which subject is ICT-based tools for mediation and access to knowledge. L. Grisoni is leading this project, along with S. Bartholeyns (historian, Lille 3) and S. Chaumier (sociologist, Univ. Artois).

5. New Software and Platforms

5.1. Revil

SCIENTIFIC DESCRIPTION

Revil is an application for building and manipulating 3D SceneGraphs for Mixed-Reality Artistic Performances.It relies on the approach of revealing virtual content in the physical space by intersecting it with performers and spectator's bodies and props.

FUNCTIONAL DESCRIPTION

It provides a GUI for setting up the projectors, depth cameras and scene objects. It is based on OpenScene-Graph, OpenNI2 and is entirely controllable via OpenSoundControl messages so that it can be connected to Digital Musical Instruments and other interactive systems.

- Participants: Florent Berthaut, Cagan Arslan
- Contact: Florent Berthaut
- URL: http://forge.lifl.fr/Revil

5.2. libgina

LibGINA is a library for fast prototyping of gestural interaction.
In 2015, new features were added in the context of Nicolas Bremard's thesis. The software was used in various projects.

- Participants: Nicolas Bremard and Laurent Grisoni
- Contact: Laurent Grisoni

5.3. SmartInteraction

SmartInteraction is a library, result from the FUI SmartStore project. It allows mobile services to be activated easily through automatic connection to interaction public spots, without specific user action.

- Participants: Samuel Degrande, Laurent Grisoni
- Contact: Samuel Degrande

6. New Results

6.1. Physical and Perceptual Independence of Ultrasonic Vibration and Electrovibration for Friction Modulation

Eric Vezzoli, Wael Ben Messaoud, Michel Amberg, Betty Lemaire-Semail, Frédéric Giraud, Marie-Ange Bueno
Two different principles are available to modulate the user perceived roughness of a surface: electrovibration and ultrasonic vibration of a plate. The former enhances the perceived friction coefficient and the latter reduces it. In this work, we highlighted the independence of the two effects on the physical and perceptual point of view to confirm the increased range of sensation that can be supplied by the two coupled techniques. Firstly, a tribometric analysis of the induced lateral force on the finger by the two coupled effects has been achieved, then a study on the dynamic of the two effects is reported. In the end, a psychophysical experiment on the perception of the two coupled techniques confirms the approach.

6.2. Preliminary design of a multi-touch ultrasonic tactile stimulator

Sofiane Ghenna, Christophe Giraud-Audine, Frédéric Giraud, Michel Amberg, Betty Lemaire-Semail
Currently there is no solution able to provide a multitouch tactile stimulation based on friction reduction tactile devices. The main objective of this work is to achieve a control method which allows to have a differentiated tactile stimulation on two fingers simultaneously, by superimposing two vibration modes. The proof of concept has been established on a 1D beam, where the tactile stimulation could be differentiated on two selected positions. We have presented the key design rules, as well as the control method. Finally, a psychophysical evaluation has shown that users can detect the location of nodes and antinodes of vibration with an average success rate of 78%

6.3. Generalised modal analysis for closed-loop piezoelectric devices

Christophe Giraud-Audine, Frédéric Giraud, Michel Amberg, Betty Lemaire-Semail.

Stress in piezoelectric material can be controlled by imposing the electrical field. Thanks to a feedback, this electrical field can be a function of some strain related measurement so as to confer to the piezoelectric device a closed loop macroscopic behaviour.We address the modelling of such system by extending the modal decomposition methods to account for the closed loop. To do so the boundary conditions are modified to include the electrical feedback circuit, hence allowing a closed-loop modal analysis. A case study is used to illustrate the theory and to validate it. The main advantage of the method is that design issue such as coupling factor of the device and closed loop stability are simultaneously captured.

6.4. Pressure dependence of friction modulation in ultrasonic devices

Wael Ben Messaoud, Eric Vezzoli, Frédéric Giraud, Betty Lemaire-Semail
Ultrasonic vibrating devices are able to modulate the friction of a finger sliding on them. The underlying principles of the friction reduction are still unclear, and this work is carried out to investigate the influence of the ambient pressure on the friction modulation. A specific tactile stimulator has been used for this purpose and the friction between the finger sliding on the device has been recorded for an ambient pressure of 0.5 and 1 atm showing a significant difference for comparable experimental conditions. A comparison with the model proposed in literature is performed underlying that the squeeze film interaction can be present but not the only responsible of the friction modulation in this kind of devices.

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

7.1.1. Ayodyo (10 Keuros) (sept. 2015-mar 2016)

Embedded software tools for movement-enriched musical instrument. 10 Keuros contract.

7.1.2. Holusion (15 Keuros) (jan-mar 2015)

STAR on holographic displays, and methodological recommendations for interaction design and HCI principles.

7.1.3. Bipolar-production (3 Keuros), nov. 2015-fev. 2016

Licence for a software result issued from Y. Rekik thesis (multi-touch public interaction, software aiming at strengthening tactile interaction)

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. MATRICE

24 month project. lead: Lille school of architecture. Partners: Telecom Lille, Ecole des mines de douai, Centrale Lille, Lille school of design. Subject: 3D printing for construction industry. Funding for MINT: 12 months engineer, 12 months post-doc.

8.1.2. Iconographie Numérique (Sept. 2015-Dec. 2018)

From sept. 2015 to dec. 2018.
Funding from MEL, 24 months for post-doctoral position.
Subject: Design of a digital tool for historians and archaeologists.

8.1.3. Art/science projects

Pauline de Chalendar (FreeHands project). Shown at Panorama exposition sept-dec. 2015, Fresnoy (Tourcoing). Also shown at VISAP, IEEE Infoviz ArtTrack, august 2015, Chicago.
Pauline Delwaulle
Out of space: Mirror Lake Station Pictanovo project 2013-2015 in collaboration with Mathilde Lavesnne. Shown at "Portes ouvertes, La Malterie, October 17th to 19th 2014; "Expériences interactives" de Pictanovo, l'Hospice d'Havré, May 28th to July 10th 2015; La cartographie, Espace Culture de l'Université de Lille 1, October 6th to December 11th 2015; "Hyper-archéologie", Centre Arc-en-ciel de Liévin, January 29th to February 29th 2016

8.2. National Initiatives

8.2.1. Touchit (13th FUI, May 2012-2015)

Participants: Michel Amberg, Frédéric Giraud, Betty Lemaire-Semail [correspondant].

The purpose of this project is twofold. It aims at designing and implementing hardware solutions for tactile feedback based on programmable friction. It also aims at developing the knowledge and software tools required to use these new technologies for human-computer interaction. Grant for MINT is balanced on 272 keuro handled at University for L2EP, and 220 Keuros for Inria.

Partners: STMicroelectronics, CEA/LETI, Orange Labs, CNRS, EASii IC, MENAPIC and ALPHAUI.

Competitive clusters involved: Minalogic, Cap Digital and MAUD.

8.2.2. Smart-Store (12th FUI, 2011-2014, extended to 2015)

Participants: Samuel Degrande [correspondant], Laurent Grisoni, Fabrice Aubert.

The aim of this project is to set up, in the context of retail, some middleware and hardware setup for retail interactive terminal, that allows customer to connect with their own smart-phone on a system that includes a large screen, and allows to browse some store offer, as well as pre-order and/or link to further reconsulting. SME Ides-3com leads this FUI, which also includes Immochan, Oxylane, and VisioNord. Grant for MINT is 301 Keuros. This project started on September 2012 (start of this project has been delayed due to administrative problems), for a duration of 36 months.

Associated competitivity cluster: PICOM (retail)

8.2.3. Equipex IRDIVE (ANR project 2012-2020)

3 Meuros project, co-funded by ERDF for the developpement 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.

8.2.4. 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.

8.2.5. Projet FUI HID: lead Holusion (2016-2018)

Participants: Laurent Grisoni [correspondant], Samuel Degrande, Fabrice Aubert.

290 Keuros for MINT. Funding for two 18 months contracts and 24 months of post-doc.
Subject: rationalized process for industrial use of holographic displays.
MINT contribution: anamorphic software tools for holographics displays, and study of interactive aspects, including collaborative activities.

8.2.6. InriaRT

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

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).

8.3. International Initiatives

8.3.1. Participation In other International Programs

8.3.1.1. Mac Gill University, Canada, (CIRRMT, Marcelo Wanderley)

Technological tool for an Opera, Two years project, Planned for January 2017. Composed by Arnaud Petit, written by Alain Fleischer.

8.3.1.2. Université de Liège

Application for project C-SHADE

8.3.1.3. Institut Superior Technico, Lisbon (Joaquim jorge)

Application for project C-SHADE

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific events organisation

9.1.1.1. General chair, scientific chair

Frédéric Giraud: General co-chair EMR'2015 (Lille)

9.1.1.2. Member of the organizing committees

Laurent Grisoni: Workshop on Collaboration Meets Interactive Surfaces (CMIS): workshop at ACM ITS tabletop. Co-organised with Andres Lucero, Craig Anslow, Pedro Campos

9.1.2. Scientific events selection

9.1.2.1. Member of the conference program committees

Laurent Grisoni: Computer Graphics International (CGI, 32nd event) , GRAPP (Computer Graphics theory and applications, 11th event), ISEA (21st International Symposium on Electronic Art), MOCO (2nd International workshop on Motion and Computing), VRIPHYS (12th wokshop on Virtual Reality Interaction and Physical Simulation)

9.1.2.2. Reviewer

Florent Berthaut: Reviewer for ACM CHI Conference

9.1.3. Journal

9.1.3.1. Member of the editorial boards
Frédéric Giraud: Associate Editor IEEE Transactions on Haptics

9.1.3.2. Reviewer - Reviewing activities

Frédéric Giraud: reviewer for IEEE Transactions on Mechatronics, IEEE Transactions on Power Electronics, Elsevier Sensors and Actuators
Christophe Giraud-Audine: reviewer for IEEE Transactions on Mechatronics, IEEE Transactions on Power Electronics, IEEE Transactions on Haptics, IEEE Transactions on Industrial Electronic

9.1.4. Scientific expertise

Frédéric Giraud: Expert for the ANR (france), MITACS acceleration (CANADA) Laurent Grisoni: ANR CES 38 2015, 2016 («numérique et société» commitee), Fondecyt (CHILE national research agency), CIR (credit impot recherche) evaluation for French ministry of industry.

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

- Licence: Florent Berthaut, Tableur et Programmation VBA, LEA L3 TCI (22h), 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, Conception Web, LEA M1 TSM (16,5h) et LEA M1 RICI (48h), Bases de données, 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, 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 in progress: Sofiane Ghenna, Contrôle multimodal d'acionneurs piézo-électriques pour applications tactiles, F.Giraud, C.Giraud-Audine
- PhD in progress: Eric Vezzoli, oct 2013, B. Lemaire-Semail, F. Giraud
- PhD in progress: Wael ben Messaoud, Développement et contrôle d'un Stimulateur Tactile pour textures réelles, oct 2012, B. Lemaire-Semail, M.-A. Bueno
- Phd in progress: Hanae Rateau, l'interaction esquissée, oct. 2012, L. Grisoni
- Phd in progress: Nicolas Bremard, oct 2012, L. Grisoni/F. Aubert
- 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)

9.3. Popularization

9.3.1. Laurent Grisoni

Geste d'interaction, immersion, RV: une vue sur les enjeux, workshop VR/Rehabilitation, Tourcoing (imaginarium), mars 2015.

La réalité augmentée (sa réalité), Déjeuner technologiques du master Informatique de Lille 1, mars 2015

Dessin et Interaction (homme-machine), Journée épistémologie Sciences et Cultures du Visuel, Tourcoing (imaginarium), juin 2015

Situated Interaction and contemporary art, Journées scientifiques Inria, juin 2015, nancy

Hands on 3D Models (Virtual Reality and Physicality), 4th Sino-French Symposium on VR, Xi'An (Chine), aout 2015

Sketch and Human-Computer Interaction, invited talk at the LJK (Inria Rhones-Alpes), Nov 2015 and at the doctoral school of LACTH (Lille school of architecture) Nov. 2015

L'interaction en général, le geste et le tactile en particulier, Séminaire Inria/Euratechnologie, déc. 2015

9.3.2. *Florent Berthaut*

Reflets: a mixed-reality display for musical performances. Public demonstration for the Bristol Bright Night at the @Bristol Science Museum, September 2015, Bristol, UK

10. Bibliography

Major publications by the team in recent years

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[2] G. CASIEZ, N. ROUSSEL. *No more bricolage! Methods and tools to characterize, replicate and compare pointing transfer functions*, in "Proceedings of UIST'11", ACM, October 2011, pp. 603-614, http://dx.doi.org/10.1145/2047196.2047276

[3] G. CASIEZ, N. ROUSSEL, R. VANBELLEGHEM, F. GIRAUD. *Surfpad: riding towards targets on a squeeze film effect*, in "Proceedings of CHI 2011", ACM, May 2011, pp. 2491-2500, "Honorable mention" award (top 5%), http://dx.doi.org/10.1145/1978942.1979307

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Publications of the year

Articles in International Peer-Reviewed Journals

[11] C. GIRAUD-AUDINE, F. GIRAUD, M. AMBERG, B. LEMAIRE-SEMAIL. *Generalized modal analysis for closed-loop piezoelectric devices*, in "Smart Materials and Structures", August 2015, vol. 24, n° 8, 085028 [*DOI :* 10.1088/0964-1726/24/8/085028], https://hal.archives-ouvertes.fr/hal-01254871

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