

Declaration of Jeremy Cooperstock, Ph.D. in Support of  
Petition for *Inter Partes* Review of  
U.S. Patent No. 8,896,524 B2

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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META PLATFORMS, INC.,  
Petitioner

v.

IMMERSION CORPORATION,  
Patent Owner

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Case IPR2023-00943  
U.S. Patent No. 8,896,524 B2  
Issue Date: November 25, 2014

Title: CONTEXT-DEPENDENT HAPTIC CONFIRMATION SYSTEM

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**DECLARATION OF JEREMY COOPERSTOCK, PH.D.**

Declaration of Jeremy Cooperstock, Ph.D. in Support of  
Petition for *Inter Partes* Review of  
U.S. Patent No. 8,896,524 B2

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I, Jeremy Cooperstock, declare as follows:

## **I. INTRODUCTION AND QUALIFICATIONS**

### **A. Qualifications and Experience**

1. I am a full professor in the Department of Electrical and Computer Engineering at McGill University. My Curriculum Vitae is attached as **Exhibit A**.

2. I received my B.Sc. in Electrical Engineering (with Honors) from the University of British Columbia in 1990, my M.Sc. in Computer Science from the University of Toronto in 1992, and my Ph.D. in Electrical and Computer Engineering from the University of Toronto in 1996.

3. I am a member of the Centre for Intelligent Machines, and a founding member of the Centre for Interdisciplinary Research in Music Media and Technology at McGill University. I presently direct a group of approximately 50 researchers at the Shared Reality Lab at McGill, which focuses on computer mediation to facilitate high-fidelity human communication and the synthesis of perceptually engaging, multimodal, immersive environments. I led the development of the Intelligent Classroom, the world's first Internet streaming demonstrations of Dolby Digital 5.1, multiple simultaneous streams of uncompressed high-definition video, a high-fidelity orchestra rehearsal simulator, a simulation environment that renders graphic, audio, and vibrotactile effects in response to footsteps, and a mobile

game treatment for amblyopia.

4. My work on the Ultra-Videoconferencing system was recognized by an award for Most Innovative Use of New Technology from ACM/IEEE Supercomputing and a Distinction Award from the Audio Engineering Society. The research I supervised on the Autour project earned the Hochhausen Research Award from the Canadian National Institute for the Blind and an Impact Award from the Canadian Internet Registry Association, and my Real-Time Emergency Response project won the Gold Prize (brainstorm round) of the Mozilla Ignite Challenge. I am also a recipient of several “best paper” awards from scholarly societies for my research.

5. I have worked with IBM at the Haifa Research Center, Israel, and the Watson Research Center in Yorktown Heights, New York, the Sony Computer Science Laboratory in Tokyo, Japan, and was a visiting professor at Bang & Olufsen, Denmark, where I conducted research on telepresence technologies as part of the World Opera Project. I led the theme of Enabling Technologies for a Networks of Centres of Excellence on Graphics, Animation, and New Media (GRAND) and I am an associate editor of the Journal of the AES, the Frontiers Journal in Virtual Reality, and the Institute of Electrical and Electronics Engineers (IEEE) Transactions on Haptics.

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6. I have carried out significant research involving design and implementation of haptic feedback systems, virtual and augmented reality, and mobile computing applications. My work in these areas has been recognized with several best paper awards. In recognition of my expertise in the domain of haptics, I was invited to serve as an Associate Editor for the IEEE Transactions on Haptics, Associate Editor for the Frontiers in Virtual Reality, and Associate Editor for the World Haptics Conference.

7. My experience in academic and practical situations as well as my hands-on experience with multimedia production systems provides me with an appreciation of the technology involved with U.S. Patent No. 8,896,524 B2.

8. I have been retained by counsel for Petitioner to provide my expert opinion in connection with the above-captioned proceeding as set forth herein.

**B. Materials Considered**

9. The analysis that I provide in this Declaration is based on my education, research, and experience, as well as the documents I have considered. In forming my opinions, I have read and considered U.S. Patent No. 8,896,524 B2 (“524 patent”) [Ex. 1001] and its prosecution history. I have cited to the following documents in my analysis below:

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| <b>Exhibit No.</b> | <b>Description of Document</b>                                                                                                              |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1001</b>        | U.S. Patent No. 8,896,524 B2 to David M. Birnbaum et al. (filed August 24, 2012 and issued November 25, 2014) (“’524” or “’524 patent”)     |
| <b>1003</b>        | U.S. Patent No. 7,952,566 B2 to Ivan Poupyrev et al. (filed July 31, 2007, issued May 31, 2011) (“Poupyrev”)                                |
| <b>1004</b>        | U.S. Patent Application Publication No. 2009/0322498 A1 to Jue Byung Yun et al. (filed May 5, 2009, published December 31, 2009) (“Yun”)    |
| <b>1005</b>        | U.S. Patent No. 6,300,936 B1 to Adam C. Braun et al. (filed November 14, 1997, issued October 9, 2001) (“Braun”)                            |
| <b>1006</b>        | U.S. Patent No. 6,169,540 B1 to Louis B. Rosenberg et al. (filed June 17, 1997, issued January 2, 2001) (“Rosenberg”)                       |
| <b>1007</b>        | Excerpts from <i>Microsoft Computer Dictionary</i> (5th ed. 2002)                                                                           |
| <b>1008</b>        | Joint Claim Construction Statement filed in <i>Immersion Corp. v. Meta Platforms, Inc.</i> , No. 6:22-cv-00541-ADA (filed January 21, 2023) |
| <b>1009</b>        | Prosecution history of the ’524 patent                                                                                                      |

## II. PERSON OF ORDINARY SKILL IN THE ART

10. I am informed by counsel that, under the patent laws in effect before the America Invents Act (“AIA”) of 2011, an assessment of claims of a patent filed before the AIA took effect (*i.e.*, before March 2013 for purposes of my analysis)

should be undertaken from the perspective of a person of ordinary skill in the art as of the earliest claimed priority date (*i.e.*, the “time the invention was made”). For purposes of the ’524 patent, I have assumed that date to be August 24, 2012, the filing date of the patent application that resulted in the ’524 patent. I am also informed that in the related district court litigation, Patent Owner has asserted that the ’524 patent is entitled to a December 19, 2011 priority date. I express no opinion on whether the ’524 patent is actually entitled to such an earlier date. This issue is not relevant here because all prior art relied upon pre-dates that date, and my analysis and conclusions (including POSITA definition) would not change if a date in 2011 were applied. In the event a priority date prior to August 24, 2012 may later become relevant, for example based on arguments later presented by Patent Owner, I reserve my right to provide opinions on that issue at that time.

11. I have also been informed by counsel that to determine the appropriate level of a person having ordinary skill in the art, the following factors may be considered: (1) the types of problems encountered by those working in the field and prior art solutions thereto; (2) the sophistication of the technology in question, and the rapidity with which innovations occur in the field; (3) the educational level of active workers in the field; and (4) the educational level of the inventor.

12. The ’524 patent states that it relates, in one embodiment, to “a device

that produces haptic effects.” (’524, 1:6-7.) The Background section of the ’524 patent explains that “[h]aptics is a tactile and force feedback technology that takes advantage of a user’s sense of touch by applying haptic feedback effects (i.e., ‘haptic effects’), such as forces, vibrations, and motions, to the user.” (’524, 1:11-14.) These techniques were well-known and widely available commercially by the August 2012 filing date of the ’524 patent.

13. In my opinion, a person of ordinary skill in the art as of August 2012 would have possessed a bachelor’s degree in electrical engineering or computer science (or an equivalent degree), and two years of practical or industry experience in the field of human computer interaction, including implementation of computer-based systems and software for providing haptic feedback effects to a user. A person could also have qualified as a person of ordinary skill in the art with some combination of (1) more formal education (such as a master’s of science degree or higher) and less practical or industry experience, or (2) less formal education and more practical or industry experience. Under either formulation, a person of ordinary skill in the art would have understood how to interface with haptic feedback devices using software and/or hardware, and would have understood computer-user interface design including, for example, receiving input from a user through a computer input device (such as touch screen, mouse, or other input device) and

displaying information to the user via a graphical user interface.

14. My opinions regarding the level of ordinary skill in the art are based on, among other things, my decades of experience in the field, my understanding of the basic qualifications that would have been relevant to an engineer tasked with investigating methods and systems in the relevant area, and my familiarity with the backgrounds of colleagues, research associates, and students, both past and present, who have worked on systems for generating haptic feedback effects.

15. Although my qualifications and experience exceed those of the hypothetical person having ordinary skill in the art defined above, my analysis and opinions regarding the '524 patent have been based on the perspective of a person of ordinary skill in the art as of August 2012.

### **III. STATEMENT OF LEGAL PRINCIPLES**

#### **A. Claim Construction**

16. I am informed by counsel that a purpose of claim construction is to determine what a person of ordinary skill in the art would have understood the claim terms to mean. Claim terms are generally given their ordinary and customary meaning, which is the meaning that the term would have to a person of ordinary skill in the art in question as of the effective filing date.

17. I am informed by counsel that the person of ordinary skill in the art is

deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification. I understand that the patent specification, under the legal principles, has been described as the single best guide to the meaning of a claim term, and is thus highly relevant to the interpretation of claim terms. And I understand for terms that do not have a customary meaning within the art, the specification usually supplies the best context of understanding the meaning of those terms.

18. I am also informed by counsel that other claims of the patent in question, both asserted and unasserted, can be valuable sources of information as to the meaning of a claim term. Because the claim terms are normally used consistently throughout the patent, the usage of a term in one claim can often illuminate the meaning of the same term in other claims. Differences among claims can also be a useful guide in understanding the meaning of particular claim terms.

19. I am informed by counsel that the prosecution history can further inform the meaning of the claim language by demonstrating how the inventors understood the invention and whether the inventors limited the invention in the course of prosecution, making the claim scope narrower than it otherwise would be. Extrinsic evidence, such as dictionaries, may also be consulted in construing the claim terms.

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20. I am informed by counsel that, in *inter partes* review (IPR) proceedings, a claim of a patent shall be construed using the same claim construction standard that would be used to construe the claim in a civil action filed in a U.S. district court (which I understand is called the “*Phillips*” claim construction standard), including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.

21. I have been instructed by counsel to apply the “*Phillips*” claim construction standard for purposes of interpreting the claims in this proceeding, to the extent they require an explicit construction. The description of the legal principles set forth above thus provides my understanding of the “*Phillips*” standard as provided to me by counsel.

22. I am informed by counsel that, in the pending litigation between Petitioner and Patent Owner, claim constructions have been proposed by Petitioner and/or Patent Owner for certain terms in the challenged claims, *i.e.*, “**confirmation haptic effect**,” “**context metadata**,” and “**haptic parameter**.” (Ex. 1008, 002.) As I will explain below, it is unnecessary for me to construe any terms of the ’524 patent or opine on the correctness of any proposed construction, because the prior art discloses and renders obvious the challenged claims under all of the constructions

proposed by the parties or any other reasonable construction.

**B. Obviousness**

23. I am also informed by counsel that a patent claim is obvious if, as of the effective filing date, it would have been obvious to a person having ordinary skill in the field of the technology (the “art”) to which the claimed subject matter belongs.

24. I am also informed by counsel that the following factors should be considered in analyzing obviousness: (1) the scope and content of the prior art; (2) the differences between the prior art and the claims; and (3) the level of ordinary skill in the pertinent art. I also understand that certain other facts known as “secondary considerations” such as commercial success, unexplained results, long felt but unsolved need, industry acclaim, simultaneous invention, copying by others, skepticism by experts in the field, and failure of others may be utilized as indicia of nonobviousness. I understand, however, that secondary considerations should be connected, or have a “nexus,” with the invention claimed in the patent at issue.

25. I am also informed by counsel that a reference qualifies as prior art for obviousness purposes when it is analogous to the claimed invention. The test for determining what art is analogous is: (1) whether the art is from the same field of endeavor, regardless of the problem addressed, and (2) if the reference is not within the field of the inventor’s endeavor, whether the reference still is reasonably

pertinent to the particular problem with which the inventor is involved.

26. I am also informed by counsel that a person of ordinary skill in the art is assumed to have knowledge of all prior art. I understand that one skilled in the art can combine various prior art references based on the teachings of those prior art references, the general knowledge present in the art, or common sense. I understand that a motivation to combine references may be implicit in the prior art, and there is no requirement that there be an actual or explicit teaching to combine two references. Thus, one may take into account the inferences and creative steps that a person of ordinary skill in the art would employ to combine the known elements in the prior art in the manner claimed by the patent at issue. I understand that one should avoid “hindsight bias” and ex post reasoning in performing an obviousness analysis. But this does not mean that a person of ordinary skill in the art for purposes of the obviousness inquiry does not have recourse to common sense.

27. I am also informed by counsel that when determining whether a patent claim is obvious in light of the prior art, neither the particular motivation for the patent nor the stated purpose of the patentee is controlling. The primary inquiry has to do with the objective reach of the claims, and that if those claims extend to something that is obvious, then the entire patent claim is invalid.

28. I am also informed by counsel one way that a patent can be found

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obvious is if there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims. I understand that a motivation to combine various prior art references to solve a particular problem may come from a variety of sources, including market demand or scientific literature. I understand that a need or problem known in the field at the time of the invention can also provide a reason to combine prior art references and render a patent claim invalid for obviousness. I understand that familiar items may have obvious uses beyond their primary purpose, and that a person of ordinary skill in the art will be able to fit the teachings of multiple prior art references together like the pieces of a puzzle. I understand that a person of ordinary skill is also a person of at least ordinary creativity. I understand when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp. If this finite number of predictable solutions leads to the anticipated success, I understand that the invention is likely the product of ordinary skill and common sense, and not of any sort of innovation. I understand that the fact that a combination was obvious to try might also show that it was obvious, and hence invalid, under the patent laws. I understand that if a patent claims a combination of familiar elements according to known methods, the combination is likely to be

obvious when it does not more than yield predictable results. Thus, if a person of ordinary skill in the art can implement a predictable variation, an invention is likely obvious. I understand that combining embodiments disclosed near each other in a prior art reference would not ordinarily require a leap of inventiveness.

29. I am also informed by counsel that obviousness may be shown by demonstrating that it would have been obvious to modify what is taught in a single piece of prior art to create the patented invention. Obviousness may also be shown by demonstrating that it would have been obvious to combine the teachings of more than one item of prior art. I understand that a claimed invention may be obvious if some teaching, suggestion, or motivation exists that would have led a person of ordinary skill in the art to combine the invalidating references. I also understand that this suggestion or motivation may come from the knowledge of a person having ordinary skill in the art, or from sources such as explicit statements in the prior art. I understand that when there is a design need or market pressure, and there are a finite number of predictable solutions, a person of ordinary skill may be motivated to apply common sense and his skill to combine the known options in order to solve the problem.

30. I am also informed by counsel the following are examples of approaches and rationales that may be considered in determining whether a piece of

prior art could have been combined with other prior art or with other information within the knowledge of a person having ordinary skill in the art:

- (1) Some teaching, motivation, or suggestion in the prior art that would have led a person of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention;
- (2) Known work in one field of endeavor may prompt variations of it for use in the same field or a different field based on design incentives or other market forces if the variations would have been predictable to a person of ordinary skill in the art;
- (3) Combining prior art elements according to known methods to yield predictable results;
- (4) Applying a known technique to a known device, method, or product ready for improvement to yield predictable results;
- (5) Applying a technique or approach that would have been “obvious to try” (choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success);
- (6) Simple substitution of one known element for another to obtain predictable results; or

(7) Use of a known technique to improve similar products, devices, or methods in the same way.

31. I am also informed by counsel that, when determining whether a claimed combination is obvious, the correct analysis is not whether one of ordinary skill in the art, writing on a blank slate, would have chosen the particular combination of elements described in the claim. Instead, I understand the correct analysis considers whether one of ordinary skill, facing the wide range of needs created by developments in the field of endeavor, would have seen a benefit to selecting the combination claimed.

32. I am also informed by counsel that the test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference. The test for obviousness, in other words, is not whether the references could be physically combined but whether the claimed inventions are rendered obvious by the teachings of the prior art as a whole.

#### **IV. THE '524 PATENT**

##### **A. Overview of the Specification**

33. The '524 patent, entitled "Context-Dependent Haptic Confirmation System," purports to disclose a system that produces a "confirmation haptic effect" in response to a user interaction with a user interface element. ('524, Abstract.) The

Background of the '524 patent explains that “[h]aptics is a tactile and force feedback technology that takes advantage of a user’s sense of touch by applying haptic feedback effects (i.e., ‘haptic effects’), such as forces, vibrations, and motions, to the user.” (’524, 1:11-14.) The Background section further acknowledges the existence of prior art devices that could generate confirmation haptic effects:

A device, such as a mobile device, touchscreen device, and personal computer, can be configured to generate confirmation haptic effects in response to a user’s interaction with the device, as a confirmation that the user has successfully interacted with the device. For example, when a user interacts with the device using, for example, a button, touchscreen, lever, joystick, wheel, or some other control, a haptic signal can be generated, where the haptic signal causes the device to produce an appropriate confirmation haptic effect. The user can experience the confirmation haptic effect, and can be made aware of the successful interaction with the device.

(’524, 1:14-26.)

34. The '524 patent discloses an embodiment in which a confirmation haptic effect is produced “in response to an interaction with a user interface element of a device, such as a button displayed within a touchscreen or a keyboard, where the confirmation haptic effect can be customized based on context metadata, or some other metadata, associated with the interaction of the user interface element.” (’524,

1:59-65.) With respect to this “context metadata,” the written description explains that it “can include data indicating one or more physical properties of the user interface element, such as the size or shape of the user interface element,” and can also include “indicating functionality of the user interface element.” (’524, 1:65-2:3.) “Context metadata can also include data indicating a history of interaction with the user interface element.” (’524, 2:6-8.)

35. This context metadata is then used to customize the haptic effect provided to the user. “The customization of the confirmation haptic effect can be a modification of one or more haptic parameters, such as, but not limited to, magnitude, duration, frequency, and waveform.” (’524, 2:17-20.)

## **B. Overview of the Prosecution History**

36. During prosecution of the patent application that issued as the ’524 patent, the proposed claims were rejected by the Examiner as anticipated and/or obvious in view of U.S. Pat. App. Pub. No. 2005/0134561 to Tierling et al. and U.S. Patent No. 6,046,726 to Keyson. (EX1009, 0065-0069 (April 10, 2014 Non-Final Rejection).) In response to that rejection, the applicants amended independent claims 1 and 11 to recite the limitation of “wherein the context metadata comprises at least one of: data indicating a functionality of the user interface element, or data indicating a history of the user interface element,” which had previously been recited

in dependent claims 6 and 13:

1. (Currently Amended) A non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a confirmation haptic effect, the generating the confirmation haptic effect comprising:

receiving context metadata associated with a user interaction of a user interface element, wherein the context metadata comprises at least one of: data indicating a functionality of the user interface element, or data indicating a history of the user interface element;

mapping the received context metadata to one or more haptic parameters;  
generating a haptic signal based at least in part on the one or more haptic parameters; and

sending the haptic signal to an actuator to generate the confirmation haptic effect.

11. (Currently Amended) A computer-implemented method for producing a confirmation haptic effect, the computer-implemented method comprising:

receiving context metadata associated with a user interaction of a user interface element, wherein the context metadata comprises at least one of: data indicating a functionality of the user interface element, or data indicating a history of the user interface element;

mapping the received context metadata to one or more haptic parameters;  
generating a haptic signal based at least in part on the one or more haptic parameters; and

sending the haptic signal to an actuator to generate the confirmation haptic effect.

(Ex. 1009, 0082, 0084 (July 8, 2014 Amendment).) The applicant argued that the

cited references did not disclose these added limitations of claims 1 and 11. (*Id.*, 0087-0090.) The Examiner subsequently allowed the claims.

37. As discussed further below, prior art that was not cited during the prosecution discloses these limitations that were purportedly missing from the references cited during prosecution.

### **C. The Challenged Claims**

38. This Declaration addresses claims 1-4, 6-8, and 11-14 of the '524 patent. Claims 1 and 11 are independent claims. Independent claim 1 recites:

1. A non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a confirmation haptic effect, the generating the confirmation haptic effect comprising:
  - [a] receiving context metadata associated with a user interaction of a user interface element, wherein the context metadata comprises at least one of: data indicating a functionality of the user interface element, or data indicating a history of the user interface element;
  - [b] mapping the received context metadata to one or more haptic parameters;
  - [c] generating a haptic signal based at least in part on the one or more haptic parameters; and

[d] sending the haptic signal to an actuator to generate the confirmation haptic effect.

(’524, 11:42-57 (claim 1) (bracketed notations, *e.g.*, [a], added).) Claim 11 recites “[a] **computer-implemented method**” with steps that mirror the functions recited in claim 1. (’524, 12:36-49 (claim 11).) I will provide more detail about the challenged claims in my detailed analysis below.

## V. APPLICATION OF THE PRIOR ART TO CHALLENGED CLAIMS

39. I have reviewed and analyzed the prior art references and materials listed in **Part I.B** above. In my opinion the challenged claims of the ’524 patent would have been obvious to a person of ordinary skill in the art based on the following combinations of the prior art.

| Ground | Claims          | Basis for Challenge (Obviousness) |
|--------|-----------------|-----------------------------------|
| 1      | 1-2, 6-8, 11-14 | Poupyrev, Yun                     |
| 2      | 2-4, 12         | Poupyrev, Yun, Braun, Rosenberg   |

40. I am informed by counsel that each of these references qualifies as prior art to the challenged claims because each reference was filed and/or published before the ’524 patent priority date (August 24, 2012), as well as the December 19, 2011 date that Patent Owner has asserted in the litigation.

**A. Brief Summary and Overview of the Prior Art**

**1. Prior Art Common to All Grounds**

**(a) Poupyrev [Ex. 1003]**

41. **Poupyrev**, U.S. Patent No. 7,952,566 B2, is entitled “Apparatus and Method for Touch Screen Interaction Based on Tactile Feedback and Pressure Measurement.” I am informed that Poupyrev qualifies as prior art because it was filed on July 31, 2007 and issued on May 31, 2011, both dates being before the filing date of the challenged claims.

42. As its title indicates, Poupyrev discloses techniques for providing haptic feedback to a user in response to a user making contact with a touch screen display. (Poupyrev, Abstract, 1:9-11.) The techniques in Poupyrev involve measuring the pressure applied to the touch screen. (Poupyrev, 1:53-58.) Figure 1 shows an exemplary apparatus for implementing an embodiment in Poupyrev:

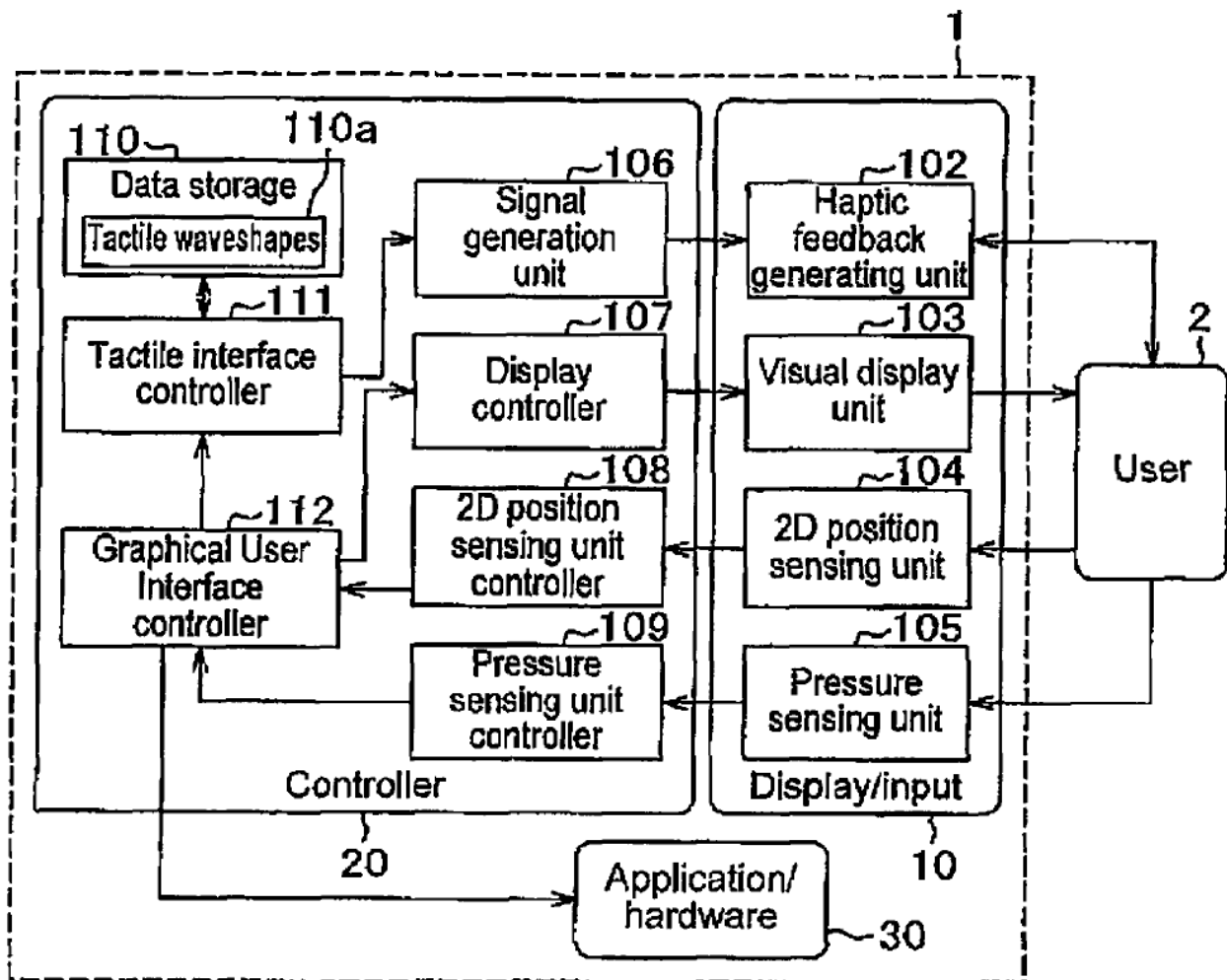


**Figure 1**

(Poupyrev, Fig. 1, 2:1:61-65.) Figure 1 shows apparatus 1 that includes display/input section 10, which “displays on a touch screen thereof images of buttons, keys, switches or any other Graphic User Interface (GUI) objects to prompt a user 2 to interact with the apparatus 1.” (Poupyrev, 4:66-5:2.) “The display/input section 10 further detects a touch position of a user’s finger or a pointing device on the screen and pressure applied when the finger or pointing device touches the

screen. The display/input section **10** further provides different types of tactile feedback in response to the user's input operation." (Poupyrev, 4:66-5:7, 8:6-8 ("It is desirable to provide different levels of the tactile feedback with a GUI object depending on the pressure applied on the GUI object.").)

43. Figure 1 also shows the control section **20**, which receives and responds to the touch position and pressure information provided by the display/input section **10**. More specifically, control section **20** "dynamically correlates: (i) the touch position on the screen or a GUI object selected by the user's input operation; (ii) the pressure applied on the screen by the user's input operation; and (iii) a current logical state of the selected GUI object; with the type of tactile feedback to be presented to the user **2**." (Poupyrev, 5:11-16.) The third section shown in Figure 1 is the application section **30**, on the bottom, which "performs various operations or functions in response to the user's input operation detected by the display/input section **10**. The application section **30** may include various applications and software units or hardware." (Poupyrev, 5:18-22.)

44. Display/input section **10** detects a user touching the screen using either a finger or pointing device. (Poupyrev, 1:67-2:1, 6:61-67, 7:48-49 (T1).) The pressure sensing unit **105**, part of the display/input section **10** in Figure 1 above, "measure[s] pressure applied to the touch screen by the user's input operation."

(Poupyrev, 5:46-47, 5:33-34 (identifying “pressure sensing unit **105**” as being used with visual display unit **103**)). The 2D position sensing unit **104**, also part of display/input section **10**, “detects where the user is touching on the touch screen.” (Poupyrev, 6:3-4.)<sup>1</sup>

45. As shown in Figure 1, pressure and position information is conveyed, respectively, to pressure sensing unit controller **109** and position sensing unit controller **108**, both parts of the controller section **20**. (Poupyrev, Fig. 1.) Pressure sensing unit controller **109** “determines the value of pressure applied when the user is touching on the screen.” (Poupyrev, 7:1-3.) Position sensing unit controller **108** “determines the position where the user **2** is touching on the screen.” (Poupyrev, 7:3-4.) This information is then conveyed to the graphical user interface controller **112**, which is also part of the control section **20**. (Poupyrev, 7:4-5, Fig. 1.)

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<sup>1</sup> I note that the written description of Poupyrev sometimes mixes up the numerals (**104**, **105**) used to refer to the pressure sensing unit and the position sensing unit of Figure 1. (Poupyrev, 5:24-25 (“[A] two-dimensional (2D) position sensing unit **104** and a pressure sensing unit **105**.”), 5:46-47 (“... pressure sensing unit **104**”), 6:4-5 (“... position sensing unit **105**...”).) For consistency, I will refer to “pressure sensing unit” as **105** and the “position sensing unit” as **104**, consistent with the depiction in Figure 1. An ordinarily skilled artisan would have regarded these inconsistencies as immaterial typographical errors, and none of them would have impeded the ability of an ordinarily skilled artisan to fully understand and apply the teachings of Poupyrev on which I rely in this Declaration.

46. The GUI controller **112** then “determines which GUI object the user **2** is intending to interact with.” (Poupyrev, 7:14-15.) Examples of GUI objects include “images of buttons, sliders, drawing, scroll bars, hyper links and etc.” (Poupyrev, 5:27-31.) GUI controller **112** responds by changing the current state of the GUI object. For example, in the case of a graphical button, GUI controller **112** can cause the visual appearance of the GUI object to change to reflect that it is being pressed. (Poupyrev, 7:15-25, 7:55-63.)

47. The GUI controller also sends commands to tactile interface controller **111**, another component of the control section **20** in Figure 1, which “generates appropriate commands for driving the tactile signal generation unit **102**.” (Poupyrev, 7:29-31.) Tactile signal generation unit **102**, which is part of display/input section in Figure 1, may be formed using “piezoelectric bimorph actuators,” and “various types of mechanical or electrical or electromagnetic actuators/motors... to generate the tactile feedback depending on a size/mass of the display and/or available power.” (Poupyrev, 5:38-45.)

**(b) Yun [Ex. 1004]**

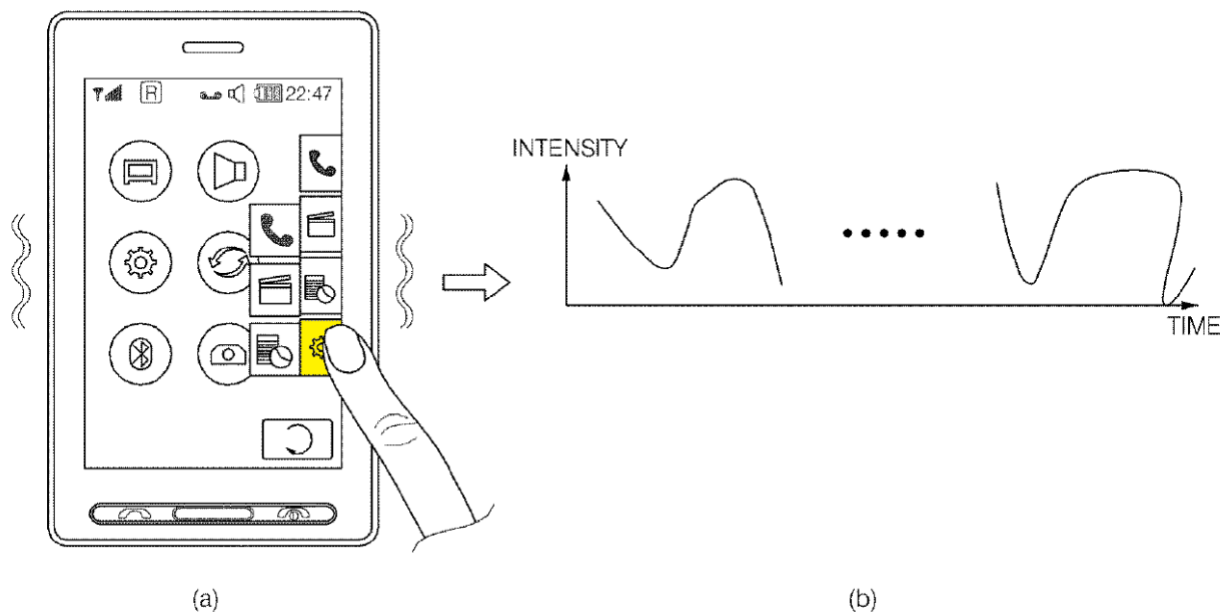
48. **Yun**, U.S. Patent Application Publication No. 2009/0322498 A1, is entitled “Haptic Effect Provisioning for a Mobile Communication Terminal.” I am informed that Yun qualifies as prior art because it was filed on May 5, 2009 and

published on December 31, 2009, both dates being before the filing date of the challenged claims.

49. Yun discloses a technique similar to Poupyrev for providing haptic feedback to a user of a mobile terminal. (Yun, Abstract, ¶0002.) Yun explains that a mobile terminal can include “a mobile phone, a smart phone, a laptop book computer, a digital broadcast receiver, a personal digital assistant (PDA), a portable multimedia player (PMP), or a navigation device.” (Yun, ¶0029.) The mobile terminal includes a number of components such as a touch screen for accepting user input. (Yun, ¶0035.) The mobile terminal also includes haptic module 157, which “may provide various haptic effects (such as vibrations) that can be perceived by the user. If the haptic module 157 generates vibration as a haptic effect, the intensity and pattern of vibration generated by the haptic module 157 may be altered in various manners.” (Yun, ¶0042.)

50. Yun discloses numerous examples in which the mobile terminal can provide different haptic feedback (*e.g.*, different vibration intensities and patterns) based on the particular action the user is taking. Figure 36 depicts one such example, in which a mobile terminal generates a haptic effect in response to the user selecting a particular menu icon on a touch screen display:

**FIG. 36**



(Yun, Fig. 36 (highlighting added).) Figure 36 shows a screen image on a mobile terminal “including a plurality of menu icons.” (Yun, ¶0109.) “In order to enter a menu corresponding to the chosen menu icon,” Yun explains, “the chosen menu icon may be touched. In this case, a haptic effect corresponding to the menu may be generated.” (Yun, ¶0110.) “In this manner, it is possible to generate different haptic effects for different menu items. Thus, it is possible for a user to easily determine which of the menu items has been touched or approached by using the sense of touch.” (Yun, ¶0079, Fig. 9.)

51. My Declaration relies on Yun primarily for the “**context metadata**” limitation of the independent claims, including the further option that the context

metadata may comprise “**data indicating a functionality of the user interface element.**” A key feature of Yun for purposes of the claimed “**context metadata**” is the ability of the mobile terminal to use information about the functionality of the menu icon to produce a customized haptic effect. For example, Figure 36 as shown in **yellow** highlighting above shows the user selecting a menu icon for a gear, which an ordinarily skilled artisan (or even a user of a conventional smart phone) would have recognized as pertaining to device settings. As Yun explains:

Referring to FIG. 36, if a user touches or approaches and thus chooses one of the menu icons, the name of the chosen menu icon may be analyzed, and a haptic effect corresponding to the name of the chosen menu icon may be generated. For example, if the user chooses a menu icon ‘setting’, haptic effects (such as vibration effects) respectively corresponding to alphabet letters ‘s’, ‘e’, ‘t’, ‘t’, ‘i’, ‘n’, and ‘g’ may be sequentially output. Alternatively, the user may set a haptic effect for the word ‘setting’ in advance. In this case, the haptic effect corresponding to the word ‘setting’ may be generated.

(Yun, ¶0109.) Yun therefore discloses that, when the user chooses a menu icon, the mobile terminal uses the textual name of the menu icon to determine the appropriate haptic effects. The resulting haptic effect is shown in part (b) of Figure 36 above, which shows the varying intensity of the multiple haptic effects generated as a result of the user’s selection of the “setting” menu option.

52. I will provide more information about Yun in my discussion of the claim limitations below.

**2. Additional Prior Art for Ground 2 (Claims 2-4 and 12)**

**(a) Braun [Ex. 1005]**

53. **Braun**, U.S. Patent No. 6,300,936 B1, is entitled “Force Feedback System Including Multi-Tasking Graphical Host Environment and Interface Device.” I am informed that Braun qualifies as prior art because it was filed on November 14, 1997 and issued on October 9, 2001, both dates being before the filing date of the challenged claims.

54. My Declaration relies on Braun for a narrow purpose – for its teachings regarding the ability of a user to modify certain haptic parameters and the user interfaces enabling the user to do so. My Declaration cites Braun for **Ground 2** addressing dependent claims 2-4 and 12.

55. Braun discloses a technique for providing “force feedback” to a user of an interface device, such as a mouse or joystick. “Force feedback” generally refers to a technology that generates tactile feedback through an input device, such as vibrations, in order to simulate physical forces. (*See Microsoft Computer Dictionary* (5th ed. 2002), p.221 (**EX1007**) (“**force feedback** *n.* A technology that generates push or resistance in an input/output device. Force feedback enables an input/output

device, such as a joystick or a steering wheel, to react to the user's action in appropriate response to events displayed in the screen.”.) Force feedback was (and remains today) commonly used by video gaming controllers to enhance game play. The '524 patent makes clear that the term “force feedback” is generally equivalent to or synonymous with “haptic feedback” or “haptic effects,” as those terms are used in the patent. (See '524, 1:11-14 (“Haptics is a tactile and force feedback technology that takes advantage of a user's sense of touch by applying haptic feedback effects (i.e., ‘haptic effects’), such as forces, vibrations, and motions, to the user.”); *see also* Rosenberg, Ex. 1006, discussed below, 1:53-55 (“In some interface devices, tactile and/or haptic feedback is also provided to the user, more generally known as ‘force feedback.’”)).)

56. Braun explains that a force feedback effect or sensation can include vibrations having parameters defining the vibration effect. (Braun, 18:62-19:4.) “For example, a vibration force effect may have parameters of duration, frequency, magnitude, and direction.” (Braun, 19:2-3; *see also id.*, 17:17-19 (“For example, the assigned force sensation **244** can be a vibration force having a specified frequency, magnitude, duration, etc.....”).) Figure 5 shows an exemplary user interface dialog box **240** showing various options that allow the user to customize these parameters:

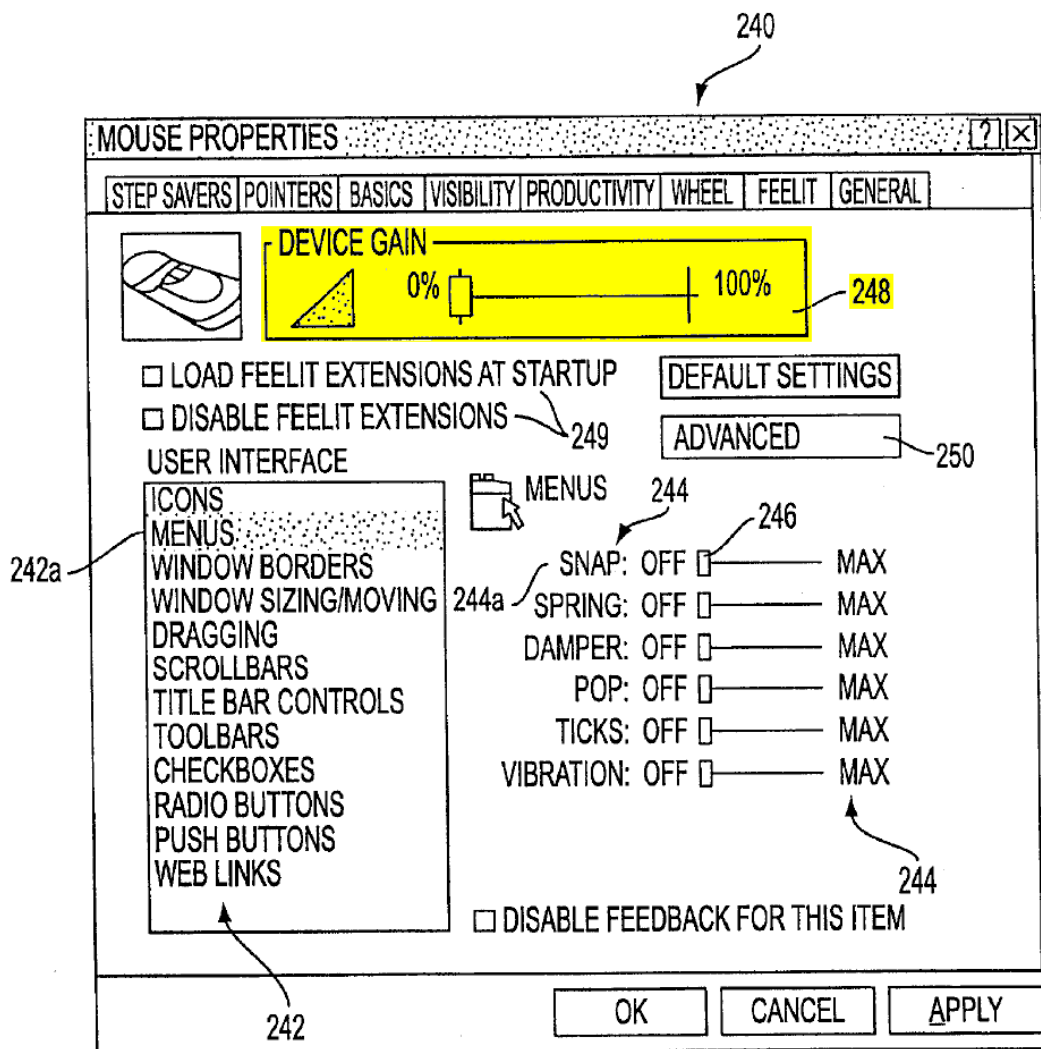


FIG. 5

(Braun, Fig. 5 (highlighting added).) Dialog box **240** in Figure 5 shows a list of user interface objects **242** including icons, menus, among others. Each of these objects can have one or more associated force sensations **244**, including a snap, spring, vibration, among others. Each force sensation is shown with an accompanying slider **246** that the user can move to the right to specify the magnitude of the force effect.

(Braun, 17:30-38, 17:53-57.) For example, as shown in Figure 5, the user is specifying the magnitude of the “SNAP” force effect **244a** for the “MENUS” user interface object **242a**. (Braun, 17:34-38.)

57. The key feature of Braun for purposes of my Declaration is the device gain **248** slider control shown in highlighting in Figure 5, which allows the user to globally adjust the magnitude of all the force sensations for all user interface objects. As Braun explains, device gain **248** allows the user “to set the percentage of maximum magnitude for all the forces for items **242**....” (Braun, 17:62-65.)

58. I will provide more detail about Braun in my discussion of **Ground 2** below.

**(b) Rosenberg [Ex. 1006]**

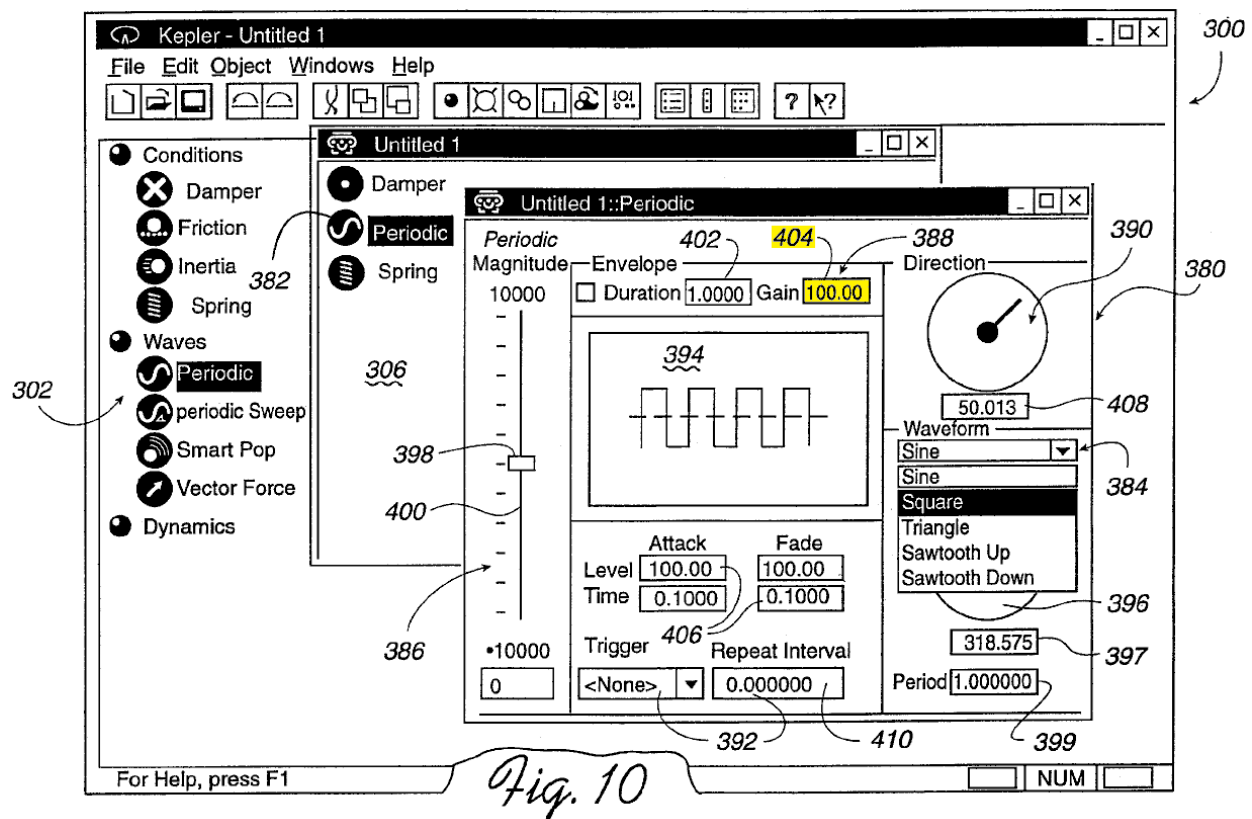
59. **Rosenberg**, U.S. Patent No. 6,169,540 B1, is entitled “Method and Apparatus for Designing Force Sensations in Force Feedback Applications.” I am informed that Rosenberg qualifies as prior art because it was filed on June 17, 1997 and issued on January 2, 2001, both dates being before the filing date of the challenged claims.

60. Rosenberg discloses a design tool for designing force sensations for use with a force feedback interface device, such as a computer mouse. (Rosenberg, Abstract, 1:36-37, 1:61, 9:10-14.) Rosenberg is closely related to Braun, both

having originated from Patent Owner and naming two common inventors. Braun also expressly incorporates-by-reference the disclosures of Rosenberg, and Braun's disclosures relating to Figure 5 above also expressly mention Rosenberg. (Braun, *e.g.*, 17:37-40, 18:8-14.) It does not appear that either Braun or Rosenberg was cited to the Patent Office during prosecution of the '524 patent, despite all three originating from Patent Owner.

61. My Declaration cites Rosenberg primarily for limitations of dependent claims 3-4 that recite use of a “**multiplier**” to modify one or more haptic parameters based on user input. Braun as discussed above discloses a technique for modifying haptic parameters but does not specifically mention the use of a multiplier. The term “**multiplier**,” as anyone familiar with arithmetic would recognize, generally refers to a quantity or value by which another number (referred to as the multiplicand) is multiplied. (*See Microsoft Computer Dictionary* (5th ed. 2002), p.354 [EX1007] (“**multiplier** *n.* 1. In arithmetic, the number that indicates how many times another number (the multiplicand) is multiplied.”).)

62. As noted previously, Figure 5 of Braun discloses a device gain **248** slider control that allows the user to adjust the magnitude of the force sensations or effects provided to the user. Rosenberg discloses a similar user interface **300** for adjusting the parameters of force sensations or effects:



(Rosenberg, Fig. 10 (highlighting added).) Figure 10 shows a user interface 300 for modifying the parameters associated with a periodic wave sensation. (Rosenberg, 19:58-62.) Figure 10 shows a number of “[e]nvelope parameters 388 [that] allow the user to shape the waveform into a desired effect.” (Rosenberg, 20:18-19.) The key parameter shown here is 404, shown in highlighting, which performs substantially the same function as the device gain 248 parameter in Braun. As Rosenberg explains, this parameter is “a gain field 404 (where ‘gain’ can be used as a global scaling factor or multiplier for force magnitudes output by the interface

device 14)....” (Rosenberg, 20:19-23.)

63. I will provide more information about Rosenberg in my discussion of  
**Ground 2** below.

**B. Ground 1: Claims 1-2, 6-8, 11-14 Are Obvious Over Poupyrev in  
View of Yun**

**1. Claim 1**

64. The preamble of claim 1 recites “[a] **non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a confirmation haptic effect, the generating the confirmation haptic effect comprising....**” I express no opinion on whether or not the preamble limits the scope of claim 1, as Poupyrev discloses and renders it obvious even if it is limiting.

65. Poupyrev discloses a technique for generating “**a confirmation haptic effect,**” which takes the form of tactile feedback provided to the user through the touch screen display. Figure 1 shows an exemplary apparatus for implementing an embodiment in Poupyrev:

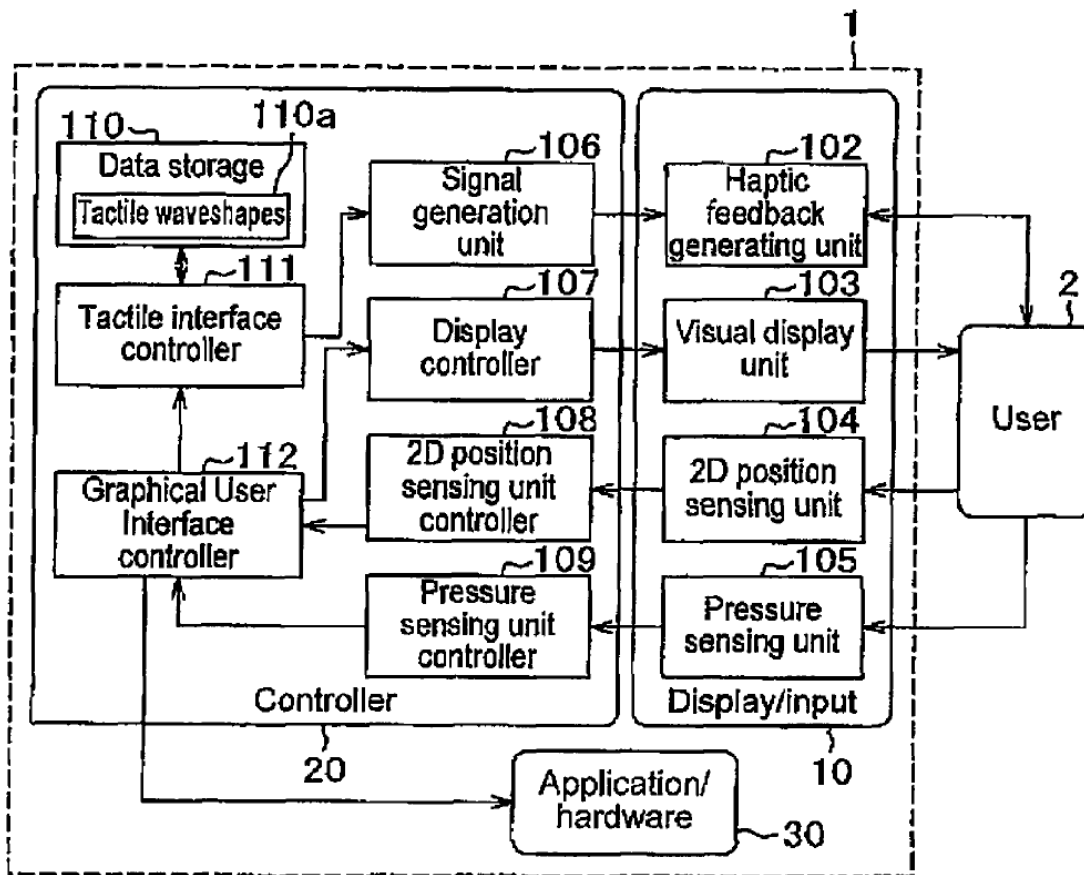


**Figure 1**

(Poupyrev, Fig. 1, 2:1:61-65.) Figure 1 shows apparatus 1 that includes display/input section 10, which “displays on a touch screen thereof images of buttons, keys, switches or any other Graphic User Interface (GUI) objects to prompt a user 2 to interact with the apparatus 1.” (Poupyrev, 4:66-5:2.) “The display/input section 10 further detects a touch position of a user’s finger or a pointing device on the screen and pressure applied when the finger or pointing device touches the screen. The display/input section 10 further provides different types of tactile

feedback in response to the user's input operation.” (Poupyrev, 4:66-5:7, 8:6-8 (“It is desirable to provide different levels of the tactile feedback with a GUI object depending on the pressure applied on the GUI object.”).) The “**haptic effect**” in Poupyrev thus takes the form of tactile feedback provided to the user in response to interacting with a GUI object. (Poupyrev, 5:8-10 (“It should be noted, in this specification, that the word ‘tactile’ and ‘haptic’ indicate the same sensory effect and are used interchangeably.”).)

66. The haptic effect in Poupyrev also qualifies as “**a confirmation haptic effect**” because it occurs in response to user interaction with a GUI object and confirms the user interaction with the GUI object. (Poupyrev, 6:14-19 (“The controller section **20** controls the display/input section **10** to change the tactile feedback depending on the position, pressure of the user's touch on the screen and the current logical state of GUI object, attempting to simulate the interactive operations with physical interface objects.”).) Figure 5 shows an example of confirmation haptic events:

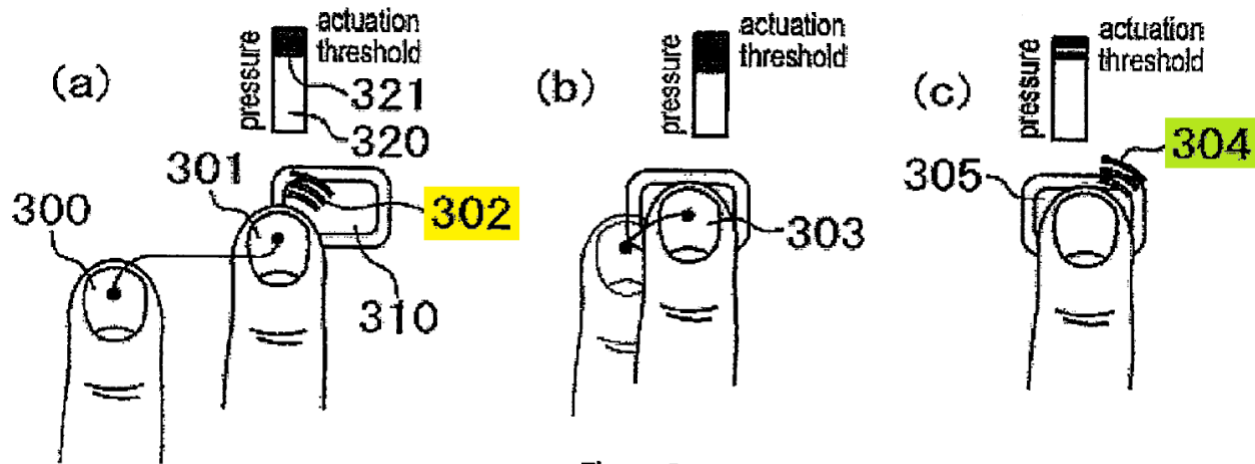


Figure 5

(Poupyrev, Fig. 5 (highlighting added).) Figure 5 shows the apparatus providing haptic feedback **302** and **304**. Starting with Figure 5(a), the user has slid its finger from initial position **300** to position **301** at the boundary of GUI object **310**. (Poupyrev, 8:56-67.) The apparatus “provides a tactile feedback **302** to allow the user **2** to ‘feel’ the GUI object **310**.” (Poupyrev, 8:63-67.) The user has at this stage selected but not yet activated (actuated) the GUI object. (Poupyrev, 8:41-42 (“Accordingly, the user **2** can feel the GUI objects on the screen without activating them”).) Figure 5(b) shows that the user has subsequently moved its finger further inside GUI object **310** and increased the pressure (*i.e.*, how strong it is pressing down on the screen) to a level above actuation threshold **321**. (Poupyrev, 9:4-12.) This indicates that “the GUI object **310** is actuated,” and in response, “tactile feedback **304** is provided as well as visual feedback **305** to inform the user **2** that the GUI object **310** was selected and actuated.” (Poupyrev, 9:6-11, 8:47-49 (“Accordingly,

it is possible to let the user 2 knows [sic] that the selected GUI object 203 is activated with the haptic feedback”).) Poupyrev makes clear that different haptic feedback effects can be provided for the “selected” and “activated” states of a GUI object. (Poupyrev, 8:50-52 (“In the present embodiment, the different haptic feedbacks are provided to distinct the logical states of GUI object, namely ‘selected state’ and ‘activated state’.”).)

67. Each of tactile feedback 302 and 304 separately and independently discloses a “**confirmation haptic effect**” because each of them confirms either that the user has selected a GUI object (302), or that the user has successfully activated (actuated) the GUI object (304). (Poupyrev, 8:12-19 (“In an embodiment of the present invention, the pressure and tactile feedback are used to separate two modes of the interaction with the screen: a) the user feels GUI objects with tactile feedback, which selects items but not actuates them[,] b) the user can actuate GUI objects by pressing on them stronger, the actuation is also accompanied with tactile feedback.”).) This functionality mirrors the description of confirmation haptic effects in the written description of the ’524 patent. (’524, 1:14-18 (“A device such as a mobile device, touchscreen device, and personal computer, can be configured to generate confirmation haptic effects in response to a user’s interaction with the device, as a confirmation that the user has successfully interacted with the device.

For example, when a user interacts with the device using, for example, a button, touchscreen, lever, joystick, wheel, or some other control, a haptic signal can be generated, where the haptic signal causes the device to produce an appropriate confirmation haptic effect.”.)

68. I note that the ’524 patent does not require that a “**confirmation haptic effect**” be limited to a haptic effect occurring only when the user actually activates a user interface element – both the selection **302** and actuation **304** haptic effects above confirm the user’s interaction with the GUI object. But even if “**confirmation haptic effect**” was limited to a situation in which a user actually activated a user interface element, tactile feedback **304** clearly discloses any such requirement.

69. In fact, Poupyrev discloses a further embodiment expressly described as providing “confirmation” tactile feedback. In this embodiment, “an additional step for confirming the completion of actuating operation, such as adding another pressure threshold or detecting releasing of the finger, may be added to avoid accidental actuation.” (Poupyrev, 9:13-16.) This example is depicted in Figure 11:

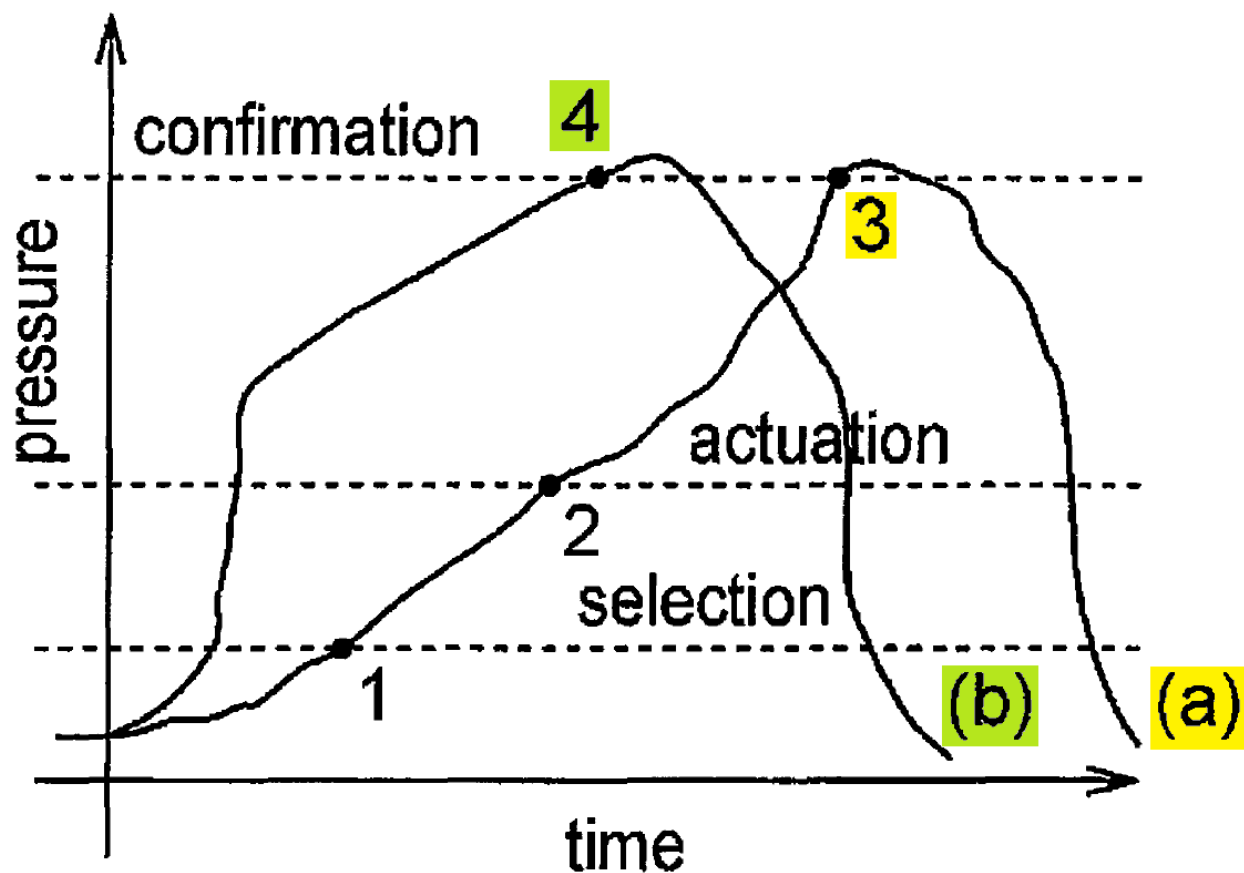


**Figure 11**

(Poupyrev, Fig. 11 (highlighting added).) Figure 11 shows two exemplary pressure curves (a) and (b) showing tactile feedback provided to the user based on the pressure applied to a GUI object over time. In both of these examples, the user has touched and pressed on a GUI object and then increased the amount of pressure. For Curve (a), at Point 1 the user has passed the “selection” pressure threshold causing tactile feedback to be provided – but the GUI object is not yet actuated. (Poupyrev, 12:30-34.) “The user presses further to pass the actuation threshold where a different

tactile feedback is provided (Point 2). In this example, however, the GUI object is not actuated yet. To actuate the GUI object, the user should press further to the confirmation threshold that also provides still another tactile feedback (Point 3).”

(Poupyrev, 12:34-37.) Point 3 thus discloses “**a confirmation haptic effect**” under the above-mentioned (narrower) construction of the term because it confirms that the user has successfully activated the GUI object. Poupyrev explains that “the reason for providing this additional threshold or confirmation threshold is to avoid accidental activation of the GUI objects.” (Poupyrev, 12:38-40.)

70. Curve (b) differs from Curve (a) because, as shown, the user has quickly pressed down on the GUI object with increasing pressure, thus resulting in only tactile feedback at Point 4, the confirmation level. (Poupyrev, 12:49-53.) This is because the user increased the pressure rapidly and thus did not press long enough at lower pressure levels to trigger the selection and actuation tactile feedback thresholds shown in Curve (a). Point 4 thus provides yet another example of a “**confirmation haptic effect**,” under a narrow interpretation of that term, because it confirms that the user has successfully activated the GUI object.

71. I am informed that in the pending litigation, Petitioner has proposed that “**confirmation haptic effect**” be construed as “*a haptic effect used to confirm the interaction with the user interface element.*” (Ex. 1008, 002.) Poupyrev

discloses such a haptic effect, as explained, because the tactile feedback delivered to the user is used to confirm that the user has selected, or activated (actuated) a GUI object. This is because the purpose of the tactile feedback (for both selection and actuation) is to confirm for the user that they have interacted with the GUI object.

72. I am also informed by counsel that Patent Owner in the pending litigation has proposed that “**confirmation haptic effect**” be given its plain and ordinary meaning, but to the extent any construction is necessary, proposed the following definition: “*one of multiple possible tactile feedback events for a single user interface element, customized based on context metadata, to confirm the interaction with the user interface element.*” (Ex. 1008, 002.) This construction appears to add additional limitations to Petitioner’s proposal that do not appear to be reflected in the claim language or required by the written description, including (1) redefining “**haptic effect**” to “tactile feedback event” and (2) requiring that a single user interface element have multiple possible tactile feedback events. With respect to (1), Poupyrev itself makes clear that it treats the term “haptic” and “tactile” feedback as synonyms. (Poupyrev, 5:9-11 (“It should be noted, in this specification, that the word ‘tactile’ and ‘haptic’ indicate the same sensory effect and are used interchangeably.”).) With respect to (2), even if this were deemed a requirement of a “**confirmation haptic effect**,” Poupyrev makes clear that a single GUI object can

have multiple possible tactile feedback events. In the examples above, a single GUI object such as a button could deliver different haptic feedback in response to the user selecting, and then activating (actuating), the GUI object. And as will be explained for claim 1 [a]-1 [b] below, it would have been obvious based on Poupyrev alone or in view of Yun that confirmation haptic effects are “*customized based on context metadata*,” as proposed by Patent Owner.

73. Poupyrev also discloses and renders obvious “[a] **non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a confirmation haptic effect**,” as recited in the preamble. Poupyrev also explains that control section 20 discussed above “may be embodied with a computer... which may include a CPU [*i.e.*, central processing unit], a memory, an external data storage, and an input/output interface.” (Poupyrev, 6:23-26; *see also id.*, 7:34-36 (discussing that data storage 110, within control section 20, may be “[a]ny widely available data storage devices,” including “flash memory, ROM, hard drive as well as network storage.”).) Poupyrev further discloses that “[v]arious functions performed by sub-sections of the control section 20 and the application section 30 may be realized by executing corresponding software installed in the computer...” (Poupyrev, 6:26-29.) It would have been obvious to an ordinarily skilled artisan that the software

executed in Poupyrev would have taken the form of instructions, which would have been stored in a non-transitory data storage device in order to allow the CPU to retrieve and execute them. Poupyrev therefore discloses and renders obvious a computer memory such as network storage, flash memory, hard drive, etc. (“**non-transitory computer-readable medium**”) that has software instructions that, when executed by the CPU, cause the CPU to generate a confirmation haptic effect as recited in the preamble.

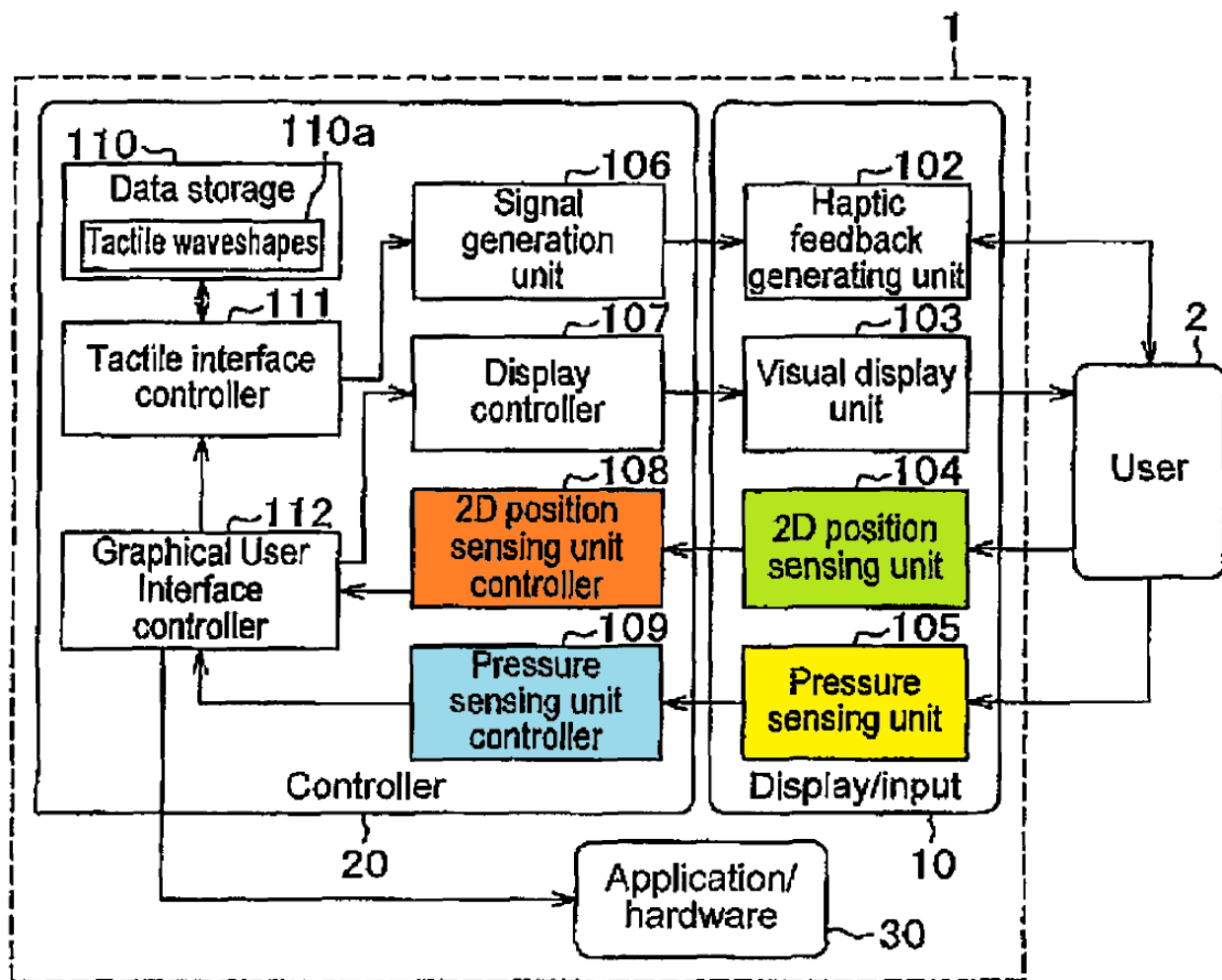
- (a) **“receiving context metadata associated with a user interaction of a user interface element, wherein the context metadata comprises at least one of: data indicating a functionality of the user interface element, or data indicating a history of the user interface element;” (Claim 1[a])**

74. For purposes of claim 1[a], **“a user interface element”** corresponds to a graphical user interface (GUI) object in Poupyrev displayed to the user on a touch screen device. Poupyrev explains that “[t]he display/input section **10** displays on a touch screen thereof images of buttons, keys, switches or any other Graphic User Interface (GUI) objects to prompt a user **2** to interact with the apparatus **1**.” (Poupyrev, 4:66-5:2.) These GUI objects can include “images of buttons, sliders, drawing, scroll bars, hyper links and etc.” (Poupyrev, 5:28-31.)

75. The claimed **“user interaction”** for claim 1[a] thus takes the form of

an action in which the user interacts with a GUI object, such as by making contact using a finger or pointing device. (Poupyrev, 1:67-2:1, 6:61-67.) Poupyrev explains that “[t]he interaction starts when the user **2** touches the screen (touch down event T1). The user **2** can then either drag a finger across the input space (drag or slide state T2) or hold it steady in one place (hold state T3).” (Poupyrev, 7:48-51.) For example, in the case of a button GUI object, the claimed “**user interaction**” corresponds to the user touching and holding an area of the screen associated with the button object.

76. The “**context metadata**” in Poupyrev takes the form of data about the user’s interaction with the GUI object, which includes at least information about **(1)** the *position* on the screen where the interaction is occurring, and **(2)** the *amount* of pressure applied by the user. Figure 1 depicts that both of these pieces of information are received by at least controller **20**:



### Figure 1

(Poupyrev, Fig. 1 (highlighting added).) Figure 1 shows position sensing unit **104**, part of display/input section **10**, which “detects where the user is touching on the touch screen.” (Poupyrev, 6:3-4.)<sup>2</sup> Sensing unit **104** as shown feeds into position

<sup>2</sup> As observed in **Part V.A.1(a)**, the written description of Poupyrev sometimes mixes up the numerals (104, 105) used to refer to the pressure sensing unit and the

sensing unit controller **108**, part of controller **20**, which “determines the position where the user **2** is touching on the screen.” (Poupyrev, 7:3-4.) Figure 1 also shows pressure sensing unit **105**, part of the display/input section **10**, that “measure[s] pressure applied to the touch screen by the user’s input operation.” (Poupyrev, 5:46-47, 5:33-34 (identifying “pressure sensing unit **105**” as being used with visual display unit **103**).) Pressure sensing unit **105** as shown feeds into pressure sensing unit controller **109**, which “determines the value of pressure applied when the user is touching on the screen.” (Poupyrev, 7:1-3.) As also shown in Figure 1, the position and pressure and data are received by GUI controller **112**, which is part of controller **20**. (Poupyrev, 7:4-5 (“The determined data [from the position and pressure sensing controllers] is communicated to the GUI controller **112**.”).) As explained in more detail below, Poupyrev also confirms that the controller uses the detected position and pressure to determine the haptic feedback provided to the user.

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position sensing unit of Figure 1. (Poupyrev, 5:24-25 (“[A] two-dimensional (2D) position sensing unit **104** and a pressure sensing unit **105**.”), 5:46-47 (“... pressure sensing unit **104**”), 6:4-5 (“... position sensing unit **105**....”).) For consistency, this Declaration will refer to “pressure sensing unit” as **105** and the “position sensing unit” as **104**, consistent with numerals used in Figure 1. As noted, an ordinarily skilled artisan would have regarded these inconsistencies as immaterial typographical errors that would not have impeded an ordinarily skilled artisan from fully understanding and applying the teachings of Poupyrev.

(Poupyrev, 2:10-14 (“The controller section determines a form of the haptic feedback to be generated depending on (i) the detected touch position, (ii) the detected pressure value and (iii) the determined current logical state of the graphical user interface object.”).) It therefore would have been obvious that the “**context metadata**” in Poupyrev, which includes information about position and pressure, would have been “**receiv[ed]**” by at least controller **20** of Figure 1.

77. I am informed that, in the pending litigation, Petitioner has proposed that “**context metadata**” be defined as “*any data associated with an interaction with the user interface element,*” whereas Patent Owner has argued that this term should be given its plain and ordinary meaning and thus proposed no construction. (Ex. 1008, 002.) Petitioner’s proposed construction is satisfied by at least the position and pressure data in Poupyrev, individually or collectively, because it comprises data associated with the user’s interaction with the GUI object.

78. My mapping is also consistent with the written description of the ’524 patent which explains that the claimed “**context metadata**” can include “sensor input data, such as a detected force produced by a touch applied to the user interface element by the user.” (’524, 2:15-17; *see also id.*, 5:35-38 (“For example, a sensor can generate sensor input data associated with a pressure produced by a user touching a user interface element (such as a keyboard or a button displayed within a

touchscreen).”) The information about position and pressure in Poupyrev mirrors the examples of context metadata in the ’524 patent.

79. Claim 1[a] further specifies that the “**context metadata**” comprises either “data indicating a functionality of the user interface element,” or “data indicating a history of the user interface element.” Although claim 1[a] requires only one of these categories, the proposed combination covers both, each providing further data about the user’s interaction with the user interface element.

80. With respect to data indicating a history of the user interface element, Poupyrev discloses and renders obvious that the context metadata received by the controller also includes a history of the GUI object (“**the user interface element**”), which the controller uses to determine the tactile feedback to be provided to the user. (Poupyrev, 7:39-42 (“In another embodiment of the present invention, a history of the previous input and a history of the previous states of the GUI objects is used to determine the tactile feedback to the user **2.**”).) This history includes prior touch positions and pressure values associated with the GUI object, which is in turn used to determine the logical state of the GUI object:

The controller section determines a current logical state of the graphical user interface object using a history of detected touch positions and a history of detected pressure values. The controller section determines

a form of the haptic feedback to be generated depending on (i) the detected touch position, (ii) the detected pressure value and (iii) the determined current logical state of the graphical user interface object.

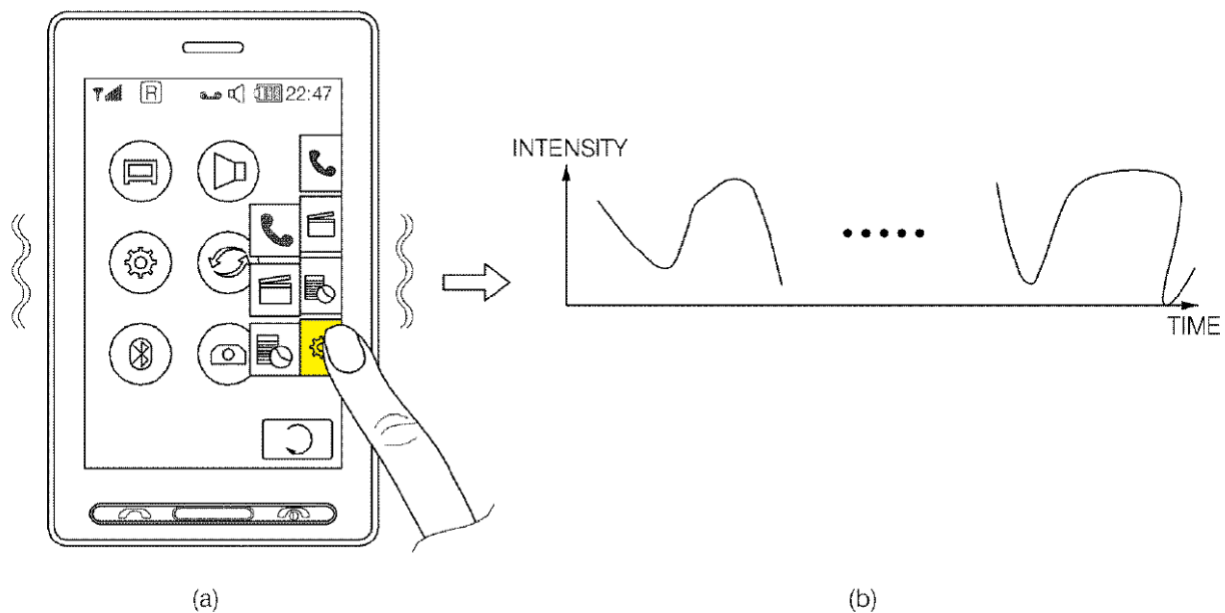
(Poupyrev, 2:8-14; *see also* 2:22-33.) The “**context metadata**” received in Poupyrev therefore also includes “**data indicating a history of the user interface element,**” which can include history of previous states of the GUI object and/or history of prior touch positions and pressure values associated with the GUI object. It would have been obvious that this data would have been “**receiv[ed]**” by at least controller **20** and/or GUI controller **112** in Poupyrev, because it is used by the controller to determine the appropriate tactile feedback to provide to the user as indicated above. (Poupyrev, 2:8-14, 7:29-34, 7:39-42.)

81. Poupyrev does not appear to expressly disclose context metadata that also includes “**data indicating a functionality of the user interface element.**” As noted, the claim only requires context metadata comprising data indicating either history or functionality, and as such, the history data in Poupyrev alone is sufficient. But in the event Patent Owner were to argue that Poupyrev’s showing is in any way deficient, it would have been obvious in further view of **Yun**, for the context metadata received by the controller in Poupyrev to also include “**data indicating a functionality of the user interface element.**”

82. Yun discloses a technique similar to Poupyrev for providing haptic feedback to a user of a mobile terminal. (Yun, Abstract, ¶0002.) A mobile terminal can include “a mobile phone, a smart phone, a laptop book computer, a digital broadcast receiver, a personal digital assistant (PDA), a portable multimedia player (PMP), or a navigation device.” (Yun, ¶0029.) The mobile terminal includes a number of components including a touch screen for accepting user input. (Yun, ¶0035.) The mobile terminal in Yun also includes haptic module **157** that “may provide various haptic effects (such as vibrations) that can be perceived by the user. If the haptic module **157** generates vibration as a haptic effect, the intensity and the pattern of vibration generated by the haptic module **157** may be altered in various manners.” (Yun, ¶0042.) Yun discloses numerous examples in which the mobile terminal can provide different haptic feedback (*e.g.*, different vibration intensities and patterns) based on the particular action the user is taking.

83. Figure 36 depicts one such example, in which a mobile terminal generates a haptic effect in response to the user selecting a particular menu icon:

**FIG. 36**



(Yun, Fig. 36 (highlighting added).) Figure 36 shows a screen image on a mobile terminal “including a plurality of menu icons.” (Yun, ¶0109.) “In order to enter a menu corresponding to the chosen menu icon,” Yun explains, “the chosen menu icon may be touched. In this case, a haptic effect corresponding to the menu may be generated.” (Yun, ¶0110.) “In this manner, it is possible to generate different haptic effects for different menu items. Thus, it is possible for a user to easily determine which of the menu items has been touched or approached by using the sense of touch.” (Yun, ¶0079, Fig. 9.)

84. A key feature of Yun, for purposes of the “**context metadata**” limitation, is that the terminal device uses information indicating the functionality

of the menu icon to identify its corresponding haptic effect. For example, as shown in **yellow** highlighting in Figure 36 above, the user is selecting a menu icon for a gear, which an ordinarily skilled artisan (or even a user of a conventional smart phone) would have recognized as pertaining to device settings. As Yun explains:

Referring to FIG. 36, if a user touches or approaches and thus chooses one of the menu icons, the name of the chosen menu icon may be analyzed, and a haptic effect corresponding to the name of the chosen menu icon may be generated. For example, if the user chooses a menu icon ‘setting’, haptic effects (such as vibration effects) respectively corresponding to alphabet letters ‘s’, ‘e’, ‘t’, ‘t’, ‘i’, ‘n’, and ‘g’ may be sequentially output. Alternatively, the user may set a haptic effect for the word ‘setting’ in advance. In this case, the haptic effect corresponding to the word ‘setting’ may be generated.

(Yun, ¶0109.) Yun therefore discloses that, when the user chooses a menu icon, the mobile terminal uses the textual name of the menu icon to determine the appropriate haptic effects. The resulting haptic effect is shown in part (b) of Figure 36 above, which shows the varying intensity of the multiple haptic effects generated as a result of the user’s selection of the “setting” menu option.

85. ***Manner, Rationale and Motivation to Combine (Poupyrev and Yun):***

Poupyrev, as explained previously, discloses an electronic device that can generate confirmation haptic effects for a GUI object with which the user is interacting. It

would have been obvious to combine Poupyrev with Yun, predictably resulting in the electronic device of Poupyrev with the further ability to receive “**context metadata**” that includes data indicating a functionality of the GUI object as taught in Yun. Under the proposed combination, therefore, the “**context metadata**” received and processed by the electronic device in Poupyrev would have also included the name of the GUI object with which the user is interacting.

86. The controller in Poupyrev, therefore, would have received “**context metadata... indicating a functionality of the user interface element,**” because it would have received (along with the pressure and position information) data identifying the name associated with the GUI object with which the user is interacting. It would have been obvious that the name of the GUI object would have provided at least an indication of “**a functionality**” of the element, as claimed. Using the example in Yun above, the name “setting” would have identified the functionality associated with a settings menu. As explained in more detail below, this would have enabled the controller in Poupyrev to provide tactile feedback customized to the GUI object with which the user is interacting.

87. Poupyrev and Yun are analogous references in the same field of the ’524 patent of devices that produce haptic effects. (’524, 1:4-7.) Both references disclose similar techniques for generating haptic effects (such as vibrations) in

response to user interaction with user interface elements through a touch screen display. These references would also have been reasonably pertinent to a number of problems facing the inventors, such as how to identify a particular user interface element with which the user is interacting, and then provide a specific haptic effect corresponding to that user interface element.

88. The proposed combination with Yun would have provided a compelling benefit to the system of Poupyrev – the ability to deliver customized tactile feedback based on a functionality of the GUI object with which the user is interacting. This benefit is expressly identified in Yun, which explains that “[i]n this manner, it is possible to generate different haptic effects for different menu items. Thus, it is possible for a user to easily determine which of the menu items has been touched or approached by using the sense of touch.” (Yun, ¶0079.) Using Figure 36 of Yun as an example, the tactile feedback for the setting menu icon would have been different from the feedback provided for the phone menu icon, and so forth. Accordingly, an ordinarily skilled artisan would have been motivated to implement Poupyrev to receive context metadata indicating a functionality of the GUI object in order to deliver “**a confirmation haptic effect**” that indicates at least a functionality of the GUI object with which the user is interacting.

89. As further explained for the preamble of claim 1, the claimed

**“confirmation haptic effect”** can correspond to the tactile feedback provided in Poupyrev when the user selects or activates (actuates) a GUI object by pressing and holding for a period of time. Under the proposed combination with Yun, therefore, the controller in Poupyrev would have been enabled to vary that confirmation haptic effect based on a functionality of the GUI object. This would have provided the further benefit of providing tactile feedback that not only indicates to a user that the GUI object has been selected or activated, but allows the user to further determine through the tactile feedback the identity of the GUI object that is being selected or activated.

90. An ordinarily skilled artisan would also have been motivated to implement the proposed combination such that, as disclosed in Yun, the context metadata would have included the actual textual name of the GUI object. This is because the content of the user interface element name in Yun actually defines the particular haptic effects that can be delivered when that element is selected. In the first exemplary embodiment from Yun discussed above, “if the user chooses a menu icon ‘setting’, haptic effects (such as vibration effects) respectively corresponding to alphabet letters ‘s’, ‘e’, ‘t’, ‘t’, ‘i’, ‘n’, and ‘g’ may be sequentially output.” (Yun, ¶0109.) The alphabetic letters in the name can thus dictate the haptic feedback effects that will be provided to the user. This would have provided a benefit to

Poupyrev of enabling distinct haptic effects, *e.g.*, the tactile feedback provided for a particular GUI object would have been different from the feedback provided for other GUI objects based on differences in their names. The effectiveness of these haptic effects would have been further enhanced by the fact that, as described in Yun, they would have been based directly on the alphabetic characters making up the name of the GUI object.

91. An ordinarily skilled artisan would have had at least a reasonable expectation of success. The use of textual names to identify the GUI objects in Poupyrev would have involved nothing more than rudimentary programming techniques familiar to even beginning programmers. An ordinarily skilled artisan would have found the disclosures of Poupyrev and Yun more than adequate to implement the teachings on which I rely in this Declaration, using conventional programming techniques and without undue experimentation.

**(b) “mapping the received context metadata to one or more haptic parameters;” (Claim 1[b])**

92. The “**one or more haptic parameters**” corresponds in the prior art to parameters that define the haptic effects provided to the user. I am informed that in the pending litigation, Petitioner has argued that “**haptic parameter**” should be construed as “*a quantity of a haptic effect quality, such as magnitude, frequency,*

*duration, amplitude (i.e., strength), waveform, or any other kind of quantifiable haptic parameter,”* whereas Patent Owner contends this term should be given its plain and ordinary meaning and does not require construction. (Ex. 1008, 002.) Petitioner’s proposal is echoed in the written description of the ’524 patent, and is satisfied by the prior art. (’524, 6:23-25 (“A haptic parameter is a quantity of a haptic effect quality, such as magnitude, frequency, duration, amplitude (i.e., strength), waveform, or any other kind of quantifiable haptic parameter.”).)

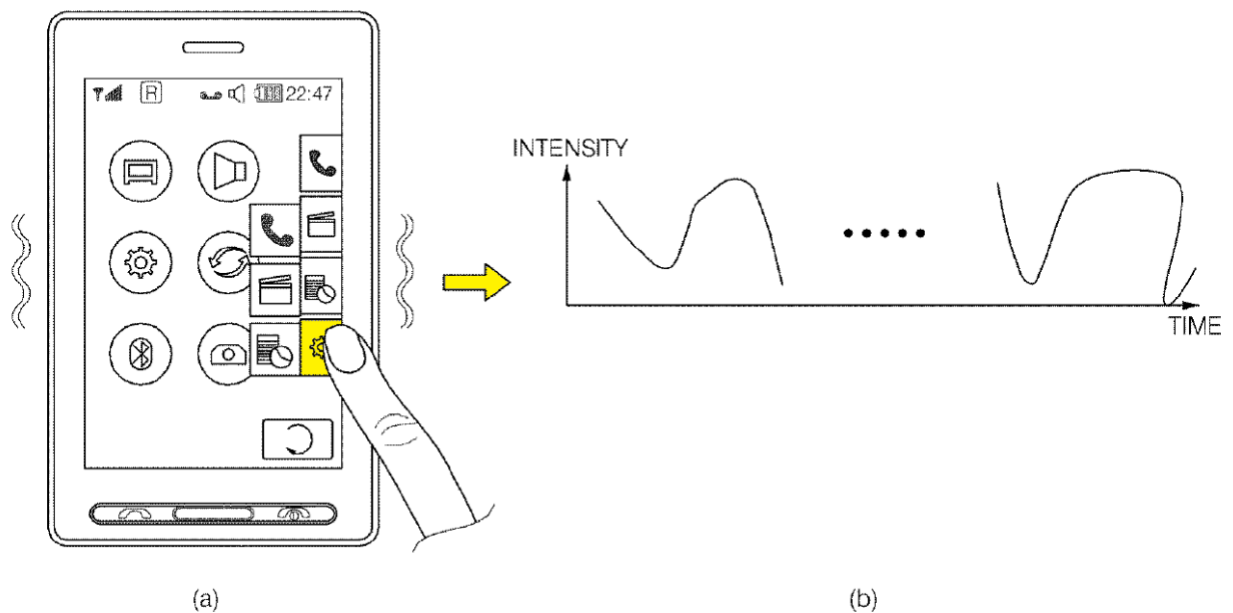
93. Poupyrev discloses at least two parameters that are identified as examples in the ’524 patent, *i.e.*, frequency and amplitude. (Poupyrev, 2:41-43 (“In another embodiment of the present invention, the haptic feedback is controlled in either a frequency, an amplitude or both amplitude and frequency simultaneously.”).) Yun discloses similar haptic parameters of vibration intensity and pattern. (Yun, ¶0042 (“If the haptic module **157** generates vibration as a haptic effect, the intensity and the pattern of vibration generated by the haptic module **157** may be altered in various manners.”).) It would have been obvious that the “intensity” parameter in Yun corresponds to at least the “amplitude” and/or “magnitude” parameters identified as examples in the ’524 patent. The ’524 patent equates amplitude with strength, and treats intensity being as synonymous with both amplitude and magnitude. (’524, 10:5-8 (“Examples of a haptic parameter can

include a magnitude haptic parameter, a frequency haptic parameter, a duration haptic parameter, an amplitude (i.e., strength) haptic parameter, and a waveform haptic parameter...”), 5:49-51 (“...the magnitude (or amplitude or intensity) of the confirmation haptic effect should be increased.”).) The term amplitude in the context of vibration haptic effects would have been understood as referring generally to the maximum amount of oscillation provided by the actuator, which would have determined the intensity and strength of the vibration. It would also have been obvious that the “pattern” parameter in Yun corresponds to at least a waveform haptic parameter disclosed in the ’524 patent. (’524, 7:46-49 (“Yet another example of a haptic parameter is a waveform haptic parameter (identified in FIG. 2 as waveform **234** [sic; **233**]), where a waveform duration haptic parameter defines a waveform value of the confirmation haptic effect.”).) This is shown in part (b) of Figure 36 of Yun above, which shows how the haptic effect for each letter in the menu icon name has a distinct waveform of intensity over time. (Yun, Fig. 36, Part (b).) The proposed combination, therefore, discloses at least four of the exemplary haptic parameters identified in the ’524 patent.

94. With respect to the step of “**mapping the received context metadata**” to one or more of these haptic parameters, this occurs when the controller in Poupyrev determines the amplitude, frequency, intensity and/or pattern of the haptic

effect to be provided based on the context metadata of claim 1[a]. For example, as explained for claim 1[a], the context metadata in Poupyrev in view of Yun can include “**a functionality of the user interface element**,” and under this proposed combination, the step of “**mapping**” occurs when the controller in Poupyrev uses the context metadata about the GUI object (including a functionality of the GUI object) to determine the appropriate haptic feedback to provide to the user. As noted previously, Yun states that “if a user touches or approaches and thus chooses one of the menu icons, the name of the chosen menu icon may be analyzed, and a haptic effect corresponding to the name of the chosen menu icon may be generated.” (Yun, ¶0109.) As a result, the pattern and intensity of the haptic effect (“**one or more haptic parameters**”) are selected based on the name of the GUI object. This is shown in Figure 36, discussed above:

**FIG. 36**



(Yun, Fig. 36 (highlighting added).) As shown, user activation of the “**setting**” menu icon resulted in a haptic effect having a vibration intensity and pattern that is specific to the name of that menu icon, as shown in part (b) of Figure 36. (Yun, ¶0109 (“For example, if the user chooses a menu icon ‘setting’, haptic effects (such as vibration effects) respectively corresponding to alphabet letters ‘s’, ‘e’, ‘t’, ‘t’, ‘i’, ‘n’, and ‘g’ may be sequentially output.”), Yun, ¶0133 (“As described above, according to the present invention, it is possible to generate different haptic effects having different intensities and/or different patterns for different haptic regions of an object such as a menu icon, a control icon, a touch key and an image for controlling the operation of a mobile terminal.”).) It would have been obvious that determining the haptic

feedback provided to the user would have involved correlating (“**mapping**”) the context metadata – which includes the name of the chosen GUI object – to the intensity and pattern parameters (“**one or more haptic parameters**”) of the confirmation haptic effect provided to the user.

95. Similarly in the case of “**a history of the user interface element,**” as explained for claim 1[a], the controller in Poupyrev performs the step of “**mapping**” to identify the appropriate haptic feedback based on the context metadata (*i.e.*, position, pressure, history). This is because the controller in Poupyrev determines the logical state of the GUI object based on its history, and then uses the logical state in selecting the appropriate haptic feedback to be provided:

The controller section determines a current logical state of the graphical user interface object using a history of detected touch positions and a history of detected pressure values. The controller section **determines a form of the haptic feedback to be generated** depending on (i) the detected touch position, (ii) the detected pressure value and (iii) the determined current logical state of the graphical user interface object.

(Poupyrev, 2:8-14; *see also id.*, 7:39-42 (“In another embodiment of the present invention, a history of the previous input and a history of the previous states of the GUI objects is used to determine the tactile feedback to the user 2.”).) Poupyrev expressly discloses mapping (*i.e.* dynamically correlating) the context metadata with

the tactile feedback presented to the user:

The control section **20** dynamically correlates: (i) the touch position on the screen or a GUI object selected by the user's input operation; (ii) the pressure applied on the screen by the user's input operation; and (iii) a current logical state of the selected GUI object; with the type of tactile feedback to be presented to the user 2.

(Poupyrev, 5:11-16.) Item (iii) above, “a current logical state of the selected GUI object” (*id.*), is based directly on a history of the GUI object as explained above, which in turn is used to determine the appropriate type of tactile feedback. And as explained above, “the type of tactile feedback to be presented to the user **2**” (*id.*), is based on the frequency and/or amplitude parameters (“**one or more haptic parameters**”). (Poupyrev, 2:41-43 (“In another embodiment of the present invention, the haptic feedback is controlled in either a frequency, an amplitude or both amplitude and frequency simultaneously.”), 10:43-67 (describing how to vary frequency, amplitude, and other parameters to generate tactile feedback).) Poupyrev thus discloses a step in which the controller “dynamically correlates” (*i.e.*, “**map[s]**”) the context metadata to the one or more haptic parameters.

96. I note that the '524 patent does not prescribe any particular process or technique for carrying out the “**mapping**” step. The written description of the '524 patent, in fact, describes the “**mapping**” step as requiring nothing more than

correlating at least one haptic parameter to at least some portion of the context metadata:

As part of the mapping, the context metadata can be mapped to the one or more haptic parameters (identified in FIG. 2 as context metadata mapping **221**). More specifically, the one or more haptic parameters can each include a value that can be based, at least in part, on the context metadata.

(’524, 6:36-41.) The proposed combination works in the same way. In both the “**history**” and “**functionality**” context metadata examples from claim 1 [a], the one or more haptic parameters, *e.g.*, intensity/amplitude, pattern, frequency, are based at least in part on the context metadata relating to the GUI object.

- (c) “**generating a haptic signal based at least in part on the one or more haptic parameters; and**” (Claim 1[c])
- (d) “**sending the haptic signal to an actuator to generate the confirmation haptic effect.**” (Claim 1[d])

97. Because these two limitations are closely-related, I will address them together. For purposes of claim 1 [c], the claimed “**haptic signal**” corresponds to a signal generated by signal generation unit **106** (Fig. 1) in Poupyrev, which is sent to haptic feedback generating unit **102** which comprises an actuator that generates the confirmation haptic effect. These components and the flow of the haptic signal are shown in Figure 1 of Poupyrev:

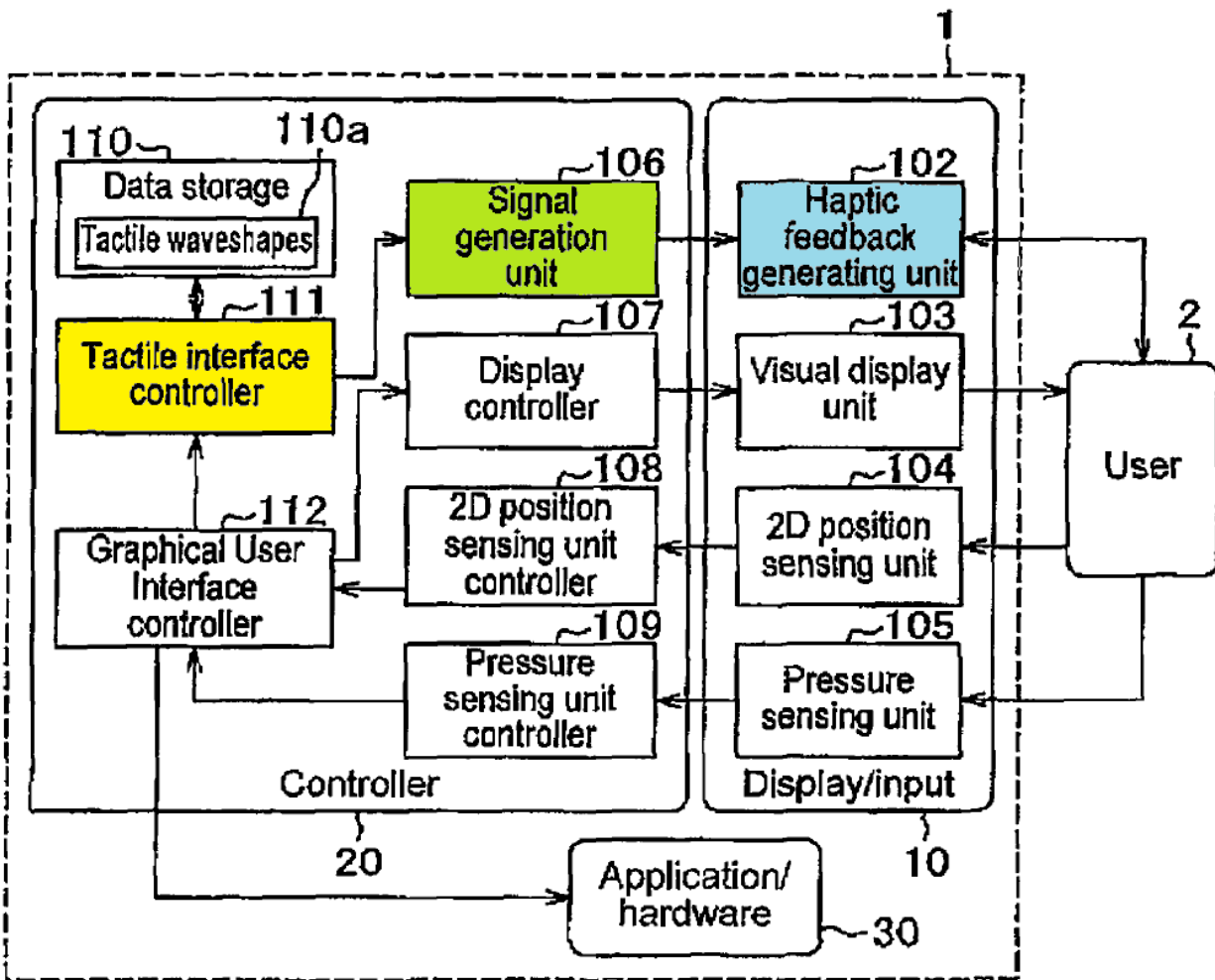


**Figure 1**

(Poupyrev, Fig. 1 (highlighting added).) Poupyrev explains that, after the haptic parameters discussed for claim 1[b] have been identified, the GUI controller 112 sends appropriate commands to the tactile interface controller 111, which in turn sends appropriate commands to signal generation unit 106, as shown in Figure 1. (Poupyrev, 7:29-31, 6:43-46.) “The signal generating unit 106 generates and provides a signal to the tactile feedback generating unit 102 for driving tactile

feedback generating elements or the piezoelectric actuators.” (Poupyrev, 6:43-46.)

“The haptic feedback generating unit 102 may be formed with piezoelectric bimorph actuators with single or multiple layer structure.” (Poupyrev, 5:38-40.)

98. Accordingly, the claimed “**haptic signal**” corresponds in Poupyrev to the signal generated and sent by signal generation unit 106, and the claimed “**actuator**” corresponds to tactile feedback generating unit 102 that receives the haptic signal and generates a corresponding haptic effect. And as explained for the preamble, the haptic effect provided by the controller qualifies as a “**confirmation**” haptic effect, as claimed. And this “**confirmation haptic effect,**” as explained for claim 1[b], would have been selected based on context metadata including data indicating a history or functionality of the GUI element.

## 2. Claim 2

99. Claim 2 recites: “**The non-transitory computer-readable medium of claim 1, further comprising modifying the one or more haptic parameters based on user input.**” The ability to modify the one or more haptic parameters would have been obvious based on Poupyrev in view of Yun. As shown below, Yun expressly discloses the ability to modify one or more of the haptic parameters.

100. As explained for claim 1[b], the “**one or more haptic parameters**” for Yun include at least the vibration intensity and pattern. Yun explains that, in one

embodiment, “[a] user may determine in advance the intensity and pattern of vibration to be output for the input character or the input character string.” (Yun, ¶0071.) Two claims in the published Yun application, in fact, expressly disclose display of “a menu for setting at least one of the type, the intensity, and the pattern of a haptic effect for each of the haptic regions on the touch screen.” (Yun, claims 11, 20.) It would therefore have been obvious that Yun discloses the ability of the user to “**modif[y]**” at least the intensity and pattern haptic parameters associated with a haptic effect, for example, by modifying default haptic parameters or by modifying parameters that had been previously set by the user. (Yun, ¶0106 (“If vibration is generated as a haptic effect, the intensity and the pattern of vibration to be generated for the predefined word may be set and altered by the user.”).)

101. I note that in the example in Paragraph 0071 of Yun described above, user modification of the intensity and pattern is described in the context of the character input mode feature of Figure 7 rather than the menu icon feature of Figure 36 on which I rely for claim 1. (Yun, ¶¶0069-0071, Fig. 7.) But it would have been obvious that user modifications to the intensity and/or pattern parameters for input characters and/or for character strings as described in Paragraph 0071 of Yun would also have applied to the haptic effects provided for those same characters and/or character strings when used as the name of menu icons according to the menu icon

embodiment of Figure 36. This because, as explained, the menu icon feature in Yun in one embodiment generates haptic effects *based on the individual characters in the name of the menu icon*. (Yun, ¶0109 (“For example, if the user chooses a menu icon ‘setting’, haptic effects (such as vibration effects) respectively corresponding to alphabet letters ‘s’, ‘e’, ‘t’, ‘t’, ‘i’, ‘n’, and ‘g’ may be sequentially output.”).) In an alternative embodiment, “the user may set a haptic effect for the word ‘setting’ in advance.” (Yun, ¶109.) It would have been obvious that by modifying the intensity and/or pattern for individual characters and/or a character string via the character input feature discussed above (Yun, ¶0071), those modifications would also have applied to the haptic effects generated when a menu icon is selected whose name contains those characters or that character string. For example, user modification to the intensity and/or pattern for the character “t” would have applied to the haptic effects corresponding to that character – both in response to input of that character in character input mode and in response to selection of a menu whose name includes one or more instances of that character. Under the alternative embodiment discussed above, user modification to the intensity and/or pattern for the character string “setting” would have applied to the haptic effects provided *both* in response to input of that character string in character input mode, and in response to selection of a menu whose name includes that string.

102. An ordinarily skilled artisan would have been motivated to implement Yun in this manner to provide greater uniformity and consistency in the haptic effects provided to the user. In many human-computer interfaces, consistency was and remains today a highly desirable goal because it enables the user to transfer knowledge obtained through one aspect of the user interface to other aspects. In the context of the proposed combination, it would have been beneficial for the knowledge and recognition the user obtains about haptic effects through one feature (*e.g.*, the character input mode of Figure 7) to also apply to other features of the device (*e.g.*, the menu icon selection of Figure 36). The proposed combination therefore renders obvious “**modifying the one or more haptic parameters based on user input.**”

103. And moving beyond the menu icon feature of Figure 36 discussed above, it would have been obvious to allow user modification of at least the intensity haptic parameter – regardless of the user interface context in which the haptic effect is generated. This is because, as was well-known, each user could have differed from other users in their ability to perceive haptic vibrations based on several factors including the user’s age, health, level of familiarity with the device, surrounding environment, among others. Accordingly, a haptic vibration with an intensity appropriate for one user may have been too weak for another user, or too strong for

yet another user. Allowing the user to modify the intensity parameter, as disclosed in Yun, would have benefitted the proposed combination by affording a greater degree of user customization, thus improving the effectiveness and comfort of haptic effects provided to the user.

### 3. Claim 6

104. Claim 6 recites: “**The non-transitory computer-readable medium of claim 1, wherein the context metadata further comprises at least one of: data indicating one or more physical properties of the user interface element, or sensor input data.**” As explained for claim 1 [a], the “**context metadata**” comprises (among other things) information about the position on the screen where user interaction is taking place, and the amount of pressure applied by the user. Both of these pieces of data comprise “**sensor input data**,” because they are provided by components that Poupyrev expressly describes as sensors.

105. For example, as explained for claim 1 [a], the display/input section **10** (Figure 1) includes “a two-dimensional (2D) position sensing unit 104 and a pressure sensing unit 105.” (Poupyrev, 5:23-26.) With respect to the *position* sensing unit, it “detects where the user is touching on the touch screen.” (Poupyrev, 6:3-4.) That information is provided to position sensing unit controller **108**, part of controller **20**, which “determines the position where the user **2** is touching on the screen.”

(Poupyrev, 7:3-4.) With respect to the *pressure* sensing unit, pressure sensing unit **105**, it “measure[s] pressure applied to the touch screen by the user’s input operation.” (Poupyrev, 5:46-47, 5:33-34.) That information is in turn fed into pressure sensing unit controller **109**, which “determines the value of pressure applied when the user is touching on the screen.” (Poupyrev, 7:1-3.) Poupyrev therefore discloses at least two examples in which the context metadata “**comprises... sensor input data.**” The “**sensor input data**” comprises data about position and pressure that were input and communicated to the controller using, respectively, the position and pressure sensing units and controllers as described in detail above.

#### 4. Claim 7

106. Claim 7 recites: “**The non-transitory computer-readable medium of claim 1, wherein the one or more haptic parameters comprises at least one of: a magnitude haptic parameter, a frequency haptic parameter, a duration haptic parameter, an amplitude haptic parameter, or a waveform haptic parameter.**”

As fully explained for claim 1**[b]**, the proposed combination discloses and renders obvious at least four distinct haptic parameters, including for Poupyrev, “**frequency**” and “**amplitude**” haptic parameters. (Poupyrev, 2:41-43 (“[T]he haptic feedback is controlled in either a frequency, an amplitude or both amplitude and frequency simultaneously.”), 10:43-64.) With respect to Yun, as explained for

claim 1 [b], it discloses “**one or more haptic parameters**” that include at least an intensity parameter that qualifies as an “**amplitude**” and/or “**magnitude**” haptic parameter, and a pattern parameter that qualifies as at least a “**waveform**” parameter. (Yun, ¶0042 (“If the haptic module **157** generates vibration as a haptic effect, the intensity and pattern of vibration generated by the haptic module **157** may be altered in various manners.”).)

## 5. Claim 8

107. Claim 8 recites: “**The non-transitory computer-readable medium of claim 1, wherein the user interface element comprises at least one of: a physical element of a device or a virtual element of a device.**” As explained for claim 1 [a], the “**user interface element**” comprises at least “**a virtual element of a device,**” such as a selectable option like a button displayed on the touch screen of a device. This is consistent with the ’524 patent, which expressly identifies a button displayed on a touchscreen device as an example of a virtual interface element. (’524, 4:4-7.) Poupyrev explains that “[t]he display/input section **10** displays on a touch screen thereof images of buttons, keys, switches or any other Graphic User Interface (GUI) objects to prompt a user **2** to interact with the apparatus **1**.” (Poupyrev, 4:66-5:2.) These GUI objects can include “images of buttons, sliders, drawing, scroll bars, hyper links and etc.” (Poupyrev, 5:28-31.)

## 6. Claims 11-14

108. Claims 11-14 are method claims that are substantially identical to claims 1-2 and 6-7, as shown in the table below.

| Claim 1 (Computer Medium)                                                                                                                                                                                                                                                         | Claim 11 (Method)                                                                                                                                                                                                                                                                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1[pre]. A non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a confirmation haptic effect, the generating the confirmation haptic effect comprising:                                  | 11[pre]. A computer-implemented method for producing a confirmation haptic effect, the computer-implemented method comprising:                                                                                                                                                    |
| [a] receiving context metadata associated with a user interaction of a user interface element, wherein the context metadata comprises at least one of: data indicating a functionality of the user interface element, or data indicating a history of the user interface element; | [a] receiving context metadata associated with a user interaction of a user interface element, wherein the context metadata comprises at least one of: data indicating a functionality of the user interface element, or data indicating a history of the user interface element; |
| [b] mapping the received context metadata to one or more haptic parameters;                                                                                                                                                                                                       | [b] mapping the received context metadata to one or more haptic parameters;                                                                                                                                                                                                       |
| [c] generating a haptic signal based at least in part on the one or more haptic parameters; and                                                                                                                                                                                   | [c] generating a haptic signal based at least in part on the one or more haptic parameters; and                                                                                                                                                                                   |
| [d] sending the haptic signal to an actuator to generate the confirmation haptic effect.                                                                                                                                                                                          | [d] sending the haptic signal to an actuator to generate the confirmation haptic effect.                                                                                                                                                                                          |

| <b>Claim 2</b>                                                                                                                                                                                                                                                                      | <b>Claim 12</b>                                                                                                                                                                                                                                                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The non-transitory computer-readable medium of claim 1, further comprising modifying the one or more haptic parameters based on user input.                                                                                                                                         | The computer-implemented method of claim 11, further comprising modifying the one or more haptic parameters based on user input.                                                                                                                                         |
| <b>Claim 6</b>                                                                                                                                                                                                                                                                      | <b>Claim 13</b>                                                                                                                                                                                                                                                          |
| The non-transitory computer-readable medium of claim 1, wherein the context metadata further comprises at least one of data indicating one or more physical properties of the user interface element, or sensor input data.                                                         | The computer-implemented method of claim 11, wherein the context metadata comprises at least one of data indicating one or more physical properties of the user interface element, or sensor input data.                                                                 |
| <b>Claim 7</b>                                                                                                                                                                                                                                                                      | <b>Claim 14</b>                                                                                                                                                                                                                                                          |
| The non-transitory computer-readable medium of claim 1, wherein the one or more haptic parameters comprises at least one of a magnitude haptic parameter, a frequency haptic parameter, a duration haptic parameter, an amplitude haptic parameter, or a waveform haptic parameter. | The computer-implemented method of claim 11, wherein the one or more haptic parameters comprises at least one of a magnitude haptic parameter, a frequency haptic parameter, a duration haptic parameter, an amplitude haptic parameter, or a waveform haptic parameter. |

109. As shown, the only material difference between claims 1-2, 6-7 and claims 11-14 is that the former claims recite a computer-readable medium having stored instructions for performing the recited functions, while the latter claims recite a computer-implemented method for performing those same functions. For purposes of claims 11-14, as explained for claim 1, these enumerated functions are performed

by apparatus in Poupyrev, which be implemented using a computer. (Poupyrev, 6:23-26 (“The control section **20** and the application section **30** may be embodied with a computer (not shown in the figure), which may include a CPU, a memory, an external data storage, and an input/output interface.”).) The proposed combination therefore discloses a “**computer-implemented method**,” and for the same reasons as claims 1-2 and 6-7, renders obvious claims 11-14

**C. Ground 2: Claims 2-4 and 12 Are Obvious Over Poupyrev and Yun in View of Braun and Rosenberg.**

110. Claims 2-4 and 12 generally relate to features for allowing modification of “**the one or more haptic parameters**” of claims 1 and 11, based on user input. Claims 2 and 12 are obvious based on Poupyrev and Yun as explained for **Ground 1**, but Poupyrev and Yun do not appear to disclose the more specific features of claims 3-4. But these additional features of claims 3-4, are obvious in further view of **Braun** and **Rosenberg**, as discussed below. And because claims 3-4 depend on claim 2 (which is substantially similar to claim 12), I will also explain how Braun and Rosenberg apply to claims 2 and 12.

**1. Claims 2 and 12**

111. Claim 2 recites: “**The non-transitory computer-readable medium of claim 1, further comprising modifying the one or more haptic parameters based**

**on user input.”** As fully explained for claim 1[c], the “**one or more haptic parameters**” under the proposed combination include at least the strength of the vibration haptic effect, *e.g.*, amplitude and/or magnitude haptic parameters. Claim 12 depends from independent claim 11 and is substantially identical to claim 2.

112. **Braun** discloses a technique for modifying at least a magnitude haptic parameter based on user input. Braun discloses a technique for providing “force feedback” to a user of an interface device, such as a mouse or joystick. As explained in **Part V.A.2(a)**, force feedback generally refers to a technology that generates tactile feedback through an input device in order to simulate physical forces, and was commonly used by video gaming controllers. As noted, “force feedback” in this context is generally synonymous with “haptic feedback” or “haptic effects.” (*See* ’524, 1:11-14 (“Haptics is a tactile and force feedback technology that takes advantage of a user's sense of touch by applying haptic feedback effects (i.e., ‘haptic effects’), such as forces, vibrations, and motions, to the user.”); *see also* Rosenberg, Ex. 1006, discussed below, 1:53-55 (“In some interface devices, tactile and/or haptic feedback is also provided to the user, more generally known as ‘force feedback.’”).)

113. Braun explains that a force feedback effect or sensation can include vibrations having parameters defining the vibration effect. (Braun, 18:62-19:4.) “For example, a vibration force effect may have parameters of duration, frequency,

magnitude, and direction.” (Braun, 19:2-3; *see also id.*, 17:17-19 (“For example, the assigned force sensation **244** can be a vibration force having a specified frequency, magnitude, duration, etc.....”).) Figure 5 shows an exemplary user interface dialog box **240** showing various options that allow modification of these parameters, including the magnitude parameter, based on user input:

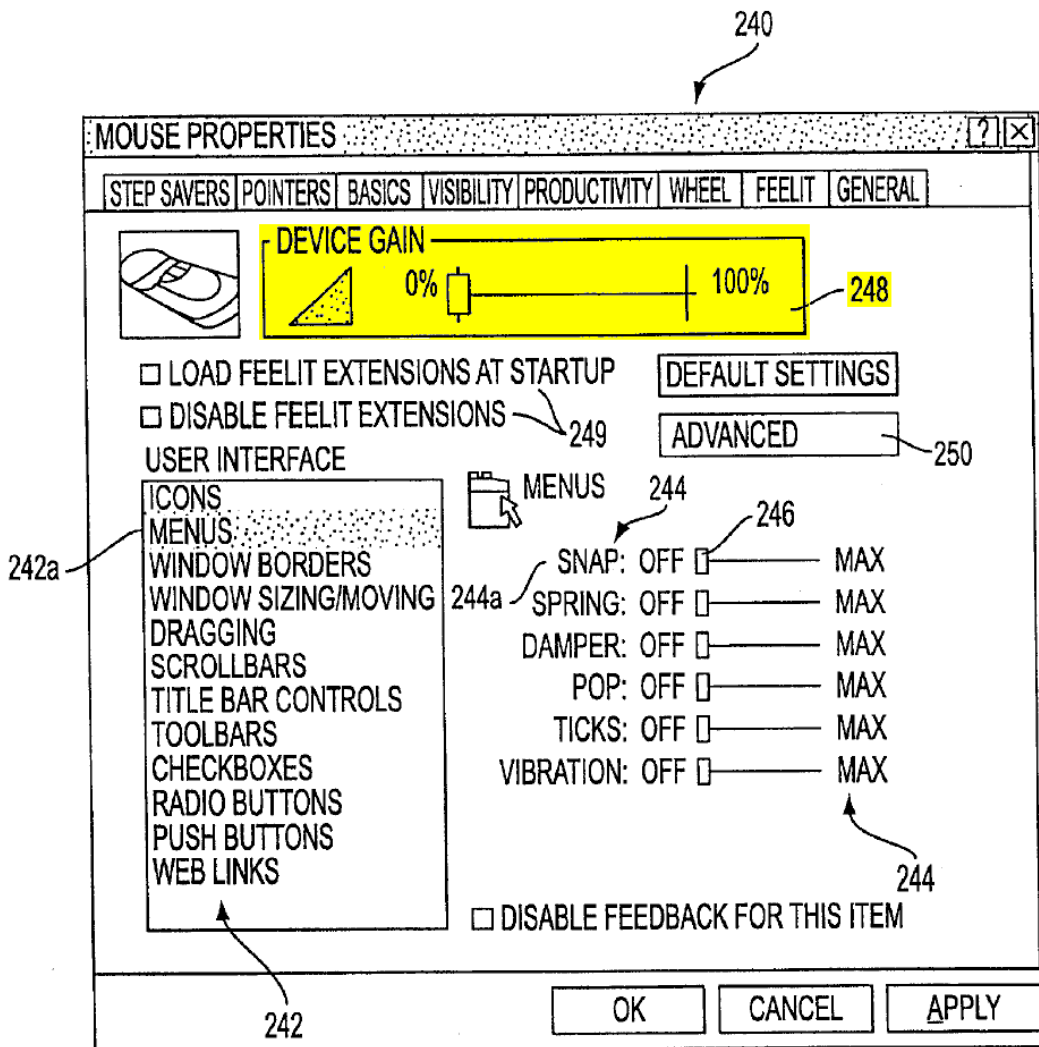


FIG. 5

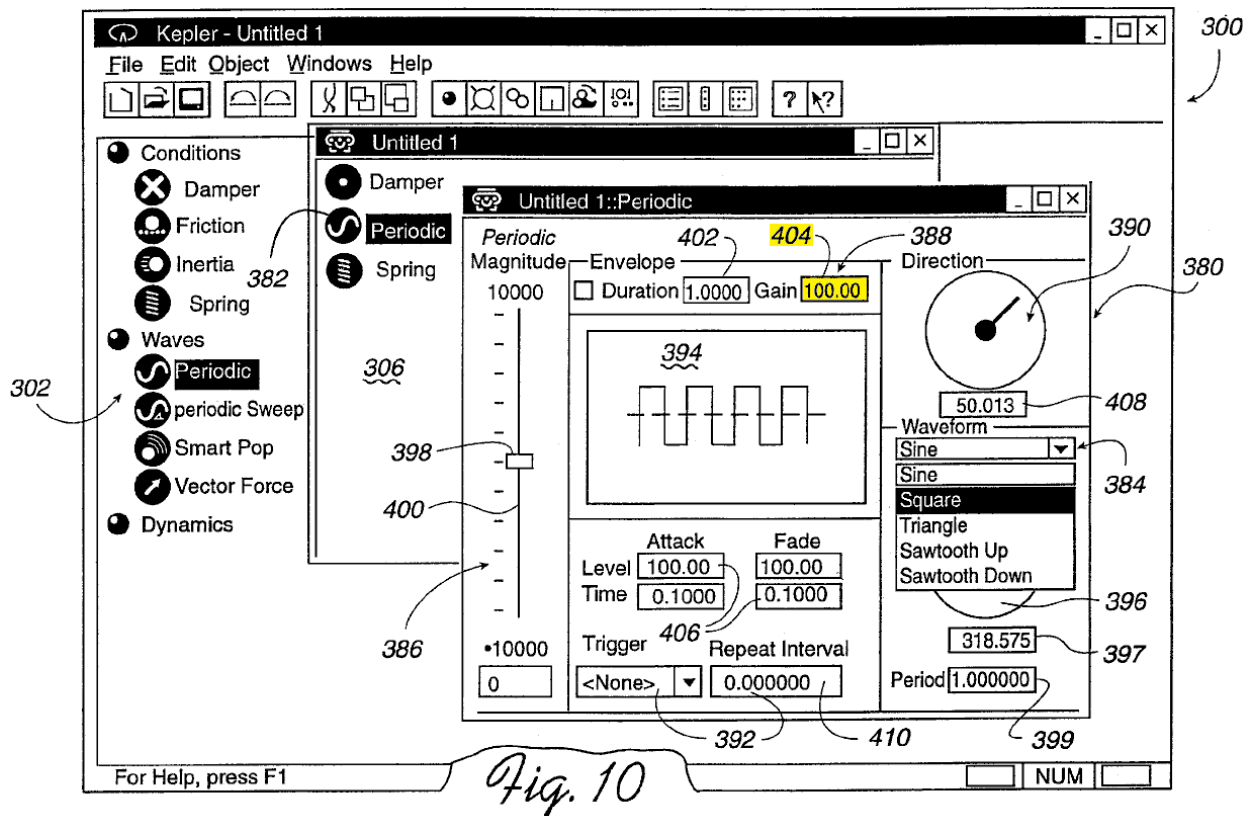
(Braun, Fig. 5 (highlighting added).) Dialog box **240** in Figure 5 shows a list of user interface objects **242** including icons, menus, among others. Each user interface object can have one or more associated force sensations or effects **244**, such as snap, spring, vibration, among others. Each force sensation or effect is also shown with an accompanying slider **246** ranging from “OFF” to “MAX,” which the user can move to the right to specify its magnitude. (Braun, 17:30-38, 17:53-57.) For example, as shown in Figure 5, the user is specifying the magnitude of the “SNAP” force effect **244a** for the “MENUS” user interface object **242a**. (Braun, 17:34-38.)

114. The key feature of Braun for purposes of **Ground 2** is the device gain **248** slider control shown in highlighting, which allows the user to globally adjust the magnitude of force sensations or effects for user interface objects between 0% and 100%. Braun explains that device gain **248** allows the user “to set the percentage of maximum magnitude for all the forces for items **242**....” (Braun, 18:62-65.)

115. **Rosenberg** discloses a similar feature. Rosenberg describes a tool for designing force sensations for use with a force feedback interface device, such as a computer mouse. (Rosenberg, Abstract.) Rosenberg is closely related to Braun, both having originated from Patent Owner and having two common named inventors. Braun also expressly incorporates-by-reference the disclosures of Rosenberg, and Braun’s disclosures relating to Figure 5 above also expressly

mention Rosenberg. (Braun, *e.g.*, 17:37-40, 18:8-14.)

116. Rosenberg discloses a similar user interface **300** for adjusting the parameters of force sensations or effects, including the magnitude:



(Rosenberg, Fig. 10 (highlighting added).) Figure 10 shows user interface **300** for modifying the parameters associated with a periodic wave sensation. (Rosenberg, 19:58-62.) Figure 10 shows a number of “[e]nvelope parameters **388** [that] allow the user to shape the waveform into a desired effect.” (Rosenberg, 20:18-19.) The key parameter shown here is field **404**, in highlighting, which performs a function similar to device gain **248** in Braun. As Rosenberg explains, this field is “a gain

field **404** (where ‘gain’ can be used as a global scaling factor or multiplier for force magnitudes output by the interface device **14**)....” (Rosenberg, 20:19-24.)

117. Braun and Rosenberg thus disclose “**modifying the one or more haptic parameters based on user input**,” *i.e.*, modifying at least the magnitude haptic parameter based on user input (for example through device gain **248** slider control of Braun or gain field **404** in Rosenberg).

118. *Rationale and Motivation to Combine (Ground 1 Prior Art with Braun and Rosenberg)*: It would have been obvious to combine the prior art cited for **Ground 1** (Poupyrev and Yun) with Braun and Rosenberg. The combination would have predictably resulted in the electronic device described for **Ground 1**, with the further ability to enable modification (based on user input) of a haptic parameter that defines the maximum magnitude for haptic effects. This, in turn, would have predictably resulted in modifying the magnitude parameter of the confirmation haptic effect delivered to the user. As explained for claim 1[a], the ’524 patent treats “magnitude” as synonymous with amplitude and intensity as disclosed in Poupyrev and Yun. The claimed “**user input**” could have been obtained using any number of well-known techniques, such as a slider control disclosed in Braun, a text field as disclosed in Rosenberg, or any number of other conventional techniques. The “**user input**” would have taken the form of a percentage value

provided by the user, as described in both Braun and Rosenberg, which would have defined “the percentage of maximum magnitude” (Braun, 18:62-65) for the confirmation haptic effect provided to the user. (*See also* Rosenberg, 14:2 (“... 50% magnitude”).)

119. Braun and Rosenberg are analogous references in the same field of the ’524 patent of devices that produce haptic effects. Both references disclose similar techniques for generating haptic effects (such as vibrations) in response to user interaction with a device, which can have adjustable parameters such as magnitude. These references would also have been reasonably pertinent to a number of problems facing the inventors, such as how to enable modification of one or more haptic parameters based on user input. And as noted, Braun refers to and incorporates-by-reference the disclosures of Rosenberg, thus confirming that they are analogous references and fully combinable with one other. (Braun, *e.g.*, 17:37-40, 18:8-14.)

120. The proposed combination would have provided a clear benefit to the system based on **Ground 1** – the ability of the user to customize the magnitude of haptic vibration effects provided through the electronic device. As explained in my discussion of claim 2 for **Ground 1**, it was well known that each user could have differed from other users in their ability to perceive haptic vibrations based on several factors including the user’s age, health, level of familiarity with the device,

surrounding environment, among others. Accordingly, a haptic vibration with an intensity appropriate for one user may have been too weak for another user, or too strong for yet another user. Allowing the user to modify the magnitude parameter, as disclosed in Braun and Rosenberg, would have provided a clear benefit to the proposed combination by affording a greater degree of user customization thus improving the effectiveness and comfort of haptic effects provided to the user.

121. An ordinarily skilled artisan would have had at least a reasonable expectation of success. Although Braun and Rosenberg disclose force feedback effects provided through a user input device such as a mouse or joystick, whereas Poupyrev and Yun disclose haptic effects provided through a touch screen display, an ordinarily skilled artisan would have found this difference to lack any significance. The terms “force feedback” and “haptic,” as noted, are synonymous in this context. Braun’s and Rosenberg’s focus on computer mouse and joystick devices is simply a by-product of the fact that their applications were filed in the 1990s, before touch screen displays capable of delivering haptic feedback effects were widely known and available to the public. By the August 2012 filing date of the ’524 patent, such devices were commonplace. Moreover, the vibration effects generated in Poupyrev/Yun and Braun/Rosenberg would have been generated using conventional devices such as actuators, and the ability to control the magnitude of

vibration effects was a well-known feature of conventional actuators. The ability to obtain user input on which to base such a modification would have involved nothing more than rudimentary programming techniques familiar to even beginning programmers, such as soliciting user input through a graphical user interface. An ordinarily skilled artisan would have found the disclosures of Poupyrev, Yun, Braun, and Rosenberg more than adequate to implement the teachings on which I rely in this Declaration, using conventional programming techniques and without having to resort to undue experimentation.

## 2. Claim 3

122. Claim 3 recites: “**The non-transitory computer-readable medium of claim 2, wherein the user input comprises one or more multipliers defined by the user; and wherein each value included for each of the one or more haptic parameters is based on the one or more multipliers.**” As explained for claim 2 above, the “**user input**” in Braun and Rosenberg corresponds to a percentage value provided by the user, for example through device gain 248 slider control of Braun, gain field 404 in Rosenberg, or other user input mechanism. It would have been obvious that a percentage value provided by a user “**comprises one or more multipliers defined by the user,**” and that at least a value of the magnitude haptic parameter is “**based on the one or more multipliers.**”

123. The term “**multiplier**,” as anyone familiar with arithmetic would have recognized, generally refers to a quantity or value by which another number (referred to as the multiplicand) is multiplied. (*See Microsoft Computer Dictionary* (5th ed. 2002), p.354 [EX1007] (“**multiplier** *n.* 1. In arithmetic, the number that indicates how many times another number (the multiplicand) is multiplied.”).) It would have been obvious that the percentage value provided by a user (“**user input**”) comprises a multiplier because it would have been used to scale the magnitude of haptic feedback effects that will be delivered to the user. For example, if the “**user input**” specified a maximum magnitude of 50% for vibration haptic effects, then the magnitude value corresponding to each haptic effect delivered to the user would have been multiplied (*e.g.*, by “0.5”) and thus delivered at a correspondingly reduced magnitude. Indeed, Rosenberg explicitly identifies the value in gain field 404 as a “**multiplier**.” (Rosenberg, 20:19-24 (“For example, parameters 388 preferably include... a gain field 404 (where ‘gain’ can be used as a global scaling factor or **multiplier** for force magnitudes output by the interface device 14)...”), 14:2 (“... 50% magnitude”).))

124. It therefore would have been obvious under the proposed combination that “**the user input comprises one or more multipliers defined by the user,**” *i.e.*, a percentage value provided by the user through the user interface, and that “**each**

**value included for each of the one or more haptic parameters is based on the one or more multipliers,”** *i.e.*, because the value of at least the magnitude haptic parameter is scaled based on the percentage value defined by the user, *e.g.*, by multiplying the value associated with the magnitude parameter by the percentage multiplier to calculate a haptic parameter for the magnitude of the confirmation haptic effect.

### 3. Claim 4

125. Claim 4 recites: “**The non-transitory computer-readable medium of claim 3, wherein the one or more multipliers are globally defined for all user interface elements.**” This further limitation is disclosed and rendered obvious by Braun which, as discussed above, discloses device gain **248** slider control. Figure 5 of Braun discussed above shows that the value provided by the user for device gain **248** applies to all of user interface objects **242** and all force feedback effects or sensations **244**. (Braun, 17:62-64 (“Other controls in box **240** include a device gain **248** to set the percentage of maximum magnitude for all the forces for items **242**....”).) Rosenberg similarly discloses the value in gain field **404** as “a global scaling factor or multiplier for force magnitudes output by the interface device **14**.... (Rosenberg, 20:19-23.) Under the proposed combination, therefore, it would have been obvious to implement the system based on Poupyrev and Yun such that the

percentage value provided by the user (“**the one or more multipliers**”) applied globally to all GUI objects (“**all user interface elements**”).

126. The motivation to implement the proposed combination in this manner flows directly from my observation made earlier that each user could have differed from other users in their ability to perceive haptic vibrations based on several factors. It would have been obvious and beneficial to apply the user’s preference regarding the maximum magnitude of haptic feedback effects across all GUI objects, in order to provide greater uniformity and consistency in the haptic effects delivered to the user across all features of the electronic device. This would, in turn, have resulted in an improvement to the effectiveness and comfort of haptic effects provided to the user across all GUI objects presented on the touch screen display.

## **VI. NO SECONDARY CONSIDERATIONS OF NONOBVIOUSNESS**

127. As explained in **Part III.B**, I understand that “secondary considerations” may be used as indicia of nonobviousness, provided that any such consideration has a nexus to the invention claimed. I understand from Petitioner’s counsel that Patent Owner in the related district court litigation has not yet identified any evidence related to secondary considerations with a nexus to the claimed invention. Nor am I aware of information, such as commercial success, unexplained results, long felt but unsolved need, industry acclaim, simultaneous invention,

Declaration of Jeremy Cooperstock, Ph.D. in Support of  
Petition for *Inter Partes* Review of  
U.S. Patent No. 8,896,524 B2

copying by others, skepticism by experts in the field, and failure of others, suggesting that the claims addressed in this Declaration are not obvious. To the extent Patent Owner later provides information it claims relates to secondary considerations, I reserve the right to supplement my analysis and opinions to comment on it.

## VII. CONCLUSION

128. In signing this Declaration, I recognize that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in this proceeding. If required, I will appear for cross-examination at the appropriate time. I reserve the right to offer opinions relevant to the invalidity of the patent claims at issue and/or offer testimony in support of this Declaration.

129. I hereby declare that all statements made herein of my own knowledge are true and that all statements are made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

Dated: May 22, 2023

. Respectfully submitted,

A handwritten signature in black ink, appearing to read 'Jeremy Cooperstock', written over a horizontal line.

Jeremy Cooperstock  
Paris, France

# EXHIBIT A

# CURRICULUM VITAE

Jeremy R. Cooperstock  
Version as of December 22, 2022

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## BIOGRAPHICAL

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### EDUCATION

**Ph.D.** Electrical and Computer Engineering, University of Toronto, 1996.  
Thesis: "Reactive Environments and Augmented Media Spaces."  
(Nominated for NSERC Doctoral Dissertation Award)  
Advisors: Prof. K.C. Smith and Prof. W. Buxton

**M.Sc.** Computer Science, University of Toronto, 1992.  
Thesis: "Neural Network Operated Vision-Guided Mobile Robot Arm  
for Docking and Reaching." Advisor: Prof. E. Milios.

**B.A.Sc.** Electrical Engineering, Computer Engineering Option, University of  
British Columbia, 1990 (Honours)

## AWARDS AND DISTINCTIONS

|            |                                                                                                                                                                                                         |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2022       | Honorable Mention, “The Sound of Hallucinations: Toward a more convincing emulation of internalized voices” (top 5% of papers), Human Factors in Computing Systems (CHI) [C2]                           |
| 2022       | Finalist, Best Applications Paper Award, “Speaking Haptically: from Phonemes to Phrases with a Mobile Haptic Communication System”, Transactions on Haptics [J2]                                        |
| 2019       | Honorable Mention, “Detecting Perception of Smartphone Notifications using Skin Conductance Responses” (top 5% of papers), Human Factors in Computing Systems (CHI) [C31]                               |
| 2019       | San Diego Opera, Opera Hack award, Hamsafar! (\$10,000, with 5 co-awardees)                                                                                                                             |
| 2018       | Best poster presentation award, “Enhanced Pressure-Based Multi-modal Immersive Experiences”, Augmented Human [CP9]                                                                                      |
| 2015       | Gerald W. Farnell Teaching Scholar, Faculty of Engineering (\$12,500)                                                                                                                                   |
| 2014       | US Ignite Best App in Education, <a href="#">Augmented Reality for Improved Training of First Responders</a>                                                                                            |
| 2013       | Canadian National Institute for the Blind, Hochhausen Access Technology Research Award (\$10,000)                                                                                                       |
| 2013       | Best paper award, “Vibrotactile Rendering of Splashing Fluids”, Transactions on Haptics [J15]                                                                                                           |
| 2013       | Best use of sound award, “The Walking Straight Mobile Application: Helping the Visually Impaired Avoid Veering, International Conference on Auditory Displays [C58]                                     |
| 2012       | Mozilla Foundation and NSF Gold Prize in the Mozilla Ignite Challenge (out of 305 submissions in the Brainstorming Round) (\$5,000) for <a href="#">Real-Time Emergency Response</a>                    |
| 2012       | Canadian Internet Registry Association .CA Impact Award (Applications category) for In-Situ Audio Services Project (\$5,000)                                                                            |
| 2011       | Best paper award, “What’s around me? Spatialized audio augmented reality for blind users with a smartphone”, Mobile and Ubiquitous Systems [C69]                                                        |
| 2010       | Best paper award, “Design of a Vibrotactile Display via a Rigid Surface”, Haptics Symposium [C78]                                                                                                       |
| 2009, 2010 | Nominee, NSERC Brockhouse Canada Prize                                                                                                                                                                  |
| 2009       | Best paper award, “SoundPark: Exploring Ubiquitous Computing through a Mixed Reality Multi-player Game Experiment”, 9e Conférence Internationale sur Les NOuvelles TEchnologies de la REpartition [C88] |
| 2005       | ACM/IEEE Supercomputing, Most Innovative Use of New Technology for <a href="#">Wide Screen Window on the World: Life Size HD Videoconferencing</a>                                                      |
| 2001       | Audio Engineering Society Citation Award for <a href="#">pioneering the technology enabling collaborative multichannel performance over the broadband internet</a>                                      |

## WORK EXPERIENCE

### CAREER HIGHLIGHTS

**Haptic Information Delivery** (2018-2021) My lab's haptics research has resulted in prominent visibility in the preeminent journal, IEEE Transactions on Haptics, and the two top-tier international conferences in the field, IEEE Haptics Symposium and IEEE World Haptics Conference, with a dozen publications in these forums between 2020 and 2021. Given my recognition in the field, I was invited to serve on the editorial boards of all of these bodies, in addition to the specialty section on haptics of the Frontiers Journal in Virtual Reality. Specific examples of significant contributions include the performance attained through use of our two-actuator apparatus and phonemic encoding for tactile communication of natural language [C28, J2, C6], which outperformed the previously cited best results on this task, achieved by Facebook Research Labs. A second contribution relates to the high recognition rates we attained for multi-dimensional tacton delivery (3 parameters, each at 3 levels), targeting clinical patient-monitoring scenarios. This work inspired studies of wearable vibrotactile devices for physiological monitoring of patients [C27, C16]. While our results were achieved initially using a set of three actuators [C40, C37, C29, C19], we subsequently demonstrated equivalent recognition performance via only a single vibrotactile actuator, with a novel parameter encoding scheme [C18]. We further demonstrated achievement of the highest information transfer rates reported in the literature for such a single-actuator device [C13].

**Physiological Sensing** (2017-2020) Our research for detection of smartphone notifications was recognized by an Honourable Mention (top 5% of papers) from the top-tier ACM Conference on Human Factors in Computing ([C31]), and led to a recent patent filing ([P2]). This work has the potential to serve as not only for more intelligent, context-sensitive notification delivery, but also, as a tool that can be exploited to combat the prevalent and adverse effects of Internet addiction, driven largely by “fear of missing out.”

**Real-Time Emergency Response (rtER)** (2012-2013) provides an envisionment of the future of next-generation 911 (NG-911) technologies, supporting enhanced situational awareness for first responders through the use of citizen-supplied smartphone video streams and other relevant data [J13]. Our work was recognized by the *Gold Prize* from the Mozilla Ignite Fund, featured on the web site of the White House Office of Science and Technology, and prompted the launch of a funding program by the U.S. Department of Justice.

**Autour** (2009-2018) is an “eyes-free” app for the blind, which provides a rich, spatialized audio representation of one's environment [J21, C69, C60, C57]. The project further motivated a rigorous analysis of smartphone sensor reliability, resulting in what was the first comprehensive examination of practical limits on smartphone sensors, including the problems of gyro drift [C60].

**Mobile Treatment Device for Amblyopia** (2009-2012, in collaboration with ophthalmologist R. Hess) is a patented prototype Mobile Treatment Device for Amblyopia [P7] (“lazy eye”). Initial trials [J20], based on the popular Tetris game, provided highly promising early results [J27, J23], not only restoring the use of both eyes in a majority of patients but even resulting in binocular (3D) depth perception in some. Most significantly, the treatment has been found to work successfully

on adult populations, whereas the prevailing wisdom had been that treatment was only possible on children. The technology has now been acquired by Novartis, who are commercializing the system.

**Natural Interactive Walking** (2008-2017) investigated multimodal interaction with virtual ground surfaces, resulting in important findings of tactile discrimination ability [J22] and the role of vibrotactile stimulation in perception of compliance [J28]. Our “Ecotile” prototype (patent [P4]) was showcased at numerous venues including SIGGRAPH, and led to related research involving limb modeling [C71, C55, C49], foot-water interaction [J15], and variable-friction walking interfaces [C65, C56, J6].

**Ultra-Videoconferencing** (2002-2006) is our low-latency, high-fidelity network transport, used for distance music teaching with Maestro Pinchas Zuckerman, cross-continental jazz jams, and remote sign language interpretation. The *Globe and Mail* described Cooperstock’s 2001 demonstration as “a watershed event for the elite club of the world’s computer network engineers.” Ultra-Videoconferencing garnered my research group a prestigious Citation Award from the Audio Engineering Society and the Award for Most Innovative Use of New Technology from ACM/IEEE Supercomputing (2005). This research directly constituted the basis for subsequent funding of \$2.2M from Valorisation Recherche Quebec and over \$4M from Canarie, and influenced the designs of similar telepresence videoconferencing systems from Cisco, HP, and Polycom. Our follow-up work on **Open Orchestra** (with HQP N. Bouillot, A. Olmos, T. Knight, M. Tomiyoshi), resulted in an immersive simulator for orchestral training, used by professional and semi-professional musicians [J19].

## ACADEMIC EXPERIENCE

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Jan 2018–present</b>  | <b>McGill University, Montreal, QC</b><br>Full Professor, Electrical and Computer Engineering.<br>Director, Shared Reality Lab<br>Member, McGill Institute for Aerospace Engineering<br>Member, International Laboratory on Learning Systems<br>Associate Member, Faculty of Music, Department of Theory<br>Founding Member, Centre for Interdisciplinary Research in Music, Media and Technology<br>Member, Centre for Intelligent Machines |
| <b>Feb 2022–present</b>  | <b>York University, Ontario</b><br>Affiliate Member, Vision: Science to Applications (VISTA)                                                                                                                                                                                                                                                                                                                                                 |
| <b>Sep 2018–Jun 2019</b> | <b>Technion–Israel Institute of Technology, Haifa, Israel</b><br>Visiting Professor, Industrial Engineering and Management                                                                                                                                                                                                                                                                                                                   |
| <b>Sep 2018–Jun 2019</b> | <b>IDC, Herzliya, Israel</b><br>Visiting Professor, Department of Computer Science                                                                                                                                                                                                                                                                                                                                                           |
| <b>May 2003–Dec 2017</b> | <b>McGill University, Montreal, QC</b><br>Associate Professor, Electrical and Computer Engineering                                                                                                                                                                                                                                                                                                                                           |
| <b>Aug 2011–Jul 2012</b> | <b>University of Auckland, New Zealand</b><br>Invited Professor, Department of Computer Science                                                                                                                                                                                                                                                                                                                                              |
| <b>May–June 2009</b>     | <b>Bang &amp; Olufsen, Denmark</b><br>Visiting Professor, World Opera Project                                                                                                                                                                                                                                                                                                                                                                |
| <b>Jan 2009–present</b>  | <b>Bielefeld University, Germany</b><br>Virtual Member, Center of Excellence Cognitive Interaction Technology (CITEC)                                                                                                                                                                                                                                                                                                                        |
| <b>Feb 2008</b>          | <b>Arizona State University</b><br>Visiting Scholar, School of Arts, Media and Engineering                                                                                                                                                                                                                                                                                                                                                   |
| <b>Sep 2004–Aug 2005</b> | <b>Université de Paris VI, Paris France</b><br>Invited Professor, Laboratoire des Instruments et Systemes d'Ile-de-France                                                                                                                                                                                                                                                                                                                    |
| <b>Nov 1997–May 2003</b> | <b>McGill University, Montreal, QC</b><br>Assistant Professor, Electrical and Computer Engineering.                                                                                                                                                                                                                                                                                                                                          |

## INDUSTRIAL AND CONSULTING EXPERIENCE

|                           |                                                                                                                                                                                                                                              |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Sep 2019–Oct 2021</b>  | <b>RedPill Canada VR, Montreal</b><br>Director and Advisor                                                                                                                                                                                   |
| <b>Apr–Jun 2019</b>       | <b>(Confidential project as consulting expert)</b><br>Providing expert report on topics concerning Human-Computer Interaction.                                                                                                               |
| <b>Aug–Nov 2014</b>       | <b>Menya Solutions and DRDC-Valcartier</b><br>Providing expert advice related to human-computer interfaces, visualization, and collaboration.                                                                                                |
| <b>Aug 2012</b>           | <b>Tamaggo Inc.</b><br>Provide guidance and advice on digital imagery                                                                                                                                                                        |
| <b>May 2012</b>           | <b>York University</b><br>Review draft application to Canada Excellence Research Chairs program                                                                                                                                              |
| <b>May 2002 –Nov 2003</b> | <b>Solicitor General of Canada</b><br>Media streaming configuration and user interface design.                                                                                                                                               |
| <b>May 2001</b>           | <b>National Research Council</b><br>Instructor of short course in Soft Computing, Institut des Matériaux Industriels.                                                                                                                        |
| <b>Jan–Sep 1999</b>       | <b>Audio Engineering Society</b><br>Technical leader of demonstration of multichannel and multimedia audio distribution                                                                                                                      |
| <b>Jan–Aug 1999</b>       | <b>Ontario Science Center</b><br>Scientific Director of Timescape Millenium Exhibit                                                                                                                                                          |
| <b>Jul 1998</b>           | <b>Nortel</b><br>Instructor of short course in videoconferencing systems for the Nortel International SL-1 User's Association (ILUA), Long Beach                                                                                             |
| <b>Sep 1996–Oct 1997</b>  | <b>Sony Computer Science Laboratory</b><br>Visiting Researcher, Sony Computer Science Laboratory, Tokyo, Japan. Developed speech-interface controlled VCR with visual tape database functionality. Wrote two patent applications, one filed. |
| <b>Jun–Aug 1990</b>       | <b>Fibronics Research</b><br>Visiting Researcher, Fibronics Advanced Research Center, Haifa, Israel. Developed and tested an FDDI-to-token ring bridge.                                                                                      |
| <b>May–Aug 1989</b>       | <b>IBM T.J. Watson Research Center</b><br>Research Intern, IBM T.J. Watson Research Center, Yorktown Heights, NY. Improved implementation of a VLIW architecture simulator.                                                                  |

## LITIGATION AND EXPERT WITNESS EXPERIENCE

*Parties I represented are marked by an asterisk.*

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| Sep 2022–ongoing  | <b>Apple* v. Taction Technologies, Inc</b><br>Involved in <i>Reexamination Requests</i> of U.S. Patent Nos. 10,659,885 and 10,820,117 in the United States Patent and Trademark Office.                                                                                                                                                       |
| Aug 2022–ongoing  | <b>Westwood One, LLC v. Local Radio Networks, LLC*</b><br>United States District Court, Northern District of Indiana, Case No. 1:21-cv-00088-HAB-SLC. Involved in litigation matters related to U.S. Patent Nos. 7,412,203 and 7,860,448                                                                                                      |
| Jan–May 2022      | <b>iFIT Inc. f/k/a ICON Health &amp; Fitness* v. Peloton Interactive</b><br>United States District Court, District of Delaware, Civil Action No. 20-cv-1386-RGA                                                                                                                                                                               |
| Sep 2021–ongoing  | <b>Brazos* v. Google</b><br>United States District Court, Western District of Texas Waco Division, Case Nos. 6:20-CV-00571-ADA through 6:20-CV-00585-ADA                                                                                                                                                                                      |
| Sep 2021–ongoing  | <b>AmLaw 100 Firm*</b><br>Providing independent expert consulting services for an AmLaw 100 Firm on behalf of an owner of patents covering smartphone-based vehicle operation detection. Deposition testimony on expert report.                                                                                                               |
| Jan 2021–ongoing  | <b>GUI Global Products, Ltd. v. Apple*</b><br>United States District Court, Southern District of Texas, Case No. 4:20-cv-2652 and <i>Inter Partes</i> Review of U.S. Patent Nos. 10,259,020, 10,259,021, 10,562,077, and 10,589,320 in the United States Patent and Trademark Office. Deposition testimony on expert report (2 depositions)   |
| Dec 2020–Feb 2021 | <b>Expert consultation re possible litigation in IT-related matter</b><br>Work done on behalf of Sheridan Ross P.C.                                                                                                                                                                                                                           |
| Nov 2020–ongoing  | <b>Koss v. Apple*</b><br>Civil Action No. 6:20-cv-00665, Western District of Texas. Involved in <i>Inter Partes</i> Review of U.S. Patent Nos. 10,206,025, 10,469,934, 10,506,325, 10,491,982, and 10,298,451 before the United States Patent and Trademark Office. Deposition testimony on expert reports (4 depositions).                   |
| Oct 2020–Oct 2021 | <b>ByteDance* and TikTok* v. Triller</b><br><i>Inter Partes</i> Review of U.S. Patent No. 9,691,429 before the United States Patent and Trademark Office. Deposition testimony on expert report.                                                                                                                                              |
| Sep 2020–ongoing  | <b>Content Square v. Quantum Metric* and Decibel Insight*</b><br>United States District Court, Massachusetts District Court, Case No. 1-20-cv-11184 and Delaware District Court, Case No. 20-cv-00832. Involved in invalidity arguments and petitions for <i>Inter Partes</i> Review. Deposition testimony on expert reports (5 depositions). |

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| Sep 2020–ongoing  | <b>Wiesel v. Apple*</b><br>United States District Court, Eastern District of New York, Case No. 1:19-cv-7261. Engaged for source code review of products related to the Apple Watch (case presently stayed).                                                                                                                                                                                                             |
| Aug–Oct 2020      | <b>Finish Time* v. Garmin</b><br>United States District Court, District of Maine, Case No. 2:20-cv-00184. Involved in review of infringement arguments, discovery, related to fitness applications.                                                                                                                                                                                                                      |
| Dec 2019–Nov 2022 | <b>Pinn v. Apple*</b><br>United States District Court, Central District of California, Case No. 8:19-cv1805, <i>Inter Partes</i> Review IPR2020-00999, Post Grant Review PGR2020-00066 and PGR2020-00073. Involved in preparation of expert witness declarations, code analysis involving multiple products related to earbuds and charging circuitry. Deposition testimony on expert reports, in-court trial testimony. |
| Oct 2019          | <b>Apple* v. Qualcomm</b><br><i>Inter Partes</i> Review, Case no. IPR2018-01279. Deposition testimony on expert witness declaration related to multimedia messaging.                                                                                                                                                                                                                                                     |
| Mar 2019–Feb 2022 | <b>Cruz Hernandez* v. Air Canada and Lufthansa</b><br>Canadian Transportation Agency Case no. 20-01712, Petitioner before the Agency regarding passengers' rights to compensation under EC 261/2014                                                                                                                                                                                                                      |
| May 2018–May 2019 | <b>Samsung* v. Immersion</b><br>Civil Action No. 2:2018-cv-00055 in the Eastern District of Texas and <i>Inter Partes</i> Review, case no. IPR2018-01499. Consulted on technical details and involved in preparation of two expert witness declarations related to haptic feedback effects and force feedback in a multimodal system.                                                                                    |
| May 2016–Nov 2017 | <b>Cooperstock* v. Air Canada</b><br>Petitioner before the Canadian Transportation Agency. Brought successful complaint against Air Canada for the airline's making false or misleading statements to the public, Decision No. 105-C-A-2017 ( <a href="https://otc-cta.gc.ca/eng/ruling/105-c-a-2017">otc-cta.gc.ca/eng/ruling/105-c-a-2017</a> )                                                                        |
| Jan–May 2014      | <b>St. Lewis v. Rancourt*</b><br>Provided expert report on web server location, Ontario Superior Court File No. 11-51657                                                                                                                                                                                                                                                                                                 |
| Mar–Sep 2013      | <b>Cooperstock* v. United Airlines</b><br>Brought and argued successful appeal regarding anti-SLAPP legislation before the Quebec Court of Appeal, Decision 2013 QCCA 1670 ( <a href="https://goo.gl/pgz301">goo.gl/pgz301</a> ). Argued appeal in person (September 26, 2013)                                                                                                                                           |
| Nov 2012–Aug 2017 | <b>United Airlines v. Cooperstock*</b><br>Pro se litigant, Federal Court File No. T-2084-12. Deposition as litigant (August 2013) and testified at trial (December 2016).                                                                                                                                                                                                                                                |

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| <b>Nov 2012–Jan 2017</b> | <b>United Airlines v. Cooperstock*</b><br>Pro se litigant, Quebec Superior Court File No. 500-17-074743-124.<br>Deposition as litigant (October 2014) and testified at trial (April 2016).                       |
| <b>Sep 2012</b>          | <b>Lukács* v. Air Canada</b><br>Provided expert report on database query and execution times, Canadian Transportation Agency File No. M4120-3/11-06673, Decision No. 204-C-A-2013                                |
| <b>May 2007–Jan 2008</b> | <b>Market Maker c. Brim Solutions*</b><br>Provided expert witness report and in-court testimony (October 2007) on software-related intellectual property case. Quebec Superior Court File No. 500-17-036750-076. |
| <b>Feb–Oct 2004</b>      | <b>Crawford Adjusters Canada</b><br>Provided analysis of artifacts in high definition video                                                                                                                      |
| <b>Jul 2002–May 2016</b> | <b>Court of Quebec, Small Claims Division</b><br>Brought 14 consumer rights complaints before the Court, 11 of which were successful                                                                             |

## RESEARCH DISSEMINATION

*Notes on publication strategy: In my research field, papers in the ACM CHI (H5-index=87), UIST (H5-index=46), DIS (H5-index=33), and Mobile HCI (H5-index=28) conferences are considered to be top-tier, archival publications, competitive with the top HCI journals in terms of impact and visibility. Overall acceptance rates for these conferences are typically in the 20-25% range. As a measure of research impact, my publications have garnered over 5000 citations to date (Google Scholar) with approximately half of these since 2017, an h-index of 36, and i10-index of 105. HQP under my supervision (names in bold) are typically given first authorship on co-authored work.*

## ARTICLES IN REFEREED PUBLICATIONS

- [J1] **Nathan Duarte**, R. K. Arora, G. Bennett, M. Wang, M. P. Snyder, J. R. Cooperstock, and C. E. Wagner. “Deploying wearable sensors for pandemic mitigation: a counterfactual modelling study of Canada’s second COVID-19 wave.” In: *PLOS Digital Health* PDIG-D-22-00126R1 (Sept. 2022). DOI: <https://doi.org/10.1371/journal.pdig.0000100>. URL: <https://journals.plos.org/digitalhealth/article?id=10.1371/journal.pdig.0000100>.
- [J2] **M. F. de Vargas**, **D. Marino**, **A. Weill–Duflos**, and J. R. Cooperstock. “Speaking Haptically: from Phonemes to Phrases with a Mobile Haptic Communication System.” In: *Transactions on Haptics* 14.3 (July 2021), pp. 479–490. DOI: [10.1109/TOH.2021.3054812](https://doi.org/10.1109/TOH.2021.3054812). URL: <https://ieeexplore.ieee.org/document/9337220>. 🏆 Finalist, Best Applications Paper Award.
- [J3] **P. Vyas**, **F. Al-Taha**, **J. R. Blum**, **A. Weill–Duflos**, and J. R. Cooperstock. “Ten Little Fingers, Ten Little Toes: Can Toes Match Fingers for Haptic Discrimination?” In: *Transactions on Haptics* 13.1 (2020). DOI: [10.1109/TOH.2020.2966969](https://doi.org/10.1109/TOH.2020.2966969). URL: <https://ieeexplore.ieee.org/document/8960637>. Also presented at Haptics Symposium 2020.
- [J4] **E. Sulmont**, E. Patitsas, and J. R. Cooperstock. “What Is Hard About Teaching Machine Learning to Non-Majors? Insights From Classifying Instructors’ Learning Goals.” In: *Transactions on Computing Education, Special Issue on Machine Learning Education* 19.4 (Aug. 2019). URL: <http://dl.acm.org/authorize?N682238>.
- [J5] **J. Blum**, **P. Fortin**, **F. Al-Taha**, **P. Alirezaee**, **M. Demers**, **A. Weill–Duflos**, and J. R. Cooperstock. “Getting Your Hands Dirty Outside the Lab: A Practical Primer for Conducting Wearable Vibrotactile Haptics Research.” In: *IEEE Transactions on Haptics, Special Issue on Wearable and Hand-held Haptics* 12.3 (July 2019), pp. 232–246. DOI: [10.1109/TOH.2019.2930608](https://doi.org/10.1109/TOH.2019.2930608). URL: <https://ieeexplore.ieee.org/document/8770138>.
- [J6] **G. Millet**, **M. Otis**, **D. Horodniczy**, and J. R. Cooperstock. “Design of Variable-Friction Devices for Shoe-Floor Contact.” In: *Mechatronics* 46 (2017), pp. 115–125. URL: <https://www.sciencedirect.com/science/article/abs/pii/S0957415817301034>.

- [J7] **P. Fortin** and J. R. Cooperstock. “Laughter and Tickles: Toward Novel Approaches for Emotion and Behavior Elicitation.” In: *IEEE Transactions on Affective Computing* 8.4 (2017). TAFFCSI-2016-07-0124.R1, pp. 508–521. URL: <http://ieeexplore.ieee.org/document/8052511/>.
- [J8] E. Aguilera, J. J. Lopez, and J. R. Cooperstock. “Spatial Audio for Audioconferencing in Mobile Devices: Investigating the Importance of Virtual Mobility and Private Communication and Optimizations.” In: *Journal of the Audio Engineering Society* 64.5 (May 2016), pp. 332–341. URL: <http://www.aes.org/e-lib/browse.cfm?elib=18138>.
- [J9] **D. El-Shimy** and J. R. Cooperstock. “User-Driven Techniques for the Design and Evaluation of New Musical Interfaces.” In: *Computer Music Journal* 40.2 (2016), pp. 35–46. URL: [http://www.mitpressjournals.org/doi/pdf/10.1162/COMJ\\_a\\_00357](http://www.mitpressjournals.org/doi/pdf/10.1162/COMJ_a_00357).
- [J10] **F. Tordini**, A. Bregman, and J. R. Cooperstock. “Prioritizing foreground selection of natural chirp sounds by tempo and spectral centroid.” In: *Multimodal User Interfaces, Special Issue on Auditory Display* 10.3 (Sept. 2016). Ed. by B. Katz and G. Marentakis, pp. 221–234. URL: <http://link.springer.com/article/10.1007%2Fs12193-016-0223-x>.
- [J11] R. F. Hess, **L. To**, J. Zhou, **G. Wang**, and J. Cooperstock. “3D Vision: the haves and havenots.” In: *i-Perception* 6.3 (July 2015). DOI: [10.1177/2041669515593028](https://doi.org/10.1177/2041669515593028). URL: <http://ipe.sagepub.com/content/6/3/2041669515593028.full.pdf+html>.
- [J12] **N. Hieda** and J. R. Cooperstock. “Digital Facial Augmentation for Interactive Entertainment.” In: *EAI Endorsed Transactions on e-Learning* 15.8 (Aug. 2015). DOI: [10.4108/icst.intetain.2015.259444](https://doi.org/10.4108/icst.intetain.2015.259444).
- [J13] **J. Blum**, **A. Eichhorn**, **S. Smith**, **M. Sterle-Contala**, and J. R. Cooperstock. “Real-Time Emergency Response: Improved Management of Real-Time Information During Crisis Situations.” In: *Multimodal User Interfaces* 8.2 (July 2014). JMUI-D-13-00047R3, pp. 161–173. DOI: [10.1007/s12193-013-0139-7](https://doi.org/10.1007/s12193-013-0139-7). URL: <http://www.springer.com/alert/urltracking.do?id=L4b94d11Mf77f37Sb05893a>.
- [J14] **D. Dansereau**, N. Brock, and J. R. Cooperstock. “A Particle Filter for Predicting an Orchestral Conductor’s Baton Movements.” In: *Computer Music J.* 37.2 (Apr. 2013), pp. 28–45. URL: [http://www.mitpressjournals.org/doi/pdf/10.1162/COMJ\\_a\\_00173](http://www.mitpressjournals.org/doi/pdf/10.1162/COMJ_a_00173).
- [J15] **G. Cirio**, M. Marchal, A. Lécuyer, and J. R. Cooperstock. “Vibrotactile Rendering of Splashing Fluids.” In: *Transactions on Haptics* 6.1 (May 2013), pp. 117–122. URL: [http://ieeexplore.ieee.org/xpls/abs\\_all.jsp?arnumber=6226398](http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6226398). 🏆 Best paper award.
- [J16] F. Grond, **A. Olmos**, and J. Cooperstock. “Making Sculptures Audible through Participatory Sound Design (Artists’ statement).” In: *Leonardo Music J.* 23 (Dec. 2013), pp. 12–13. DOI: [doi:10.1162/LMJ\\_a\\_00140](https://doi.org/10.1162/LMJ_a_00140). URL: <http://srl.mcgill.ca/publications/2013-LEONARDO.pdf>.
- [J17] **J. Blum**, **M. Bouchard**, and J. R. Cooperstock. “Spatialized audio environmental awareness for blind users with a smartphone.” In: *Mobile Networks and Applications* 18.3 (June 2013), pp. 295–309. DOI: [10.1007/s11036-012-0425-8](https://doi.org/10.1007/s11036-012-0425-8). URL: <http://srl.mcgill.ca/publications/2012-MONET.pdf>.

- [J18] **S. Pelletier** and J. R. Cooperstock. “Real-time free viewpoint video from a range sensor and color cameras.” In: *Machine Vision and Applications* 24.4 (May 2013), pp. 739–751. URL: <http://link.springer.com/article/10.1007%2Fs00138-012-0428-2>.
- [J19] **A. Olmos**, **N. Bouillot**, **T. Knight**, **N. Mabire**, **J. Redel**, and J. R. Cooperstock. “A High-Fidelity Orchestra Simulator for Individual Musicians’ Practice.” In: *Computer Music Journal* 36.2 (2012), pp. 55–73. URL: [http://www.mitpressjournals.org/doi/pdf/10.1162/COMJ\\_a\\_00119](http://www.mitpressjournals.org/doi/pdf/10.1162/COMJ_a_00119).
- [J20] J. M. Black, R. F. Hess, J. R. Cooperstock, **L. To**, and B. Thompson. “The measurement and treatment of suppression in amblyopia.” In: *Visualized Experiments* 14.70 (Dec. 2012). DOI: [10.3791/3927](https://doi.org/10.3791/3927). URL: <http://www.jove.com/video/3927/the-measurement-and-treatment-of-suppression-in-amblyopia>.
- [J21] **D. El-Shimy**, F. Grond, **A. Olmos**, and J. R. Cooperstock. “Eyes-Free Environmental Awareness for Navigation.” In: *Multimodal User Interfaces, Special Issue on Interactive Sonification* 5.3-4 (2012), pp. 131–141. DOI: [10.1007/s12193-011-0065-5](https://doi.org/10.1007/s12193-011-0065-5). URL: <http://www.springerlink.com/content/857h542884084ql2/>.
- [J22] B. L. Giordano, **Y. Visell**, H. Yao, V. Hayward, J. R. Cooperstock, and S. McAdams. “Identification of walked-upon materials in auditory, kinesthetic, haptic and audio-haptic conditions.” In: *Acoustical Society of America* 131.5 (May 2012). URL: <http://srl.mcgill.ca/publications/2012-JASA.pdf>.
- [J23] R. F. Hess, B. Thompson, J. M. Black, G. Maehara, P. Zhang, W. R. Bobier, **L. To**, and J. R. Cooperstock. “An iPod treatment for amblyopia: An updated binocular approach.” In: *Optometry* 83.2 (Feb. 2012), pp. 87–94. URL: <http://www.ncbi.nlm.nih.gov/pubmed/23231369>.
- [J24] **S. Pelletier** and J. R. Cooperstock. “Preconditioning for Edge-Preserving Image Super-Resolution.” In: *IEEE Transactions on Image Processing* 21.1 (June 2012), pp. 67–79. URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5898412>.
- [J25] **Z. Qi** and J. R. Cooperstock. “Toward Dynamic Image Mosaic Generation With Robustness to Parallax.” In: *IEEE Transactions on Image Processing* 21.1 (Jan. 2012), pp. 366–378. URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5959979>.
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- [J27] **L. To**, B. Thompson, **J.R. Blum**, G. Maehara, R. Hess, and J. R. Cooperstock. “A game platform for treatment of amblyopia.” In: *IEEE Transactions on Neural Systems and Rehabilitation Engineering* 19.3 (Feb. 2011), pp. 280–289. URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5713843>.
- [J28] **Y. Visell**, B. Giordano, **G. Millet**, and J. R. Cooperstock. “Vibration Influences Haptic Perception of Surface Compliance During Walking.” In: *PLoS ONE* 6.3:e17697 (Mar. 2011). DOI: [doi:10.1371/journal.pone.0017697](https://doi.org/10.1371/journal.pone.0017697). URL: <http://dx.plos.org/10.1371/journal.pone.0017697>.

- [J29] **R. Pellerin, N. Bouillot, T. Pietkiewicz**, M. Wozniowski, Z. Settel, E. Gressier-Soudan, and J. R. Cooperstock. “SoundPark: Exploring Ubiquitous Computing through a Mixed Reality Multi-player Game Experiment.” In: *Studia Informatica Universalis* 8.3 (2010). Special Issue: Best Papers from NOTERE 2009, 21 pages. URL: <http://srl.mcgill.ca/publications/2009-NOTERE.pdf>.
- [J30] R. H. Ellaway, D. Topps, K. Lachapelle, and J. R. Cooperstock. “Integrating Simulation Devices and Systems.” In: *Studies in Health Technology and Informatics* 142 (Jan. 2009). Ed. by J. D. Westwood, S. W. Westwood, R. S. Haluck, H. M. Hoffman, G. T. Mogel, R. Phillips, R. A. Robb, and K. G. Vosburgh, pp. 88–90. URL: <http://srl.mcgill.ca/publications/2009-MMVR-Ellaway.pdf>.
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- [C154] A. Chou, J. R. Cooperstock, R. El-Yaniv, M. Klugerman, and T. Leighton. “The Statistical Adversary Allows Optimal Money-Making Trading Strategies.” In: *ACM-SIAM Symposium on Discrete Algorithms (SODA)*. San Francisco, CA, USA, Jan. 1995, pp. 467–476. URL: <http://srl.mcgill.ca/publications/1995-SODA.pdf>.

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- [CP1] **M. F. de Vargas, D. Marino, A. Weill–Duflos**, and J. R. Cooperstock. “Speaking Haptically: from Phonemes to Phrases with a Mobile Haptic Communication System.” In: *World Haptics Conference*. Virtual Conference: IEEE, July 2021.

- [CP2] J. Cooperstock and **J.R. Blum**. “Touch me like it matters: exploring location and encodings for explicit and implicit communication.” In: *Haptics Symposium, Interactive Session associated with the Cross-Cutting Challenge on Using the Skin as a Medium of Communication*. Washington, DC, Mar. 2020.
- [CP3] N. Katzman, M. Gellert, T. Oron-Gilad, J. R. Cooperstock, Y. Bitan, and J. J. Schlesinger. “Wearable haptic devices to monitor soldiers’ physiology—discreet sensory input improves safety and monitoring in hostile low-light and high-noise conditions.” In: *Military Health System Research Symposium*. Department of Defense, 2020. URL: <https://mhsrs.amedd.army.mil/SitePages/Home.aspx>.
- [CP4] **P. Fortin, J. Blum**, and J. R. Cooperstock. “Towards Consistent Haptic Coupling with HaptiStrap: Doing Better than “Tight yet Comfortable”.” In: *User Interface Software and Technology (UIST)*. New Orleans, USA: ACM, Oct. 2019. Acceptance rate: 48.8%.
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- [CP8] **J. Blum**, J. R. Cooperstock, and J. Cauchard. “Pseudo-Ambience: Filling the Gap Between Notifications and Continuous Information Displays.” In: *UbiTtention Workshop on Smart & Ambient Notification and Attention Management*. Singapore: ACM, Oct. 2018. URL: <http://dl.acm.org/authorize?N682234>.
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- [CP10] **P. Fortin, J. Blum**, and J. R. Cooperstock. “Raising the Heat: Electrical Muscle Stimulation for Simulated Heat Withdrawal Response.” In: *User Interface Software and Technology (UIST)*. Quebec City, Canada: ACM, Oct. 2017. URL: <http://dl.acm.org/authorize?N682248>. Acceptance rate: 23%.
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- [CP12] **D. El-Shimy** and J. R. Cooperstock. “EmbodiComp: Embodied Interaction for Mixing and Composition.” In: *Sound and Music Computing Conference (ICMC — SMC)*. Athens, Greece, Sept. 2014.
- [CP13] **F. Tordini** and J. R. Cooperstock. “Auditory salience modeling via streaming: A behavioural view.” In: *Milestones in Music Cognition: BKN 25*. Montreal, Canada, July 2014.

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## BOOK CHAPTERS

- [B1] **T. Kim**, **J. Blum**, **P. Alirezaee**, **A. Arnold**, **P. Fortin**, and J. R. Cooperstock. “Usability of Foot-Based Interaction Techniques for Mobile Solutions.” In: *Mobile Solutions and Their Usefulness in Everyday Life*. Springer International Publishing AG, Jan. 2019, pp. 309–329. DOI: [https://doi.org/10.1007/978-3-319-93491-4\\_16](https://doi.org/10.1007/978-3-319-93491-4_16). URL: [https://link.springer.com/chapter/10.1007/978-3-319-93491-4\\_16](https://link.springer.com/chapter/10.1007/978-3-319-93491-4_16).
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- [B4] **Y. Visell** and J. R. Cooperstock. “Interacting with augmented floor surfaces.” In: *Human Walking in Virtual Environments*. Ed. by Y. Visell, A. Lécuyer, F. Steinicke, and J. Campos. Springer Verlag, 2013, pp. 377–399. URL: <http://www.springer.com/engineering/robotics/book/978-1-4419-8431-9>.
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- [B8] **F. Aubé** and **R. Shield**. “Modeling the Effect of Leadership on Crowd Flow Dynamics.” In: *Cellular Automata*. Ed. by P. Soot, B. Chopard, and A. Hoekstra. Vol. 3305. Lecture Notes in Computer Science. originally presented in International Conference on Cellular Automata for Research and Industry. Amsterdam: Springer Berlin / Heidelberg, Oct. 2004, pp. 601–611. URL: [http://dx.doi.org/10.1007/978-3-540-30479-1\\_62](http://dx.doi.org/10.1007/978-3-540-30479-1_62).

## OTHER REFEREED PUBLICATIONS

- [O1] **N. Hieda** and J. R. Cooperstock. *SharedFace2*. International Conference and Exhibition of Virtual Technologies and Uses: Laval Virtual ReVolution (refereed interactive demonstration). Laval, France, Apr. 2015.
- [O2] **Y. Visell**, **G. Millet**, and J. R. Cooperstock. *Haptic Display via a Vibrating, Rigid Surface*. Demonstration in IEEE Haptics Symposium. Waltham, MA, USA, Mar. 2010.
- [O3] **A. Law**, **J. Ip**, **B. Peck**, **Y. Visell**, P. Kry, and J. R. Cooperstock. *A Multimodal Floor for Virtual Environments*. Demonstration in SIGGRAPH Emerging Technologies. Aug. 2009.
- [O4] **M. Wozniowski**, Z. Settel, and J. R. Cooperstock. *Ménagerie Imaginaire*. Artwork Performance in New Interfaces for Musical Expression (NIME). New York, NY, USA, June 2007.

## NON-REFEREED CONTRIBUTIONS

- [N1] J. Cooperstock. “Situating UbiComp Education within or distinct from HCI?” In: *Ubiquitous Computing Education: Why, What, and How*: ed. by A. Girouard, A. L. Kun, A. Roudaut, and O. Shaer. Vol. 9. 6. Dagstuhl, Germany: Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik, Mar. 2019. URL: <http://drops.dagstuhl.de/opus/volltexte/2019/11460>.
- [N2] **E. Sheepy**, M. Orjuela-Laverde, and J. R. Cooperstock. “Encouraging active and collaborative learning in two engineering courses.” In: *Supporting Active Learning and Technological Innovation in Studies of Education*. Montreal, Canada, June 2016.
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- [N4] **F. Tordini** and J. R. Cooperstock. “Auditory salience modeling via streaming: A behavioural view.” In: *Milestones in Music Cognition: BKN 25*. Montreal, Canada, July 2014.

- [N5] J. R. Cooperstock. “Overcoming Complexity in the Teaching and Learning Environment.” In: *Materials Science and Technology*. Ralph Lloyd Harris Memorial Symposium. Montreal, Oct. 2013.
- [N6] J. R. Cooperstock. *From Rehearsal to Performance: Ensemble Learning in Open Orchestra and Distributed Rehearsal for World Opera*. Presentation in Music Anywhere, Anytime: International Symposium on Synchronous Distance Learning. Oct. 2011.
- [N7] **Benovoy, M.**, J. Cooperstock, and M. Levine. *Real-Time Facial Recognition*. Phase II Project Report for Department of National Defence. 2010.
- [N8] M. Levine, **Benovoy, M.**, and J. Cooperstock. *An Automatic Real-Time Facial Recognition System*. Phase I Project Report for Department of National Defence. 2009.
- [N9] **N. Bouillot**, E. Cohen, J. R. Cooperstock, A. Floros, N. Fonseca, R. Foss, M. Goodman, J. Grant, K. Gross, S. Harris, B. Harshbarger, J. Heyraud, L. Jonsson, J. Narus, M. Page, T. Snook, A. Tanaka, J. Trieger, and U. Zanghieri. “AES White Paper AESTD1003V1: Best Practices in Network Audio.” In: *Journal of the Audio Engineering Society* 57.9 (Sept. 2009), pp. 729–741. URL: <http://www.aes.org/e-lib/browse.cfm?elib=14839>.
- [N10] V. N. Salimpoor, **M. Benovoy**, G. Longo, J. R. Cooperstock, and R. J. Zatorre. *Qualifying the Chills Response: Differences between Transient and Prolonged Chills in Response to Music*. Presentation in Auditory Perception, Cognition, and Action Meeting. Chicago, IL, USA, 2008.
- [N11] J. Cooperstock. “Plus de largeur du bande, s’il vous plaît.” In: *L’interdisciplinarité dans les sciences et technologies de la musique (invited)*. Montreal: Association francophone pour le savoir (ACFAS), May 2006.
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- [N17] A. Saroyan, R. Harris, and J. R. Cooperstock. *Applying pedagogical principles to teaching and learning with technology*. Multi-cultural perspectives on the use of technology in education. Montreal, QC, Canada, 2000. URL: <http://www.education.mcgill.ca/NAFTA>.

## PATENTS

- [P1] **P. Fortin, J. Blum, Antoine Weill–Duflos**, and J. R. Cooperstock. “System and Method for Wearable Device Contact Force Estimation and Adjustment Feedback.” provisional application US 05001770-936USPR (United States). 2021.
- [P2] **P. Fortin**, S. Kim, and J. R. Cooperstock. “Closed-loop XR Stimulus Presentation and Perception Feedback using Multi-Channel Physiological Signals.” application US 2020P00157WO (United States). 2021.
- [P3] J. R. Cooperstock and **J. Blum**. “Improving Haptic Feedback on Wearable Devices through Accelerometer Measurements.” provisional application US 62/237,772; US 62/416,910 (United States). 2015.
- [P4] J. R. Cooperstock, **Y. Visell, A. Law**, and K. Franinovic. “Floor-based Haptic Communication System.” US 9,041,521 (United States). May 2015.
- [P5] J. R. Cooperstock, **J. Blum, M. Bouchard, A. Olmos, S. Panëels**, and **D. El-Shimy**. “Spatialized audio augmented reality for blind users with a smartphone.” provisional application US 61/727,828 (expired) (United States). 2012.
- [P6] J. R. Cooperstock, **G. Millet**, and **M. Otis**. “Floor-Based Variable Friction Display.” provisional application US 61/577,148 (expired) (United States). 2011.
- [P7] J. R. Cooperstock, **L. To**, and R. Hess. “A Tetris-style gaming approach to treat amblyopia.” US 8,066,372 (United States). Nov. 2011.
- [P8] J. Roston, J. R. Cooperstock, J. MacDougall, and **S. Spackman**. “Remote sign language interpretation system.” US 60/463,332; CA 2,426,161; US 7,395,200 (United States). Feb. 2003.
- [P9] **S. Spackman, S. Pelletier**, and J. R. Cooperstock. “High-resolution Video Synthesis.” application 2,435,791 filed July 24, 2003 (expired) (Canada). 2003.
- [P10] J. R. Cooperstock, **Y. Zhang**, and **S. Spackman**. “Adaptive Compression for the Storage, Transmission, and Arbitrary Quality Reconstruction of Spatial Data.” US 60/339,816, provisional application filed Dec. 17, 2001 (expired) (United States). 2001.
- [P11] J. R. Cooperstock and **S. Arseneau**. “A robust person tracking method and system.” US 60/234,197 provisional application, filed Sept. 20, 2000 (expired) (United States). 2000.
- [P12] J. R. Cooperstock. “Pixel Count-Sensitive PDA Tool Mechanism with Cut/Paste and/or Copy/Paste Function.” P09-022797, filed in Japan by Sony Corp. (Japan). Feb. 1997.

## TECHNOLOGY TRANSFER

License agreement signed in 2014 with amblyotech.com to commercialize amblyopia treatment (protected under US patent 8,066,372 “Binocular vision assessment and/or therapy”). The technology was subsequently [acquired by Novartis](#) in April 2020.

## RESEARCH DEMONSTRATIONS

- [D1] 3D Printed Haptic Illusions and Demonstrations. IEEE World Haptics, Tokyo, Japan (conducted by Antoine Weill–Duflos and Pascal Fortin), July 2019.
- [D2] Distributed Musical Practice and Performance, I Medici di McGill, Oscar Peterson Hall, Montreal, April 28, 2008.
- [D3] Wide Screen Window on the World: Life Size HD Videoconferencing. Supercomputing 2005, Bandwidth Challenge, Seattle, November 16, 2005.
- [D4] Streaming DSD Audio comes to the AES. Audio Engineering Society 117th Convention, San Francisco, October 31, 2004.
- [D5] Cross-continental low-latency ultra-videoconferencing. McGill-Stanford jazz jam, June 13, 2002.
- [D6] Remote master’s class using SDI video and multichannel audio. McGill-National Research Council session with Pinchas Zukerman, March 25, 2002.
- [D7] SDI video and multichannel audio. CANARIE’s 7th Advanced Networks Workshop, Toronto, November 28, 2001.
- [D8] Low-latency distributed violin duet in full-frame video. RISQ 2001 Conference, Montreal, November 5, 2001.
- The Globe and Mail noted that *“Cooperstock’s demonstration was a watershed event for the elite club of the world’s computer network engineers. No one had ever before been able to demonstrate that, under the right conditions, it is possible for natural, normal human interaction to occur over the Internet.”*
- [D9] The Recording Studio that Spans a Continent. Audio Engineering Society 109th Convention, Los Angeles, September 23, 2000.
- The Audio Engineering Society noted that this *“Landmark demonstration shows cost effective and high performance transmission systems for high quality 24-bit, 96kHz uncompressed multichannel audio are on horizon”*
- [D10] Dolby Digital 5.1 audio with MPEG-2 video around the world. Internet Global Summit INET 2000 Conference, Yokohama, July 20, 2000.
- CBC Radio noted that *“McGill University in Montreal has made Internet history by setting up the first intercontinental netcast of a live concert in surround sound and full-screen video.”*
- [D11] Dolby Digital 5.1 audio with MPEG-2 video. CANARIE’s 5th Advanced Networks Workshop, Toronto, November 29, 1999.
- [D12] First real-time Multichannel Audio Internet demo. Audio Engineering Society 107th Convention, New York, September 26, 1999.
- The Learning Technologies Networked noted that *“The performance marked the first real time multichannel audio Internet transmission, a feat made possible by software developed at McGill University by a team under the leadership of Professor Jeremy Cooperstock.”*

## INVITED TALKS

**Invited Talks to Industry, Students, and the Public**

- [T1] “Using smartphones to answer ‘What’s around me?’, ‘Am I crossing the street safely?’ and ‘Where’s the entrance?’”, Accessible Coding Demonstrations for Youth with Visual Impairment, Science Odyssey 2021, May 1, 2021.
- [T2] “From flight simulators to the passenger experience: what can we learn from pilot-training tools to improve airline customer service”, AIST–NRC Collaboration Meeting on Improving Client-Agent Interaction, January 17, 2020.
- [T3] “I Feel the Earth Move (Under My Feet): Haptic Interaction for Telepresence and Information Delivery”, Department of Information Engineering and Computer Science, University of Trento, July 4, 2019.
- [T4] “I Feel the Earth Move (Under My Feet): Haptic Interaction for Telepresence and Information Delivery”, Department of Industrial Engineering and Management, Ben Gurion University, March 11, 2019.
- [T5] “I Feel the Earth Move (Under My Feet): Haptic Interaction for Telepresence and Information Delivery”, Information Systems, University of Haifa, November 7, 2018.
- [T6] “What’s around me? Audio augmented reality for blind users with a smartphone, Pint of Science, Montreal, May 15, 2018.
- [T7] Presenter at Canadian National Institute for the Blind’s TechnoVision+ Conference, Montreal, May 5, 2017.
- [T8] “Innovations for Gaming, AR, Simulation & Training”, Innovations for gaming, augmented reality, simulation and training, and other applications, Centre d’entreprises et d’innovation de Montreal (CEIM), April 8, 2016.
- [T9] “Enhanced Human: Wearable computing that transforms how we perceive and interact with our world”, Department of Computer Science, Technion–Israel Institute of Technology, February 11, 2016.
- [T10] “Is Humanity Smart Enough for AI?”, McGill Science Outreach Program, Freaky Friday public outreach lecture, October 23, 2015.
- [T11] “Delivering a Compelling User Experience in a Computer-Mediated Environment”, HCIN 5300, Interactive Entertainment Technologies, Carleton University, March 7, 2014.
- [T12] “Multimedia as a Building Block: How audio, video and haptics integrate in a Shared Reality”, Multimedia Systems, GLIS 633, School of Information Studies, McGill University, February 13, 2014.
- [T13] “Are we there yet? Cognitive Science Challenges in Telepresence and Virtual Reality”, Student Association of Cognitive Science, Cognitive Science Research Day, McGill University, November 13, 2013.

- [T14] “Telepresence doesn’t quite cut it: Multimodal Challenges in Virtual and Shared Reality”, Institute of Telecommunications and Multimedia Applications, Universidad Politècnica de València, July 10, 2013.
- [T15] “Telepresence doesn’t quite cut it: Multimodal Challenges in Virtual and Shared Reality”, Dawson College, First Choice Science speakers series, April 17, 2013.
- [T16] “Dangerous AI or dangerous us?”, Academia Week Artificial Intelligence event, Science Undergraduate Society, McGill University, January 24, 2013.
- [T17] “They don’t use Skype on the Holodeck”, Department of Computer Science, University of British Columbia, July 4, 2012.
- [T18] “But can the Holodeck do a good Shiraz?”, School of Computer Science and IT, Royal Melbourne Institute of Technology, February 17, 2012.
- [T19] “But can the Holodeck do a good Shiraz?”, School of Information Technologies, University of Sydney, February 15, 2012.
- [T20] “Distributed Music Performance and Latency Issues”, School of Drama, Fine Art and Music, University of Newcastle (Australia), February 13, 2012.
- [T21] “But can the Holodeck do a good Pinot noir?”, Department of Computer Science, University of Otago, January 23, 2012.
- [T22] “Shared Reality: Toward perceptually convincing computer-mediated environments”, Department of Computer Science, University of Auckland, August 25, 2011.
- [T23] “This is your brain on Shared Reality: Toward perceptually convincing computed-mediated environments”, Vanier College, Science Week Presentation, March 24, 2011.
- [T24] “This is your brain on Shared Reality: Toward perceptually convincing computed-mediated environments”, Simula Lab, Oslo, May 15, 2009.
- [T25] “This is your brain on Shared Reality: Toward perceptually convincing computed-mediated environments”, Ambient Intelligence Group, CITEC, Bielefeld University, May 6, 2009.
- [T26] “Distributed and Multimodal Interaction in Virtual and Augmented Reality Environments”, McGill University, School of Physical and Occupational Therapy, November 25, 2008.
- [T27] “Shared Reality: Effective Interaction for (Demanding) Distributed Tasks”, University of Victoria, September 16, 2008.
- [T28] “Bidirectional video communication for real-time applications”, Institut für Telematik, University of Lübeck, Germany, May 15, 2008.
- [T29] “Shared Reality: Effective Interaction for (Demanding) Distributed Tasks”, Aalborg University, Esbjerg, Denmark, May 14, 2008.
- [T30] “Distributed Multimodal Interaction”, Bang & Olufsen, Struer, Denmark, May 13, 2008.

- [T31] “Distributed Musical Practice and Performance”, Biology and Music Lecture, I Medici di McGill, April 28, 2008.
- [T32] “Shared Reality: Effective Interaction for (Demanding) Distributed Tasks”, Arts, Media and Engineering, Arizona State University, February 29, 2008
- [T33] “From Videoconferencing to Shared Reality” Department of Electrical and Computer Engineering, University of British Columbia, October 4, 2007.
- [T34] “Engaging Technolog(ies) for Effective Interaction” Department of Computer Science, Hebrew University of Jerusalem, April 19, 2005.
- [T35] “Engaging Technolog(ies) for Effective Interaction” Intelligence, Agents, Multimedia Group, University of Southampton, UK, March 7, 2005.
- [T36] “From Videoconferencing to Shared Reality” l’Institut de Recherche et Coordination Acoustique/Musique (IRCAM), Paris, November 25, 2004.
- [T37] “From Videoconferencing to Shared Reality” Taiyuan University, Taiyuan, China, April 18, 2004.
- [T38] “From Videoconferencing to Shared Reality” Tsinghua University, Beijing, China, April 14, 2004.
- [T39] “From Videoconferencing to Shared Reality” Beijing University, Beijing, China, April 14, 2004.
- [T40] “From Videoconferencing to Shared Reality” Beihang University, Beijing, China, April 12, 2004.
- [T41] “From Videoconferencing to Shared Reality” Advanced Telecommunications Research (ATR), Nara, Japan, April 9, 2004.
- [T42] “From Videoconferencing to Shared Reality” Dept. of Industrial Engineering, Musashi Institute of Technology, April 5, 2004.
- [T43] “High-fidelity telepresence” Graphics and Geometric Computing Seminar Series, Technion – Israel Institute of Technology, January 1, 2003.
- [T44] “The Virtual Studio” Royal Conservatory of Music, Toronto, February 25, 2002.
- [T45] “Building a Shared Reality” Department of Computer Science, University of Toronto, February 25, 2002.
- [T46] “Distributed Concerts and Shared Reality: Just how much streamed data and computation do we need to support effective interaction?” Department of Computer Science, Clarkson University, November 1, 2001.
- [T47] “Robotics and Design” Round Table Panel, Centre Design UQAM, February 9, 2000.
- [T48] “The Shared Reality Environment” Department of Electrical and Computer Engineering, Ecole Polytechnique, Montreal, May 28, 1999.

**Invited Talks in Scholarly Conferences and Workshops**

- [T49] Speaker in “Next Gen Health Powered By The Open Grid And Edge AI”, IEEE Future Networks Forum, Montreal, October 14, 2022.
- [T50] “Touch and feel when it isn’t real: Integrating haptics into the XR experience”, InterDigital Scientific Seminar series, December 4, 2020.
- [T51] “Taking Haptics Out of the Lab and Into the Wild”, Introduction to Haptics for Next Generation XR. International Conference on Intelligent Robots and Systems Tutorial Session, October 29, 2020.
- [T52] “Assistive Technology Research in the Shared Reality Lab”, Conférence scientifique du CRIR-Institut Nazareth et Louis-Braille, September 25, 2019.
- [T53] “Learning from sparse feedback: Adapting an environmental awareness app to visually impaired user preferences”, ACM-SIGCHI sponsored summer school on Intelligent User Interfaces in the Era of IoT and Smart Environments, Haifa, Israel, October 3, 2018.
- [T54] Speaker in “AR/VR panel”, IEEE Multimedia Signal Processing Workshop, Montreal, September 23, 2016.
- [T55] “Immersive multimedia and mobile interaction: Applications to new media, gaming, medicine, and beyond” Keynote speaker, Entertainment Technology Summit, Concordia University, Montreal, September 17, 2016.
- [T56] “Leveraging video in public safety scenarios”, Ninth Canadian Public Safety Interoperability Workshop (CITIG 9), Toronto, December 1, 2015.
- [T57] “Future Cities (2040) – Mind: Human and Machine”, Institute for the Public Life of Arts and Ideas, Symposium on Future Cities, March 13, 2015.
- [T58] “UltraVideo and the Quest for Minimal Latency”, International Workshop on High Quality Dynamic cross-continental Networked Artistic interaction, World Opera Association, Struer, Denmark, August 29, 2013.
- [T59] “Assisting the blind and treating amblyopia: Two more things you can do with your smartphone”, 15e Symposium scientifique sur l’incapacité visuelle et la réadaptation (presented with J. Blum). University of Montreal, February 12, 2013.
- [T60] “Revolutions in human-device interaction: How new paradigms impact user experience”, International Conference on Consumer Electronics, Consumer Electronics Society, Las Vegas, January 12, 2013.
- [T61] “Around the World in 80 ms.” Panel presentation in Workshop of the Audio Engineering Society Convention, San Francisco, November 5, 2010.
- [T62] “UltraVideo and Virtual Presence: A Video Perspective.” Presentation on Teaching in Distributed Performance, Tromsø, Norway, October 15, 2010.

- [T63] “Future Interfaces for Audio.” Panel presentation in Workshop of the Audio Engineering Society Convention, New York, October 10, 2009.
- [T64] “World Opera Technologies and Tests”, Danish Sound Technology Network, Aalborg University, June 8, 2009.
- [T65] “The Montreal World Opera Experiments”. Presentation at the World Opera Symposium, Struer, Denmark, May 12, 2009.
- [T66] “Audio-Visual-Haptic-Tactile: Putting them all together for an engaging immersive experience”. Panel presentation in Workshop of the Audio Engineering Society Convention, Munich, Germany, May 10, 2009.
- [T67] “New Technologies for Audio over IP”. Panel presentation in Workshop of the Audio Engineering Society Convention, Munich, Germany, May 10, 2009.
- [T68] “A Platform to Create and Support Ocean Science Virtual Organizations (Oceans 2.0)” and “HSVO Health Services Virtual Organization”, RISQ 2008 Colloquium, Montreal, November 14, 2008.
- [T69] “The Future of VC: Music Teaching and High Fidelity Video”, Elevate 2008: Reaching New Heights in Educational Video-conferencing, Banff, August 27–28, 2008.
- [T70] “Creating an immersive video space”, International Symposium on The World Opera: When the Opera stage becomes worldwide, Tromsø, Norway, May 9, 2008.
- [T71] “Multimodal Streaming and Distributed Audio Interaction”, High Quality Audio over Networks (ANET II) Summit, Banff Centre, April 12, 2008.
- [T72] “Music and Games: How Fun Applications Stimulate Core Technologies”, Canadian University Software Engineering Conference, January 19, 2008.
- [T73] “From Teleoperation to Teleimmersion: Design Challenges for Distributed Interaction”, Canadian University Software Engineering Conference, January 19, 2007.
- [T74] “CANARIE sur UCLP et ROADM, deux technologies qui changent le monde des télécoms”, Round Table panel, RISQ Annual Conference, Quebec City, October 16, 2006.
- [T75] “La recherche sur en ultra-videoconference”, Panel on “Vitrine technopédagogique sur la vidéoconférence”, RISQ Annual Conference, Quebec City, October 16, 2006.
- [T76] “Broadband transmission of multimodal content at the Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT)”, RISQ-CA\*net4 Advanced Networking Day, Montreal, October 24, 2005.
- [T77] “Low-Latency Ultra-Videoconferencing and Shared Reality” Interfaces Montreal, Rencontre du Génie numérique et des Affaires. Montreal, October 11, 2005.
- [T78] “Shared Spaces” Asia-Pacific Advanced Networks (APAN) Conference, Taipei Aug. 22–27, 2005.

- [T79] “Engaging Technolog(ies) for Effective Interaction” Keynote speaker, World Conference on Educational Multimedia, Hypermedia and Telecommunications, Montreal, June 29, 2005.
- [T80] “Broadband Distance Education in 2007: Views from the Demand Side” Invited Panelist. World Conference on Educational Multimedia, Hypermedia and Telecommunications, Montreal, June 29, 2005.
- [T81] “Ultra-Videoconferencing and Intelligent Classrooms” Keynote speaker, Canadian Higher Education and Information Technology Conference, Montreal, June 28, 2005.
- [T82] “From Videoconferencing to Shared Reality” Bell University Laboratories’ Annual Conference, Toronto, November 3, 2004.
- [T83] “History of Internet Audio Experiments at McGill” High Quality Audio over Networks (ANET) Summit, Banff Centre, August 20–22, 2004.
- [T84] “Advanced Video Applications: Developments in Extreme Video” Southeastern Universities Research Association Video Development Initiative (SURA/ViDe) 6th Annual Digital Video Workshop. Indianapolis, March 24, 2004.
- [T85] “The Democratic Revolutions – Peer to Peer Meets Open Source: Design, Philosophy, Engineering” Intimate Technologies/Dangerous Zones. Banff New Media Institute, Banff Centre, April 27, 2002.
- [T86] “The Development of Ultra VC Applications and Technology” Southeastern Universities Research Association Video Development Initiative (SURA/ViDe) 4th Annual Digital Video Workshop. University of Alabama at Birmingham, April 25, 2002.
- [T87] “High quality wide-screen SDI video and multichannel audio over CA\*net3” CANARIE’s 7th Advanced Networks Workshop, Toronto, November 28, 2001.
- [T88] “Low-latency comes to videoconferencing: The Frères Jacques duet at a distance” RISQ 2001 Conference, Montreal, November 5, 2001.
- [T89] Advanced Networking and the Arts: Innovations in Outreach, Collaboration, and Performance. Panel Discussion at Internet Global Summit INET 2001 Conference, Stockholm, June 6, 2001.
- [T90] “The McGill–Calgary Advanced Learnware Network” CANARIE’s 6th Advanced Networks Workshop, Montreal, November 29, 2000.
- [T91] “Networks and Music Instruction” Panel Discussion with Pinchas Zukerman and Wieslaw Woszczyk, CANARIE’s 6th Advanced Networks Workshop, Montreal, November 29, 2000.
- [T92] “Tools for Distributed VR” Canadian Working Group on Virtualized Reality Systems, Montreal, November 28, 2000.
- [T93] “Evolution of the Intelligent Classroom” Multicultural Perspectives on the use of Technology in Education. Montreal, October 2, 2000.

- [T94] “The Brave New World of Ubiquitous Bandwidth” Internet Global Summit INET 2000 Conference, Yokohama, July 20, 2000.
- [T95] “Multichannel Audio over the Internet: The Next Phase” RISQ 2000 Conference, May 31, 2000.
- [T96] “Multichannel Audio over the Internet” CANARIE’s 5th Advanced Networks Workshop, Toronto, November 29, 1999.
- [T97] “When Telemedicine feels like Regular Medicine” Communications and Information Technology Ontario (CITO) Healthcare for the Future: Telemedicine, February 18, 1999.

## MEDIA EXPOSURE

- [M1] Ami-Télé, Ça me regarde, February 8, 2018
- [M2] Forbes, March 9, 2017
- [M3] Discovery Channel, Daily Planet, Mar. 7, 2017
- [M4] Télé-Québec, Electrons Libre, Jan. 17, 2017
- [M5] ACB Radio, Mainstream, Nov. 18, 2016
- [M6] CBC Radio, Tech Column, Aug. 8, 2016
- [M7] CJAD Radio, Tech Talk, Aug. 6, 2016
- [M8] Mobile Syrup, Aug. 4, 2016
- [M9] CBC News, Aug. 4, 2016
- [M10] Betakit, Aug. 3, 2016
- [M11] Accessible Media Inc., Live from Studio 5, Aug. 2, 2016
- [M12] La Presse, Jul. 31, 2016
- [M13] CTV News, Jul. 29, 2016
- [M14] Stevivor, Mar. 2015
- [M15] Venture Beat, Mar. 3, 2015
- [M16] Club Social (TV5), Feb. 4, 2011
- [M17] Global TV (National), Jan. 29, 2009
- [M18] Global TV (Montreal), Jan. 27, 2009
- [M19] CBC Radio, As it Happens, Jan. 27, 2009
- [M20] National Post, Jan. 27, 2009
- [M21] Montreal Gazette, Jan. 27, 2009
- [M22] Montreal Gazette, Feb. 20, 2009
- [M23] Inside Higher Education, Sept. 3, 2008
- [M24] CBC Radio (Daybreak), Sept. 3, 2008

- [M25] CJAD radio, Sept. 2, 2008
- [M26] Cabling Networking Systems, Jan. 2006
- [M27] McGill Reporter, Nov. 24, 2005
- [M28] CTV Quebec, Global News, Dec. 23, 2002
- [M29] New York Times, Technology Section, Dec. 19, 2002
- [M30] Discovery Channel, Daily Planet, Oct. 30, 2002
- [M31] CFCF (CTV Quebec) Global News, June 19, 2002
- [M32] National Post, June 15, 2002
- [M33] CBC Television, The National, May 3, 2002
- [M34] McGill Reporter, Learning the Strings, April 11, 2002
- [M35] Ottawa Citizen, March 29, 2002
- [M36] Montreal Gazette, March 27, 2002
- [M37] Globe & Mail, Dec. 1, 2001
- [M38] Canal Z, La Revanche des Nerdz, Nov. 13, 2001
- [M39] Montreal Gazette, Nov. 10, 2001
- [M40] CJAD Radio, The World Today, July 31, 2001
- [M41] McGill Reporter, April 5, 2001
- [M42] Globe & Mail Report on Business, Oct. 28, 2000
- [M43] TQS Double Clic!, Oct. 7, 2000
- [M44] McGill Reporter, Sept. 21, 2000
- [M45] UPath.com, Vol 40, 2000
- [M46] CBC (Montreal) Home Run, Aug. 22, 2000
- [M47] Montreal Gazette, Aug. 22, 2000
- [M48] CFCF (CTV Quebec) Pulse News, Aug. 21, 2000
- [M49] CBC Radio The Arts Report, July 20, 2000
- [M50] Elle Quebec, June 2000
- [M51] Journal Le Monde des Affaires, May 2000
- [M52] Canal Z, Technofolie, May 3, 2000
- [M53] TQS Double Click, April 29, 2000
- [M54] McGill Reporter, April 6, 2000
- [M55] Briefing Digital, April 2000
- [M56] Interface: La Revue de la Recherche, Vol. 21, No. 2, March-April 2000
- [M57] American Society of Mechanical Engineers, Mechanical Advantage, Vol 9, No 3, March 2000
- [M58] Canal Z, La Revanche des Nerdz, Feb. 2000

- [M59] CFCF (CTV Quebec) Pulse News, Feb. 29, 2000
- [M60] Canal Vox: CityMag, Jan. 15, 2000
- [M61] Montreal Mirror, Jan. 6, 2000
- [M62] Plan Mega: La revue du genie québécois, Ordre des ingenieurs du Québec. Vol 1, Jan. 2000
- [M63] Radio Corporation of Singapore: Science and Technology Watch, Dec. 1999
- [M64] Radio Canada (CBC French) Les Annees lumiere, Nov. 28, 1999
- [M65] Financial Times Life/Technology, Nov. 25, 1999
- [M66] CBC Radio: As it Happens, Nov. 22, 1999
- [M67] Journal de Montreal, Nov. 19, 1999
- [M68] Le Devoir, Nov. 18, 1999
- [M69] TVA CyberClub, Nov. 13, 1999
- [M70] La Presse, Sept. 26, 1999
- [M71] CJAD Radio, April 11, 1999
- [M72] Montreal Mirror, April 8, 1999
- [M73] McGill Reporter, Jan. 14, 1999
- [M74] High-Tech Shower International, Nov. 26, 1997
- [M75] CBC Newsworld "Futureworld", Oct. 5, 1996
- [M76] Discovery Channel, Sept. 18, 1996
- [M77] Toronto Star, Sept. 15, 1996
- [M78] University of Toronto Varsity, Sept. 3, 1996
- [M79] TV Ontario "Studio Two", June 26, 1995

## RESEARCH SUPERVISION

## RESEARCH PROFESSIONALS

| Name                | Period              | Project title                                       | Present Position                      |
|---------------------|---------------------|-----------------------------------------------------|---------------------------------------|
| Singh, Jaydeep      | Sep 2021–           | web developer, IMAGE project                        |                                       |
| Novack, Kaylee      | Sep 2021–Apr 2022   | medical doctor researcher on Avatar Therapy project |                                       |
| Kuo, Cyan           | Aug 2021–           | Usability Research Lead, IMAGE project              |                                       |
| Patil, Gandharv     | Jun 2021–Mar 2022   | ML Research Lead, IMAGE project                     |                                       |
| Grond, Florian      | Apr 2021–           | Audio Research Lead, IMAGE project                  |                                       |
| Eichhorn, Alexander | Feb 2013 – Aug 2013 | research associate under GRAND                      | CTO of Kidtsunami                     |
| Bouchard, Mathieu   | Jan 2011 – Nov 2018 | research assistant under MSG project                |                                       |
| Chen, Guangyi       | Jan 2010 – Jul 2010 | research associate under Canarie NEP                |                                       |
| Vincent, Coralie    | Oct 2010 – Mar 2011 | research assistant                                  | CNRS, France                          |
| Dansereau, Don      | Jun 2009 – Jan 2010 | research associate under FRQNT grant                | Senior Lecturer, University of Sydney |
| To, Long            | Jan 2009 – Sep 2011 | research associate under NSERC I2I                  | Software engineer, Abcam              |
| Blum, Jeff          | Oct 2008 – Aug 2013 | research assistant under MSG project                |                                       |

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| <b>Name</b>      | <b>Period</b>           | <b>Project title</b>                              | <b>Present Position</b>                          |
|------------------|-------------------------|---------------------------------------------------|--------------------------------------------------|
| Olmos, Adriana   | Sep 2008 –<br>July 2012 | user interface engineer under Canarie<br>NEP      | Interaction<br>designer,<br>Google/YouTube       |
| Sun, Haijian     | Sep 2008 –<br>Oct 2010  | computer engineer under Canarie<br>NEP            | programmer, Des-<br>jardins                      |
| Soukhodolski, I. | Oct 2005 –<br>Dec 2007  | web services programmer under Ca-<br>narie IIP    | Owner, W4 Tech-<br>nology                        |
| Kiewe, Howard    | Oct 2005 –<br>Dec 2007  | user interface developer under Canarie<br>IIP     | consultant                                       |
| Spackman, S.     | 2000–2006               | research associate on Canarie and<br>VRQ projects | Google, Mountain<br>View                         |
| Sarikaya, Deniz  | 2003–2004               | research assistant on VRQ projects                | deceased                                         |
| Soucy, Gilbert   | 1999                    | research associate on CFI project                 | Imaging Specialist,<br>36pix Inc., Mon-<br>treal |

## POST-DOCTORAL FELLOWS

| Name               | Period              | Project title                                                                     | Present Position                                                                 |
|--------------------|---------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Sullivan, John     | Sep 2021–Apr 2022   | Multimodal Rendering for the IMAGE Project                                        | post-doctoral fellow, Université Paris-Saclay                                    |
| Jyoti, Vishav      | Mar 2021–Feb 2022   | Mixed-Reality Platform for Simulation and Synthesis of Multi-Modal Hallucinations |                                                                                  |
| Talhan, Aishwari   | Jan 2021–Dec 2022   | Wearable Haptics                                                                  | Research Scientist, New York                                                     |
| Yoo, Yongjae       | Mar 2020–Jul 2022   | Wearable Haptics and Haptics Lead, IMAGE project                                  | Assistant Professor, Hanyang University ERICA, South Korea                       |
| Weill – Duflos, A. | Jan 2018 – Jan 2021 | Wearable Haptics                                                                  | Director of Research and Product Integration, Haply Robotics                     |
| Arnold, Andre      | Oct 2017 – Dec 2017 | Wearable Haptics                                                                  | Product Manager – AI Nuvoola                                                     |
| Panëels, S.        | Jan 2011 – Jan 2012 | Natural Interactive Walking and In-Situ Audio Services                            | Researcher, Commissariat à l'énergie atomique et aux énergies alternatives (CEA) |
| Pelletier, S.      | Nov 2009 – Jun 2011 | Real-time Image-based Rendering (Canarie NEP, 2009-2010)                          |                                                                                  |
|                    |                     | Parallax Barrier Display rendering software optimization (NSERC ENGAGE, 2011)     | Game Programmer, Behaviour Interactive                                           |
| Otis, Martin       | Jan 2010 – Dec 2010 | Natural Interactive Walking (FRQNT Scholarship)                                   | Assoc. Professor, U. Québec à Chicoutimi                                         |

Continued on next page

| Name              | Period              | Project title                                                              | Present Position                                   |
|-------------------|---------------------|----------------------------------------------------------------------------|----------------------------------------------------|
| Millet, G.        | Nov 2009 – Mar 2012 | Natural Interactive Walking                                                | Patent Examiner, EPO, The Hague                    |
| Bouillot, Nicolas | Sep 2007 – Dec 2011 | Mobile Audio Interaction (NSERC New Media Initiative, 2007-2009)           |                                                    |
|                   |                     | Open Orchestra (Canarie NEP-2 Project)                                     | Research Engineer, Société des arts technologiques |
| Darolti, Cristina | Jan – Dec 2009      | Real-time Image-based Rendering (Canarie NEP)                              | Patent Examiner, EPO, The Hague                    |
| Wang, Guangyu     | Sep 2007 – Mar 2011 | Neurosurgical Visualization and Virtual Presence (NSERC Strategic and NCE) | Facebook, Mountain View                            |
| Wang, Yan         | 2002–2003           | Channel and spatial view allocation for videoconferencing (VRQ)            | V.P. Marketing, AMH Canada                         |

## PH.D. STUDENTS

| Name                         | Period                 | Thesis title                                                     | Present Position                                                            |
|------------------------------|------------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Conan, Corentin*             | Sep 2022–<br>present   | Advanced Airspace Usability                                      |                                                                             |
| Astles, Samantha*            | Sep 2022–<br>present   | Advanced Airspace Usability                                      |                                                                             |
| Shen, Lichao*                | Oct 2021–<br>present   | Social telepresence                                              |                                                                             |
| Regimbal, J.* <sup>◇‡</sup>  | Sep 2021–<br>present   | Audio-haptic authoring for information rich content delivery     |                                                                             |
| Fortin, P.* <sup>◇</sup>     | Sep 2016 –<br>Sep 2021 | Methods and Interfaces for Closed-Loop Smartphone Communications | Asst. Professor,<br>U. Québec à<br>Chicoutimi                               |
| Blum, Jeff* <sup>†g</sup>    | Sep 2013–<br>present   | Implicit Communication for Enriched Human Interaction            |                                                                             |
| Erfani-Joorabchi, M.*        | Jan 2013 –<br>Jan 2015 |                                                                  | iOS Software Engineer, Google                                               |
| Anlauff, Jan*                | Jan 2011–<br>present   | Sensor-Actor Wearables                                           |                                                                             |
| Tordini, F.                  | Jan 2011 –<br>Feb 2018 | Auditory salience modeling for continuous processes sonification | Technology Transfer Manager, Innovation and Partnerships, McGill University |
| Ghourchian, N.* <sup>†</sup> | Jan 2010 –<br>Apr 2011 | Affective Evaluation                                             | transferred to another group                                                |
| El-Shimy, D. <sup>†</sup>    | Jan 2009 –<br>Nov 2014 | Reactive Environment for Network Music Performance               | Senior UX Research Manager, Miro                                            |
| Benovoy, M. <sup>†</sup>     | Oct 2007 –<br>Aug 2010 | Biosignals analysis                                              | transferred to another group                                                |

Continued on next page

| Name                       | Period              | Thesis title                                                                             | Present Position                                                                              |
|----------------------------|---------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Visell, Yon                | Sep 2005 – Mar 2011 | Walking on virtual ground: physics, perception, and interface design                     | Assistant Professor (ECE), UC Santa Barbara                                                   |
| Qi, Zhi                    | Jan 2004 – Dec 2008 | Towards dynamic mosaic generation with robustness to parallax effects                    | Associate Professor (School of Electronic Science & Engineering), Southeast University, China |
| Pelletier, S. <sup>p</sup> | Jan 2003 – Oct 2009 | Acceleration methods for image super-resolution                                          | Game Programmer, Behaviour Interactive                                                        |
| Yin, Jianfeng              | Sep 2000 – Aug 2008 | Toward an Alternative Approach to Multi-Camera Scene Reconstruction                      | Software engineer, Geomagical Labs                                                            |
| Sun, Wei                   | 2002–2006           | Multi-camera Object Segmentation in Dynamically Textured Scenes Using Disparity Contours | Apple Inc., Cupertino                                                                         |
| Cayouette, F. <sup>†</sup> | 2003–2006           | human tracking (withdrew from program)                                                   | Programmer, Behaviour Interactive, Montreal                                                   |
| Arseneau, S.               | 2000–2006           | Representing Junctions through Asymmetric Tensor Diffusion                               | Chief Engineer for R&D, Laser Shot, Houston                                                   |

\* McGill Engineering Doctoral Award recipient

† NSERC PGS D Scholarship recipient

‡ NSERC CGS D Scholarship recipient

◊ FRQNT Scholarship recipient

<sup>g</sup> Graphics Animation and New Media (GRAND) Scholarship recipient

<sup>p</sup> Precarn Scholarship

## ADDITIONAL PH.D. SUPERVISORY SERVICE

I co-supervised a portion of the thesis work of the following students:

- Liu, X., (Nov 2013-Dec 2015), visiting student from University of Electronic Science and Technology, China

- Xie, M., (Sep 2012-Mar 2014), visiting student from Beijing University of Aeronautics and Astronautics, China
- Grond, F. (Jul-Dec 2010), visiting student from Bielefeld University, Germany
- Zambon, S.. (Jul-Oct 2010), visiting student from Verona University, Italy
- Cirio, G. (Jun-Aug 2010), visiting student from INRIA-IRISA, France
- Rizutti, C. (Sep-Oct 2008), visiting student from Università della Calabria, Italy
- Bossi, E. (Sep-Oct 2008), visiting student from Università della Calabria, Italy
- Pellerin, R. (Jun-Sep 2008), visiting student from Conservatoire Nationale des Arts et Métiers, France
- Cupellini, E. (Jul-Aug 2007), visiting student from Università della Calabria, Italy
- Usher, J. (2003-2004), Ph.D. student, Faculty of Music, McGill University
- Mohammadi, M. (Feb-Aug 2004). visiting student from Sharif University, Iran

I served as external reviewer or examiner of the following theses:

- Mauricio Fontana de Vargas, School of Information Studies, McGill University (2022)
- Richard Olayniyan, Department of Computer Science, McGill University (2021)
- Xavier de Tingu, Université Rennes, France (2020)
- Damien Brun, Le Mans Université, France (2020)
- Cheryl Savery, Queen's University (2014)
- Alexandre Plouznikoff, École Polytechnique de Montréal (2009)
- Xiaoyong Sun, School of Information Technology and Engineering, University of Ottawa (2007)
- Nicolas Bouillot, Conservatoire Nationale des Arts et Métiers, France (2006)
- Harold Okai-Tetty, Computer Science, Rhodes University, South Africa (2006)

I served on the supervisory and/or examination committees of the following students:

- Department of Electrical and Computer Engineering: Edouard Antoniou, Oliver Astley, Carmen Au, Marc Boulé, Wei Chu, Olivier St-Martin Cormier, Vincent Levesque, Muhua Li, Rui Ma, Dante De Nigris Moreno, Jun Ouyang, Jerome Pasquero, Andrew Phan, Ala Qumsieh, Harkirat Sahambi, Wei Sun, Yick Kei Wong, Dingrong Yi, Olivier St-Martin Cormier, Karl Fayad, Shalaleh Rismeni, Lixiao Zhu
- School of Information Studies: Xiaofeng (Allan) Yong
- Faculty of Music: Jason Corey, Cory McKay, Caroline Medeiros, Sean Olive, Dale Stammen, Vanessa Yarmechuk, Mark Zadel
- Grad. School of Library and Information Studies: Charles-Antoine Julien
- Department of Educational Psychology and Counselling: Adam Finkelstein
- Department of Mechanical Engineering: Zahir Albadawi
- School of Computer Science: Paul Haroun, Wisam Al Abed

## MASTERS STUDENTS

| Name                        | Period                  | Thesis title                                                                                                             | Present Position                |
|-----------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| Bazin, Romain               | Sep 2022–               | TBD                                                                                                                      |                                 |
| Quadros,<br>Venissa Carol   | Sep 2022–               | TBD                                                                                                                      |                                 |
| Aubet, Antoine              | Sep 2022–               | TBD                                                                                                                      |                                 |
| Liu, Yujing                 | Sep 2021–               | Graphical rendering strategies for avatar therapy                                                                        |                                 |
| Wilson, É.                  | Sep 2021–               | Lightfield rendering techniques for XR musical interaction                                                               |                                 |
| Duarte, Nathan <sup>◊</sup> | Sep 2021–               | Wearable sensor deployment for pandemic mitigation                                                                       |                                 |
| Henry, Max                  | Sep 2021–               | Spatial-aware audio rendering for immersive telepresence                                                                 |                                 |
| Lewis-Lane,<br>Jonathan     | Sep 2021–               | Wearable haptic feedback for real-time training tasks                                                                    |                                 |
| Akut, Rohan                 | Jan 2021–               | Active learning for image labelling                                                                                      |                                 |
| Gannavarapu, S.             | Sep 2020–               | Haptic rendering and perception                                                                                          |                                 |
| Isran, Rayan                | Sep 2020–               | Haptic rendering and perception                                                                                          |                                 |
| Kirby, Linnea               | Sep 2020–               | Multimodal feedback to guide body-movement                                                                               |                                 |
| Knappe, Sabrina             | Sep 2020 –<br>Dec 2022– | Towards a User Interface for Audio-Haptic Exploration of Internet Graphics by People who are Blind and Partially Sighted | Ph.D. student (see above)       |
| Regimbal, J.                | Sep 2020 –<br>Aug 2021  | Haptic effects authoring in artistic and utilitarian contexts                                                            | (fast-tracked to Ph.D. program) |

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| Name                       | Period              | Thesis title                                                                                      | Present Position                             |
|----------------------------|---------------------|---------------------------------------------------------------------------------------------------|----------------------------------------------|
| Ducher, Clara <sup>‡</sup> | Sep 2019 – Sep 2021 | GAN-based interaction paradigms for photorealistic avatar creation                                | Pipeline Technical Director, Double Negative |
| Marino, David              | Sep 2019 – Nov 2021 | Implicitly Conveying Emotion While Teleconferencing                                               | R&D Scientist, Hitachi Energy, Montreal      |
| Lee, Hyejin                | Sep 2019 – Apr 2022 | Generating Convincing Simulation of Internalized Voices for Human-avatar Interaction              |                                              |
| Li, Yaxuan                 | Sep 2019 – May 2022 | Towards Context-aware Automatic Multimodal Haptic Effect Generation for Home Theatre Environments |                                              |
| Bouanane, Y.               | Jan 2019 – Dec 2020 | EchoDepth: Using a depth camera and sonification for blind navigation                             | Entrepreneur, sktch.io                       |
| Demers, Marc               | Sep 2018 – Mar 2021 | A Data-Driven Strategy for Evaluating Tacton Perceptual Similarity                                | Data Scientist, Maxen Technologies           |
| Vyas, Preeti               | Sep 2017 – Apr 2020 | Foot-based Haptic Interfaces for Numeric Information Delivery and Dance Learning                  | Ph.D. student, UBC                           |
| Sulmont, E.                | Sep 2017 – Dec 2018 | Improved Learning of Machine Learning by Non-Majors                                               | Curriculum Manager, DataCamp                 |
| Patil, Gandharv            | Jan 2017 – Dec 2019 | Min-Max Inverse Reinforcement Learning for learning bi-modal dialogue policies                    |                                              |
| Girgis, Roger              | Sep 2016 – Apr 2019 | Assessing the Use of Deep Learning in Assisting Visually Impaired People with Outdoor Exploration | Ph.D. student, MILA                          |
| Kim, Taeyong               | Sep 2016 – Aug 2019 | Exploration of foot based interaction for menu control and virtual reality applications           | HRI Researcher, Hyundai Robotics             |

Continued on next page

| Name                        | Period               | Thesis title                                                                 | Present Position                                                      |
|-----------------------------|----------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| Alirezaee, P.               | Sep 2016 – Dec 2019  | Multimodal approaches to improved hospital alarms                            | Product Designer, Unity Technologies                                  |
| Diaz, Manfred               | Sep 2016 – Aug 2017  | Interactive and Uncertainty-Aware Imitation Learning                         |                                                                       |
| Ahmer, Z.                   | Jan 2016 – Jan 2019  | Automated musical accompaniment to children's stories                        |                                                                       |
| Yin, G.                     | Sep 2015 – Oct 2018- | Augmented Reality Tools for Workplace Safety                                 | Software Engineer, Kooltra                                            |
| Fortin, P.                  | Sep 2015 – Aug 2016  | Physiological Perception of Tickling Sensation                               | (fast-tracked to Ph.D. program)                                       |
| Horodniczy, D. <sup>†</sup> | Sep 2014 – Dec 2016  | Characterization and Application of a Variable-Friction Foot Device          | Software Developer, Philips Innovative Imaging Technologies           |
| Vuibert, Vanessa            | Sep 2013 – Aug 2015  | Efficient and Accurate Performance with Unconstrained Mid-air Interaction    | Software Developer, Guavus                                            |
| Hieda, Naoto                | Sep 2012 – Aug 2015  | Digital Video Projection for Interactive Entertainment                       | Visiting Researcher, Pola Art Foundation Fellow, Concordia University |
| Viswanathan, R.             | Jan 2010 – Dec 2012  | Testing the Two-Stream Hypothesis in an Immersive Virtual Environment        | Developer, MontrealTel                                                |
| Knight, Trevor              | Jan 2010 – Sep 2011  | Music Visualization for Open Orchestra (CIRMMT Student Award)                | Software Developer, Noteloop Systems                                  |
| Li, Weizhong                | Sep 2008 – May 2009  | (recommended alternative supervision)                                        |                                                                       |
| Ip, Jessica                 | Sep 2008 – Mar 2011  | Augmented Reality for Interactive Play in a Virtual and Physical Environment | iOS developer, Shopify, Toronto                                       |

Continued on next page

| Name                         | Period              | Thesis title                                                                                              | Present Position                                             |
|------------------------------|---------------------|-----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|
| Namit, Gaurav                | May 2008 – Oct 2009 | (withdrew in 2009 to pursue social entrepreneurship venture)                                              |                                                              |
| El-Shimy, D.                 | Sep 2007 – Dec 2008 | Gestural interaction for complex tasks                                                                    | (fast-tracked to Ph.D. program)                              |
| Law, A.                      | Sep 2007 – Sep 2010 | A Vibrotactile Floor for Enabling Interaction through Virtual Walking Spaces                              | Data Systems Engineer, AECOM, Vancouver                      |
| Benovoy, M.                  | Sep 2006 – Oct 2007 | Biosignals analysis and its application in a performance setting                                          | (fast-tracked to Ph.D. program)                              |
| Audet, Samuel <sup>†</sup>   | 2005-2007           | Shadow Removal from Multi-Projector Displays via Three-Dimensional Modeling and Object Tracking           | Deeplearning4j (Skymind), Tokyo, Japan                       |
| Wozniowski, M.               | 2003-2006           | A framework for interactive three-dimensional sound and spatial audio processing in a virtual environment | research engineer, Société des arts technologiques, Montreal |
| Rudzicz, Frank*              | 2004-2006           | CLAVIUS: Understanding Language Understanding in Multimodal Interaction                                   | Professor, University of Toronto                             |
| Rioux, Francois <sup>†</sup> | 2003-2005           | Software Framework for Parsing and Interpreting Gestures in a Multimodal Virtual Reality Context          | Ph.D., Laval; Software Architect, Thales Canada              |
| Chan, Siu-Chi                | 2002-2005           | Hand and Fingertip Tracking for Gesture Recognition                                                       | Technical Staff, AMD Toronto                                 |
| Hilario, Nadia*              | 2002-2005           | Occlusion Detecion in Front Projection Environments                                                       | Software Developer, Stingray Digital                         |
| Perez, Michael               | 2002-2005           | Multimodal Human-Computer Interaction for a Public Kiosk System                                           | User Interface Designer, Nuance                              |
| Sud, Daniel                  | 2002-2005           | Design of a Multi-Projector Display System                                                                | Senior Producer, Lucky Hammers                               |

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| Name           | Period    | Thesis title                                                                                         | Present Position                        |
|----------------|-----------|------------------------------------------------------------------------------------------------------|-----------------------------------------|
| Boussemart, Y. | 2002-2005 | Design and Implementation of Framework for Immersive Environments in a Shared Context                | Chief Design Officer, Quantum-Black, UK |
| Pelletier, S.  | 2001-2003 | High-Resolution Video Synthesis from Mixed-Resolution Video Based on the Estimate-and-Correct Method | (see above)                             |
| Gu, Jinhua     | 2000-2002 | A distributed software architecture for the Shared Reality Environment.                              | VP, Radian Asset Assurance Inc., NY     |
| Yao, Jie       | 2000-2002 | Human Arm Gesture Detection and Recognition in a Classroom Environment.                              | Ph.D. student, Concordia University     |
| Zhang, Yuan    | 2000-2002 | An efficient coding method for spatial data: the rotating, hierarchical, overlapping representation. | Ph.D. student, University of Delaware   |
| Doutriaux, S.  | 1998-1999 | (withdrew in 1999 to launch start-up company)                                                        |                                         |
| Arseneau, S.   | 1998-2000 | Robust Image Segmentation Towards an Action Recognition Algorithm.                                   | (see above)                             |
| Xu, Aoxiang    | 1998-2000 | A High-Performance Audiovisual Communication System.                                                 | QNX Software Systems, Ottawa            |

\* FRQNT Graduate Scholarship recipient

† NSERC PGS M Scholar recipient

‡ McGill nominee for Northeastern Association of Graduate Schools Distinguished Thesis Award

◊ McCall MacBain Scholar

## ADDITIONAL MASTERS SUPERVISORY SERVICE

I co-supervised a portion of the thesis work of the following students:

- Dever, Ani (Sep 2017-Feb 2018), visiting student from Polytechnic University of Turin, Italy
- Gallo, Nicola (Sep 2015-Feb 2016), visiting student from Polytechnic University of Turin, Italy
- Roy, Louise (Jul-Dec 2015), visiting student from Ensimag, Grenoble, France
- Glessner, David (Feb-Jun 2012). visiting student from Ensimag, Grenoble, France
- Penin, O. (Jul-Aug 2011). visiting student from Paris-Sud 11, France

- Mabire, N. (Apr-Sep 2010). visiting student from Supélec, Metz, France
- Brulé, M. (Feb.-Aug 2009). visiting student from Université de Louis Pasteur, Strasbourg, France
- Anlauff, J. (Dec 2008-Mar 2009). visiting student from Bielefeld University, Germany
- Delattre, G. (Apr-Aug 2007). visiting student from Université Paris VI, France

I served on the supervisory and/or examination committees of the following students:

- Zhonghao Zhao (M. Eng. project), Electrical and Computer Engineering, McGill University
- Anne-Marie Burns, Faculty of Music, McGill University
- Frank Riggi, Electrical and Computer Engineering, McGill University
- Eric Benzacar, Electrical and Computer Engineering, McGill University
- Oles Protsiym, Faculty of Music, McGill University

## FUNDING

## INDIVIDUAL RESEARCH GRANTS AND CONTRACTS

| Date          | Source           | Amount    | Title/Description                                                                                                                                                                                                                                                     |
|---------------|------------------|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2023          | MEDTEQ/<br>NSERC | \$531,000 | <i>Improving Intelligibility of Speech in Noisy Environments.</i> MEDTEQ Partenar-IA funding approved pending successful review of NSERC Alliance grant                                                                                                               |
| 2023          | MEDTEQ/<br>HBHL  | \$282,188 | <i>Haptic devices for conveying non-textual visual information on the internet for individuals with vision loss.</i> MEDTEQ Partenar-IA funding through the Ministère de l'Économie, de l'Innovation et de l'Énergie                                                  |
| 2022          | HBHL             | \$50,000  | <i>Extending Internet Multimodal Access to Graphical Exploration.</i> CFREF Healthy Brains, Healthy Lives Neuro Commercialization Ignite Grant                                                                                                                        |
| 2022          | Meta             | \$30,000  | Unrestricted gift                                                                                                                                                                                                                                                     |
| 2021          | Mitacs           | \$13,333  | <i>Analyse et recherche d'optimisation d'un processus d'adaptation de contenu issu de la numérisation 3D à un contenu photo-réaliste et interactif.</i> Mitacs Accelerate – Intern: Chen, Hongjun                                                                     |
| 2021-<br>2022 | ISED             | \$608,594 | <i>Enabling Access to Graphical Image Content Published via the Internet for People Who Are Blind, Deaf-Blind or Visually Impaired.</i> Innovation, Science and Economic Development Canada (ISED), Accessible Technology Program (Total project budget of \$765,787) |
| 2019-<br>2021 | NSERC/<br>MEDTEQ | \$374,366 | <i>Mixed-Reality Platform for Simulation and Synthesis of Multi-Modal Hallucinations with Applications to Schizophrenia Treatment.</i> Collaborative Research and Development Grant with Industrial Partners, iMD Research and IA Précision Santé Mentale             |
| 2019          | NSERC            | \$25,000  | <i>360 degree imaging for navigation assistance for the visually impaired.</i> Engage Grants Program with Industrial Partner, ImmerVision.                                                                                                                            |
| 2019          | Mitacs           | \$15,000  | <i>Advanced sensor control implementations for energy optimization in commercial buildings using machine learning and data visualisation applied to building automation systems.</i> Mitacs Accelerate – Intern: Demers, Marc                                         |
| 2019          | Mitacs           | \$6,000   | <i>Facilitating Human Interaction with a Robotic Exercise Coach using Smart Objects.</i> Mitacs Globalink – Intern: Vyas, Preeti                                                                                                                                      |

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| Date      | Source  | Amount     | Title/Description                                                                                                                                                                             |
|-----------|---------|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2018      | Mitacs  | \$6,000    | <i>Mobile Remote Implicit Communication.</i> Mitacs Globalink: Intern: Blum, Jeff                                                                                                             |
| 2018      | NSERC   | \$25,000   | <i>Educational wine recommendations from initially sparse data.</i> Engage Grants Program with Industrial Partner, Wineout Inc.                                                               |
| 2017-2018 | McGill  | \$7500     | <i>Physiological confirmation of stimulus reception.</i> Faculty of Engineering TechAccelR Grant                                                                                              |
| 2017-2020 | NSERC   | \$631,650  | <i>Wearable Haptics.</i> Collaborative Research and Development Grant with InterDigital Corporation                                                                                           |
| 2017-2018 | CIRA    | \$44,500   | <i>Intelligent Agent for the Visually Impaired: Vision-based scene description and contextual awareness for Autour.</i> Canadian Internet Registry Authority .CA Community Investment Program |
| 2017-2022 | NSERC   | \$ 222,000 | <i>Multimodal Influences on Perception and Action in Computer-Mediated Environments.</i> Discovery grant.                                                                                     |
| 2017-2018 | MSP     | \$177,673  | <i>Social Media Monitoring Architecture.</i> Research Contract with Ministère de la Sécurité publique                                                                                         |
| 2015      | CIRA    | \$53,878   | <i>What's Around Me? Conveying Environmental Awareness to the Visually Impaired Community.</i> Canadian Internet Registry Authority .CA Community Investment Program                          |
| 2014-2015 | Mitacs  | \$15,000   | <i>Effect of Mobile Technologies in Emergency Response.</i> Mitacs Accelerate – Intern: Erfani-Joorabchi, Minoo                                                                               |
| 2014      | NSERC   | \$25,000   | <i>Haptic user experience delivered through the shoes.</i> Engage Grants Program with Industrial Partner, InterDigital Canada                                                                 |
| 2013-2014 | NSERC   | \$137,474  | <i>3D immersive projection infrastructure with full-body motion capture and analysis.</i> Research Tools and Instruments Grants                                                               |
| 2012-2013 | Mozilla | \$50,000   | <i>Real-Time Emergency Response.</i> Mozilla Ignite Development Challenge (in partnership with the National Science Foundation)                                                               |
| 2012-2017 | NSERC   | \$210,000  | <i>Improved Shared Reality for Multi-Party, Multimodal Simulation and Interaction.</i> Discovery grant.                                                                                       |
| 2012      | Toyota  | \$30,000   | <i>Haptic interaction with an augmented steering wheel.</i> Toyota Infotechnology Centre                                                                                                      |
| 2011      | HP      | \$60,950   | <i>Capturing attention via spatialized audio cues.</i> HP Labs Innovation Research Program (IRP)                                                                                              |
| 2011      | NSERC   | \$25,000   | <i>Improved Parallax Barrier Autostereoscopic Display Software.</i> Engage Grants Program with Industrial Partner, Holoptick Technologies Inc.                                                |

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| Date      | Source       | Amount    | Title/Description                                                                                                                                                                                                                                                         |
|-----------|--------------|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2010-2011 | Google       | \$50,000  | <i>A Spatialized Audio Map System for Mobile Blind Users.</i> Google Faculty Research Awards.                                                                                                                                                                             |
| 2010-2011 | Honda        | \$30,000  | <i>Facial Expression Recognition for Machines.</i> Honda Research Institute.                                                                                                                                                                                              |
| 2010      | UVic         | \$8,000   | <i>NEPTUNE Pleora streamer.</i> University of Victoria software license                                                                                                                                                                                                   |
| 2008-2012 | MDEIE        | \$367,195 | <i>Natural Interactive Walking.</i> Support for International Research and Innovation Initiatives, Ministère du Développement économique, de l'Innovation et de l'Exportation; for Canadian participation in EU FP-7 program with partners in France, Italy, and Denmark. |
| 2007-2010 | MDEIE        | \$15,000  | <i>Un environnement virtual pour la création de musique et de son à partir de systèmes chaotiques.</i> Support for International Research and Innovation Initiatives, Ministère du Développement économique, de l'Innovation et de l'Exportation.                         |
| 2006-2009 | NSERC        | \$317,785 | <i>A pervasive multi-user augmented space for mobile immersive interaction with sound and music.</i> (additional funding for artist collaborator received from Canada Council for the Arts) New Media Initiative STPGP 337999-06.                                         |
| 2006-2011 | NSERC        | \$100,000 | <i>Enhanced video for shared reality environments.</i> Discovery grant.                                                                                                                                                                                                   |
| 2004-2006 | NSERC        | \$136,600 | <i>Soundscape performance works via interactive environment for immersive audiovisual scene generation.</i> (additional funding for artist collaborator received from Canada Council for the Arts) New Media Initiative NMIPJ 307934-04.                                  |
| 2002-2006 | NSERC        | \$100,000 | <i>Shared Reality Interaction over High Bandwidth Connectivity.</i> Discovery grant.                                                                                                                                                                                      |
| 2000      | LUB          | \$100,000 | <i>Distributed Visualization Environment.</i> Laboratoire universitaire Bell Equipment Grant.                                                                                                                                                                             |
| 1999-2000 | Petro-Canada | \$20,500  | <i>Interactive Web Tools for Critique of Presentation Skills and Evaluation of Student Learning.</i> Young Innovator Award.                                                                                                                                               |
| 1999-2002 | FCAR         | \$45,000  | <i>Augmenting an Electronic Classroom for Improved Instructor-Student Interaction.</i> New Researchers Award.                                                                                                                                                             |
| 1999      | FCAR         | \$15,700  | <i>Augmenting an Electronic Classroom for Improved Instructor-Student Interaction.</i> Equipment Grant.                                                                                                                                                                   |
| 1999      | AES          | \$25,000  | <i>Multichannel audio over Internet.</i> Audio Engineering Society.                                                                                                                                                                                                       |

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| Date          | Source | Amount   | Title/Description                                                  |
|---------------|--------|----------|--------------------------------------------------------------------|
| 1999          | OSC    | \$15,000 | <i>Timespace Exhibit</i> . Ontario Science Center contract.        |
| 1999          | MFM    | \$10,000 | <i>Intelligent Classroom tools</i> . McGill Faculty of Management. |
| 1998-<br>2002 | NSERC  | \$76,000 | <i>Reactive Hospital Environment</i> . Discovery research grant.   |
| 1998          | FGSR   | \$20,000 | McGill Graduate Studies and Research Development Fund              |

## TEAM RESEARCH GRANTS AND CONTRACTS

(Percentages refer to my portion.)

| Date      | Source  | Amount             | Title/Description                                                                                                                                                                                                                                                                                  |
|-----------|---------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2023      | Mitacs  | \$150,000<br>(75%) | <i>Avatar Care Provider for Seniors Residences</i> Mitacs Accelerate (with K. Moffatt)                                                                                                                                                                                                             |
| 2022-2025 | CRIAQ   | \$800,000<br>(25%) | †NSERC Alliance with Consortium for Aerospace Research and Innovation of Québec (CRIAQ) <i>ADvanced Airspace Usability (ADAIR)</i> (with P. Doyon-Poulin (Poltechnique), Joon Chung (Ryerson), and 6 aerospace industrial partners)                                                                |
| 2020-2021 | CIRMMT  | \$1,500            | *Agile Seed Funding for <i>Conveying paralinguistic cues and context while teleconferencing</i> (with students David Marino, Max Henry and Pascal Fortin)                                                                                                                                          |
| 2017-2018 | SSHRC   | \$199,680<br>(10%) | † <i>Real time impact signalling and collective goods</i> Partnership Development Grant (with R. Janda and 6 co-investigators)                                                                                                                                                                     |
| 2016-2017 | NAKFI   | \$100,000<br>(20%) | <i>Empathy Mirror</i> National Academies Keck Futures Initiative Art and Science, Engineering and Medicine Grant (with B. Korgel and 3 co-applicants)                                                                                                                                              |
| 2015-2018 | FRQNT   | \$182,880<br>(25%) | † <i>Étude des modèles d'interactivité humain-robot en réalité mixte afin de réduire l'apparition des troubles musculo-squelettiques en utilisant une cellule de travail hybride</i> Recherche en équipes (with M. Otis and 6 co-applicants)                                                       |
| 2014      | Mozilla | \$20,000<br>(90%)  | * <i>Augmented Reality Tools for Improved Training of First Responders</i> Mozilla Gigabit Community Fund (with R. Dearden)                                                                                                                                                                        |
| 2011      | CIRMMT  | \$10,000<br>(90%)  | * <i>Acoustic Sculptures</i> CIRMMT Strategic Innovation Fund Award (with A. Olmos and 3 others)                                                                                                                                                                                                   |
| 2010-2011 | NSERC   | \$49,815<br>(90%)  | * <i>Novel Portable Treatment Device for Lazy Eye</i> Idea to Innovation (I2I) Booster (Phase Ib) (with R. Hess)                                                                                                                                                                                   |
| 2009-2011 | MSG     | \$200,000<br>(80%) | * <i>Location-Based Spatialized Audio Interaction for the Blind and Visually Impaired</i> Programme Appui au passage à la société de l'information (Support for the transition to an information society program), Ministère des Services gouvernementaux (MSG) (with M. Wozniowski and Z. Settel) |
| 2010-2014 | CHRP    | \$327,000<br>(?%)  | <i>Computational and statistical tools for image guided neurosurgery of brain tumors</i> NSERC Collaborative Health Research Projects (with L. Collins and 7 others)                                                                                                                               |

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| Date      | Source  | Amount               | Title/Description                                                                                                                                     |
|-----------|---------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2009-2010 | CCSIP   | \$48,000<br>(4%)     | <i>*Digitally Merged Environments</i> California-Canada Strategic Initiatives Program (with S. Brown, UCSD and 20 co-applicants)                      |
| 2009-2011 | Canarie | \$927,648<br>(40%)   | <i>†Open Orchestra</i> Network-Enabled Platforms 2 (with J. Roston and W. Woszczyk)                                                                   |
| 2010-2014 | NCE     | \$23,000,000<br>(2%) | <i>†GRAND: Graphics, Animation and New Media</i> Networks of Centres of Excellence (With K. Booth and 49 others)                                      |
| 2009      | DND     | \$47,500             | <i>†Video-Based Facial Recognition–Algorithm and Demonstration</i> Department of National Defence Contract (with M. Levine)                           |
| 2008-2009 | NSERC   | \$120,250<br>(90%)   | <i>*Novel Portable Treatment Device for Lazy Eye</i> Idea to Innovation (I2I) (with R. Hess)                                                          |
| 2008-2010 | Canarie | \$1,397,758<br>(7%)  | <i>NEPTUNE: A Platform to Create and Support Ocean Science Virtual Organizations</i> Network-Enabled Platforms (with B. Pirenne and J. Roston)        |
| 2008-2010 | Canarie | \$2,000,000<br>(18%) | <i>Health Services Virtual Organization</i> Network-Enabled Platforms (with R. Ellaway and 8 others)                                                  |
| 2008-2010 | NSERC   | \$196,000<br>(50%)   | <i>*3-D Visualization and gestural interaction with multimodal neurological data</i> Strategic Projects (with 5 others)                               |
| 2006-2009 | FRQNT   | \$146,550<br>(50%)   | <i>*Unités agenceables: Réseau d’Environnements Immersifs pour Collaboration à Distance</i> Recherche en équipes (with X.-W. Sha)                     |
| 2005-2006 | Canarie | \$825,000<br>(50%)   | <i>Undersea Window–High Definition Video Online</i> Intelligent Infrastructure Program. (with J. Roston)                                              |
| 2005-2006 | SAT     | \$1,276,000<br>(1%)  | <i>TOT2: Nouveau Territoires de la Création-Diffusion en Réseau</i> Heritage Canada New Media Research. (M. Savoie, PI)                               |
| 2004-2006 | Canarie | \$568,971<br>(33%)   | <i>Shared Spaces – High Definition Ultra-Videoconferencing</i> Advanced Applications Program. (with J. Roston)                                        |
| 2003-2004 | SAT     | \$792,082<br>(1%)    | <i>TOT1: Nouveau Territoires de la Création-Diffusion en Réseau</i> Heritage Canada New Media Research. (M. Savoie, PI)                               |
| 2002-2005 | IRIS    | \$573,000<br>(25%)   | <i>*Parallel Distributed Camera Arrays for Intelligent Environments</i> (with J. Clark, S. Fels, R. Vertegaal)                                        |
| 2002-2005 | VRQ     | \$2,180,000<br>(20%) | <i>Real-time Communication Of High-res. Multi-sensory Content via Broadband Networks.</i> Valorisation-Recherche Quebec (with W. Woszczyk and others) |
| 2001-2002 | Canarie | \$391,000<br>(30%)   | <i>Remote Video Sign-Language Interpreting.</i> Advanced Networking Apps. Services & Technologies. (with J. Roston and others)                        |

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| Date      | Source     | Amount             | Title/Description                                                                                                                     |
|-----------|------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| 2000-2002 | Canarie    | \$808,000<br>(35%) | <i>McGill Advanced Learnware Project.</i> Advanced Networking Applications Services and Technologies. (with B. Pennycook)             |
| 2000-2003 | LUB        | \$150,000<br>(50%) | <i>*Distributed Shared Visualization Environment.</i> Laboratoire universitaire Bell. (with B. Ozell)                                 |
| 2000-2001 | Royal Bank | \$2,000<br>(80%)   | <i>*Improving Teaching through an Interactive Critiquing System.</i> Teaching Improvement Fund Award. (with R. Harris and J. Blatter) |
| 1999-2002 | CFI        | \$400,000<br>(50%) | <i>†The Shared Reality Environment.</i> New Opportunities Award. (with J. Clark)                                                      |
| 1999-2000 | Royal Bank | \$10,000<br>(80%)  | <i>*Interactive Web Tools for Critique of Presentation Skills and Evaluation of Student Learning.</i> TIF (with R. Harris)            |

\*Indicates grants on which I am project leader. †Grant on which I am co-investigator.

## CENTRE RESEARCH GRANTS

| Date      | Source          | Amount      | Title/Description                                                                                                                                                                   |
|-----------|-----------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2022-2026 | IILS            | \$400,000   | FRQNT International Institute on Learning Systems, funded jointly by CNRS (France) and FRQNT (Quebec), Pablo Piantanida, PI, \$100,000 per annum                                    |
| 2019-2025 | FRQNT           | \$2,160,000 | Regroupement Stratégique pour <i>Systèmes cyberphysiques et intelligence machine matérialisée (REPARTI)</i> . (with C. Gosselin and 49 others) \$480,000 per annum.                 |
| 2015      | CFI             | \$4,366,723 | Innovation Fund: <i>Live Expression “in situ”: Musical and Audiovisual Performance and Reception</i> (with M. Wanderley and 9 others)                                               |
| 2014-2020 | FRQSC/<br>FRQNT | \$1,800,000 | Regroupement Stratégique: <i>Centre Interdisciplinaire de Recherche en Musique, Médias et Technologie</i> . (with M. Wanderley and 23 others)                                       |
| 2013-2019 | FRQNT           | \$2,160,000 | Regroupement Stratégique pour <i>l’Étude des Environnements PARTagés Intelligents répartis (REPARTI)</i> . (with D. Laurendeau and 34 others) \$359,943 per annum.                  |
| 2008-2014 | FRQSC/<br>FRQNT | \$1,800,000 | Regroupement Stratégique: <i>Centre Interdisciplinaire de Recherche en Musique, Médias et Technologie</i> . (with S. McAdams and 23 others)                                         |
| 2007-2009 | NSERC           | \$57,630    | Major Resources Support: <i>Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT)</i> . (with S. McAdams and 8 others)                                       |
| 2006-2013 | FRQNT           | \$1,530,000 | Regroupement Stratégique pour <i>l’Étude des Environnements PARTagés Intelligents répartis (REPARTI)</i> . (with D. Laurendeau and 23 others) \$100,000 per annum allocated to CIM. |
| 2002-2005 | FCAR            | \$720,000   | Regroupement Stratégique: <i>Réseau Québécois de Recherche en Réalité Artificielle Distribuée (QUERRAnet)</i> . (with F. Ferrie, R. Bergevin, P. Cohen, and others)                 |
| 2001      | CFI             | \$6,500,000 | Major Facilities Award: <i>Centre for Integrated Research in Music Media and Technology</i> . (with W. Woszczyk and 11 others)                                                      |
| 2000-2002 | FCAR            | \$113,500   | Centre de Recherches. (with F. Ferrie and 17 others)                                                                                                                                |
| 2000      | NSERC           | \$275,000   | <i>Information Systems in Support of Intelligent Machine Research</i> . (with F. Ferrie and 17 others)                                                                              |

## TEACHING

## COURSES TAUGHT

| Course title and number                                         | Description                                                                                                                                 | Semester               |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| ECSE-618<br><i>Haptics</i>                                      | Graduate course on haptic information design, co-taught with other instructors across Canada, under the informal designation of HAPTICS 501 | Winter 2021–present    |
| ECSE-421<br><i>Embedded Systems</i>                             | Undergraduate course dealing with both the theory and practice of design for embedded systems                                               | 2018–present           |
| ECSE-526<br><i>Artificial Intelligence</i>                      | Graduate level course in artificial intelligence with emphasis on machine learning and autonomous agents                                    | 1998–present           |
| *ECSE-683<br><i>Topics in Vision and Robotics</i>               | Graduate level laboratory course for RoboCup projects                                                                                       | Fall 2000<br>Fall 2002 |
| *ECSE-424/542<br><i>Human-Computer Interaction</i> <sup>†</sup> | Undergraduate (424) and graduate (542) course in human-computer interaction with emphasis on new interface paradigms                        | 2000–present           |
| ECSE-487<br><i>Computer Architecture Laboratory</i>             | Undergraduate laboratory course                                                                                                             | 1999–2018              |
| ECSE-427<br><i>Operating Systems</i>                            | Undergraduate course (core for Computer Engineering students)                                                                               | 1998                   |
| CSC-270<br><i>Introduction to Modelling and Optimization</i>    | Computer Science undergraduate course, University of Toronto                                                                                | 1993–1994              |
| CEE 1714Y<br><i>Digital Systems and Computers</i>               | Continuing Engineering Education course for the Association of Professional Engineers of Ontario                                            | 1993–1994              |
| CSC-228<br><i>File Structures and Data Management</i>           | Computer Science undergraduate course, University of Toronto                                                                                | 1992–1995              |

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| Course title and number                    | Description                            | Semester |
|--------------------------------------------|----------------------------------------|----------|
| COSC-3411                                  | Computer Science undergraduate course, | 1992     |
| <i>File Structures and Data Management</i> | York University                        |          |

\*Indicates new course that I created.

†In 2011, a project from this class placed third in the [Usability Professionals Association International Student Design Competition](#). Note that graduate students have also enrolled in this course under the designation of ECSE-681, *Colloquium in Electrical Engineering* or ECSE-689, *Recent Advances in Electrical Engineering*.

## UNDERGRADUATE SUPERVISION

**ECE Honors Undergraduate Projects (2 semesters)**

| <b>Name</b>                | <b>Year</b> | <b>Research topic</b>                                            |
|----------------------------|-------------|------------------------------------------------------------------|
| Bu, Bruce                  | 2020        | 360° Imaging for Navigation Assistance for the Visually Impaired |
| Akgul, Ahmet               | 2017-2018   | Haptic Wearables                                                 |
| Bashar, Sharhad            | 2016-2017   | Image-based environment description                              |
| Wu, Pei Yuan (Richard)     | 2016        | Mixed-Reality Human-Machine Interaction                          |
| Gordon, Adam               | 2011-12     | Virtual Presence                                                 |
| Warraich, Shahjahan        | 2010-11     | Natural Interactive Walking                                      |
| Lin, Nan                   | 2008        | Location sensing for mobile apps                                 |
| Wang, Letao                | 2007        | Interactive Agent                                                |
| Charlebois, Pierre-Olivier | 2004–2005   | Sound Objects in a Soundscape                                    |
| Myer, Sam                  | 2003        | Automated Music Transcription                                    |
| El-Refaei, Sameh           | 1998–1999   | Shared Reality simulator                                         |

**ECE Undergraduate Design Projects (2 semesters)**

| <b>Name</b>        | <b>Year</b> | <b>Research topic</b>                          |
|--------------------|-------------|------------------------------------------------|
| Cui, Bowen         | 2022-2023   | Immersive multimodal CAVE experience           |
| El Haddad, Georges | 2022-2023   | Immersive multimodal CAVE experience           |
| Fazal, Gohar Saqib | 2022-2023   | Immersive multimodal CAVE experience           |
| Mahajan, Madhav    | 2022-2023   | Immersive multimodal CAVE experience           |
| Pan, Edwin         | 2022-2023   | Touching faces in VR                           |
| Gosman, Mircea     | 2022-2023   | Touching faces in VR                           |
| Justin, Legrand    | 2022        | Vision-guided Navigation Assistance            |
| Sen, Wang          | 2022        | Vision-guided Navigation Assistance            |
| Chamberland, Noah  | 2022        | Vision-guided Navigation Assistance            |
| Natchev Keanu      | 2022        | Novel digital representation of sign language  |
| Arabian Matthias   | 2022        | Novel digital representation of sign language  |
| Destiné, Maxens    | 2022        | Novel digital representation of sign language  |
| Jarvis, Thomas     | 2022        | Natural Dialog Generation for Mental Health    |
| Kong, Norman       | 2022        | Natural Dialog Generation for Mental Health    |
| MacNaughton, Ben   | 2021-2022   | plots data parsing for IMAGE project           |
| Williams, Aidan    | 2021-2022   | plots data parsing for IMAGE project           |
| Nunez, Matteo      | 2021-2022   | Foot-fluid interaction simulation in mobile VR |
| Comeau, Francis    | 2021-2022   | Foot-fluid interaction simulation in mobile VR |
| Gure, Kaan         | 2021-2022   | Foot-fluid interaction simulation in mobile VR |
| Calin, Haluk       | 2021-2022   | ML-based Navigation Assistance                 |
| Cano, Victor       | 2021-2022   | ML-based Navigation Assistance                 |

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| <b>Name</b>         | <b>Year</b> | <b>Research topic</b>                          |
|---------------------|-------------|------------------------------------------------|
| Das Sharma, Kaustav | 2021-2022   | ML-based Navigation Assistance                 |
| Dufault, Louca      | 2021-2022   | ML-based Navigation Assistance                 |
| Simard, Felix       | 2021        | detecting benevolent sexism in text            |
| Watson, Tyler       | 2021        | detecting benevolent sexism in text            |
| Porporino, Anthony  | 2021        | detecting benevolent sexism in text            |
| Bourbeau, Charles   | 2021        | detecting benevolent sexism in text            |
| Ko, Neroli          | 2020-2021   | haptic dance shoes                             |
| Zwack, Noah         | 2020-2021   | haptic dance shoes                             |
| Zhang, Weijing      | 2020-2021   | haptic dance shoes                             |
| Szwimer, Benjamin   | 2020-2021   | visually impaired access to web graphics       |
| Zoltak, Matthew     | 2020-2021   | visually impaired access to web graphics       |
| Itovitch, Ethan     | 2020-2021   | visually impaired access to web graphics       |
| Weiss, Ben          | 2020-2021   | mixed-reality for schizophrenia treatment      |
| Bieber, Nicolas     | 2020-2021   | mixed-reality for schizophrenia treatment      |
| Khan, Marwan        | 2020-2021   | 360° imaging for navigation assistance         |
| Johansen, Anthony   | 2020-2021   | 360° imaging for navigation assistance         |
| Gurkan, Mert        | 2020-2021   | 360° imaging for navigation assistance         |
| Warsi, Osman        | 2020-2021   | 360° imaging for navigation assistance         |
| Lague, Ethan        | 2019-2020   | AR firefighter situational awareness tools     |
| Masciotra, Alex     | 2019-2020   | AR firefighter situational awareness tools     |
| Philippon, Thomas   | 2019-2020   | AR firefighter situational awareness tools     |
| Bouchard, Tristan   | 2019-2020   | AR firefighter situational awareness tools     |
| Smith, Babette      | 2019-2020   | AR and 360: camera-mediated future             |
| Smith, Lilith       | 2019-2020   | AR and 360: camera-mediated future             |
| Chen, Jennie        | 2019-2020   | Foot-fluid interaction simulation in mobile VR |
| Servera, Ryan       | 2019-2020   | Foot-fluid interaction simulation in mobile VR |
| Wong, Tyrone        | 2019-2020   | Foot-fluid interaction simulation in mobile VR |
| Bluethner, Lucas    | 2019-2020   | Foot-fluid interaction simulation in mobile VR |
| Volodina, Yuliya    | 2019        | 360° camera scene understanding                |
| Ritch, David        | 2019        | 360° camera scene understanding                |
| Lam, Guillaume      | 2019        | 360° camera scene understanding                |
| Nasseem, Veronica   | 2019        | 360° camera scene understanding                |
| Amjad, Adeeb Ibne   | 2019        | 360° camera supported intersection-crossing    |
| Amarouche, Hakim    | 2019        | 360° camera supported intersection-crossing    |
| Tang, James         | 2019        | 360° camera supported intersection-crossing    |
| Commodari, Stefano  | 2019        | 360° camera supported intersection-crossing    |
| Regimbal, Juliette  | 2019        | Haptic Wearables                               |
| Radi, Nusaiba       | 2019        | Haptic Wearables                               |
| Berman, Isaac       | 2018        | Vision-based crossing assistance               |
| Mashaal, Stuart     | 2018        | Vision-based crossing assistance               |
| Liu, Shi Yu         | 2018        | Vision-based crossing assistance               |
| Legrand, Augustin   | 2018        | Force Feedback for VR and AR                   |
| Fournier, Clément   | 2018        | Force Feedback for VR and AR                   |

Continued on next page

| <b>Name</b>                | <b>Year</b> | <b>Research topic</b>               |
|----------------------------|-------------|-------------------------------------|
| Nith, Romain               | 2018        | Force Feedback for VR and AR        |
| Malik, Numan               | 2017-2018   | Variable-Friction Surface Mechanism |
| Eshaq, Yousef              | 2017-2018   | Variable-Friction Surface Mechanism |
| Alalawi, Beshr             | 2017-2018   | Variable-Friction Surface Mechanism |
| Ahmed, Ridwan              | 2017-2018   | Variable-Friction Surface Mechanism |
| Nichyporuk, Brennan        | 2017-2018   | AI/vision-based Q&A Dialogue        |
| Benseler, Nick             | 2017-2018   | AI/vision-based Q&A Dialogue        |
| Karatzas, Thomas           | 2017-2018   | Wine recommendation engine          |
| Zhilin, Oleg               | 2017-2018   | Wine recommendation engine          |
| Simard-Morissette, Olivier | 2017-2018   | Wine recommendation engine          |
| Mirfallah Liarestani, N.   | 2017        | Autour                              |
| Kim, Yong Beom             | 2017        | Autour                              |
| Gibeault-Girard, Gabriel   | 2017        | AR firefighter display              |
| Velastegui, Nicolas        | 2017        | AR firefighter display              |
| V Cama, Carmen Aimee       | 2017        | AR firefighter display              |
| Dermont, Daniel            | 2016-2017   | Haptic shoes                        |
| Makriogiorgos, A.          | 2016-2017   | Haptic shoes                        |
| Rohlicek, Greg             | 2015-2016   | Mobile telepresence                 |
| Carter, Stephen            | 2015-2016   | Mobile telepresence                 |
| Zhang, Zhaowei             | 2015-2016   | Haptic shoes                        |
| Huynh, Alex                | 2015-2016   | Haptic shoes                        |
| Guzman, Juan               | 2015-2016   | Video analytics                     |
| Ali, Hassan                | 2015-2016   | Video analytics                     |
| Macario, Daniel            | 2015-2016   | Automated event detection           |
| Arané, Yarden              | 2015-2016   | Automated event detection           |
| Leighton, Brett            | 2015-2016   | Automated event detection           |
| Aird, Nicholas             | 2015-2016   | AR firefighter display              |
| Chen, Yuechuan             | 2015-2016   | AR firefighter display              |
| Lei, Simon                 | 2015-2016   | AR firefighter display              |
| Mendonca, Justin           | 2015-2016   | Firefighter IPS                     |
| Asfour, Justin             | 2015-2016   | Firefighter IPS                     |
| Ward, Thomas               | 2015-2016   | Firefighter IPS                     |
| Laramée, Alexandre         | 2015-2016   | Firefighter IPS                     |
| Sahib, Shivan              | 2015-2016   | Biosignal wearables                 |
| Nath, Saptaparna           | 2015-2016   | Biosignal wearables                 |
| Bramson, Shawn             | 2013-2014   | Mobile Telepresence                 |
| Larose, Andrew             | 2013-2014   | Mobile Telepresence                 |
| Dirik, Alize               | 2013-2014   | Mobile Telepresence                 |
| Mansour, Rita              | 2013-2014   | Walking Straight                    |
| Elkerdi, Ghalia            | 2013-2014   | Walking Straight                    |
| Redel, Josh                | 2012        | Augmented Meeting Collaboration     |
| Savchenko, Eugene          | 2010        | 3D interaction                      |

**ECE Undergraduate Design Projects (1 semester)**

| Name                 | Year | Name              | Year | Name                | Year |
|----------------------|------|-------------------|------|---------------------|------|
| Himmelman, Tristan   | 2009 | Glass, Emily      | 2001 | Li, (Shao-Gi) Chris | 1999 |
| Ephraim, Theo        | 2009 | Asselin, Ramy     | 2001 | El-Sharif, Osama    | 1999 |
| Peck, Benjamin†      | 2008 | Sud, Daniel       | 2001 | Nasereddin, Hazem   | 1999 |
| Mankarios, Daniel    | 2007 | Gapakov, Timofei  | 2001 | Virdi, Gurpratap    | 1999 |
| Konstantinidis, Alex | 2007 | Rosenblatt, Avi   | 2001 | Shah, Ali           | 1999 |
| Pufahl, David        | 2005 | Pekofsky, Gregory | 2001 | Djihanian, Sylvie   | 1999 |
| Zhu, Ming-Zhang      | 2005 | Kitisa, Anousack  | 2000 | Moussaoui, Khaled   | 1999 |
| Chan, Keng Chi       | 2005 | Vial, Thibaut     | 2000 | Dib Youssef         | 1999 |
| Phan, Andrew         | 2004 | Bernier, Martin   | 2000 | Tam, H.             | 1999 |
| Saiffee, Ali-Akber   | 2004 | Agha, Khurram Z.  | 2000 | Gagnon, Gabriel     | 1999 |
| Shield, Robert       | 2004 | Bhattacharya S.   | 2000 | Tjhin, P.           | 1999 |
| Aubé, Francois       | 2004 | Lavery, William   | 2000 | Luong, Mai          | 1999 |
| Rudzicz, Frank       | 2003 | Yeung, Jason      | 2000 | Lau, Sau            | 1999 |
| Sarikaya, Deniz      | 2002 | Liao, Yuan Mei    | 1999 | Tsai, Wanti         | 1999 |
| Vallianatos, K.      | 2002 | Yee, Amy          | 1999 | Lerner, Sorin*      | 1999 |
| Hassaine, Sofiane    | 2002 | Pereira, David    | 1999 | Hochstein, Lorin*   | 1999 |
| Wyse, Marisa         | 2001 | Ciambella, Gary   | 1999 | Pollack, Jonathan   | 1998 |
| Bancroft, David      | 2001 | Kassouf, Nadim    | 1999 | Nguyen, Bau         | 1998 |
|                      |      | Lee, Garvin       | 1999 |                     |      |

\*Co-supervised with James Clark

†Co-supervised with Paul Kry

**Computer Science Undergraduate Projects (1 semesters)**

|               |      |                                                                         |
|---------------|------|-------------------------------------------------------------------------|
| Nejad, Namdar | 2022 | Utilizing Context to Improve Accessible Representations of Web Graphics |
| Li, Dailun    | 2022 | Training and Testing an Open-Source French TTS Model                    |

**Mechanical Engineering Undergraduate Design Projects (2 semesters)**

|                      |           |                                       |
|----------------------|-----------|---------------------------------------|
| Sadaqa, Abdel-Rahman | 2020-2021 | Haptic illusions                      |
| Waite, Emilie        | 2020-2021 | Haptic illusions                      |
| Shi, Rock            | 2020-2021 | Haptic illusions                      |
| Fitz-Gerald, Thomas  | 2020-2021 | Haptic illusions                      |
| Pollet, Nathan       | 2020-2021 | Multimodal haptic armrest             |
| Uzan, Emanuel        | 2020-2021 | Multimodal haptic armrest             |
| Ruivo Patricia       | 2020-2021 | Multimodal haptic armrest             |
| Abravanel Tal        | 2020-2021 | Multimodal haptic armrest             |
| Fowo, Clovis         | 2017-2018 | Haptic interface for the feet         |
| Robert, Gabrielle    | 2015-2016 | Variable friction shoe                |
| King, Michael        | 2013-2014 | Variable Friction Foot-Ground Contact |

**Undergraduate Internships**

| <b>Name</b>             | <b>Year</b>                                                                    | <b>Research project</b>                                                             |
|-------------------------|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Li, Hanzi               | 2022                                                                           | (CS Intern) Internet Multimodal Access to Graphical Exploration (IMAGE)             |
| Gutiérrez, Diego Macias | (Mitacs Globalink) Haptic dance shoes                                          |                                                                                     |
| Cortes, Dafne Peña      | (Mitacs Globalink) Internet Multimodal Access to Graphical Exploration (IMAGE) |                                                                                     |
| Shen, Xing              | 2022                                                                           | (ECE Intern) Vision-Guided Navigation Assistance                                    |
| Dutta, Riana            | 2022                                                                           | (NSERC USRA) Internet Multimodal Access to Graphical Exploration (IMAGE)            |
| Pan, Edwin              | 2022                                                                           | (SURE Student) Touching Face in VR                                                  |
| Chen, Hongye            | 2022                                                                           | (ECE Intern) Internet Multimodal Access to Graphical Exploration (IMAGE)            |
| Behal, Rahul            | 2021-2022                                                                      | ML-based Navigation Assistance for the Visually Impaired                            |
| Rao Appala, Siddharth   | 2021                                                                           | (Mitacs Globalink) Making internet graphics accessible through rich audio and touch |
| Contreras, Luis F. H.   | 2021                                                                           | (Mitacs Globalink) Haptic device for sensory re-education application               |
| Bhayana, Rachit         | 2021                                                                           | (NSERC USRA) Conveying Paralinguistic and Non-Verbal Cues in Teleconferencing       |
| Reszetnik, Grace        | 2021                                                                           | (NSERC USRA) Avatar therapy for psychosis                                           |
| Jiang, Cecilia          | 2021                                                                           | (NSERC USRA) Avatar therapy for psychosis                                           |
| Radi, Rakshitha         | 2021                                                                           | (ECE Intern) Assistive Technology Project                                           |
| Marshall, Kenji         | 2020-21                                                                        | (ECE Intern) Avatar therapy for psychosis                                           |
| Pollet, Nathan          | 2020                                                                           | (SURE Student) 360° camera imaging                                                  |
| Bu, Bruce               | 2019                                                                           | (SURE Student) Haptic Wearables                                                     |
| Chen, Jennie            | 2019                                                                           | (SURE Student) Haptic Wearables                                                     |
| Zhang, Yukai            | 2019                                                                           | (SURE Student) Haptic Wearables                                                     |
| Ratnakirti, Navneet     | 2019                                                                           | (SURE Student) Sweatsponse                                                          |
| Al Taha, Feras          | 2018-2019                                                                      | (NSERC USRA) Haptic Wearables                                                       |
| Nunez, Matteo           | 2018                                                                           | (SURE Student) Haptic Wearables                                                     |

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| <b>Name</b>           | <b>Year</b> | <b>Research project</b>                                                               |
|-----------------------|-------------|---------------------------------------------------------------------------------------|
| Huang, Yixiang        | 2018        | (SURE Student) Non-Intrusive Mobile Experience Sampling                               |
| Li, Zihang            | 2018        | (Mitacs Globalink) Enhanced Remote Viewing Capabilities from a Camera Array           |
| Kaoubi, Hadir         | 2018        | (Mitacs Globalink) Autour: “What’s around me?”                                        |
| Ma, Jiantong          | 2018        | Haptic Zoom                                                                           |
| Tran, Jessica         | 2017        | Social Media Monitoring                                                               |
| Xing, Emily           | 2017        | Attention Switching Protocols in Family Conversations                                 |
| Hao, Ju               | 2017        | (Mitacs Globalink research intern) Haptic shoes                                       |
| Lisus, Daniil         | 2017        | (NSERC USRA) Natural Interactive Walking                                              |
| Tran, Andrew          | 2016-2017   | Multimodal CAVE integration                                                           |
| Sun, Nan Jin (Kelly)  | 2016-2017   | Multimodal CAVE integration                                                           |
| Liu, Yufei (Kevin)    | 2016        | Flexible graphical display of foot-ground interactions                                |
| Kashyap, Sumeha       | 2016        | (Summer Intern from Indian Institute of Technology Guwahati) Walking Straight Project |
| Hamed-Baghi, Bobak    | 2016        | (SURE Student) Game Interaction for Haptic Shoes                                      |
| Dubé, Felix           | 2016        | (SURE Student) Haptic Shoes                                                           |
| Yang, Yanzhe          | 2015        | (Mitacs Globalink) Enhanced Remote Viewing Capabilities from a Camera Array           |
| Morency-Trudel, Juan  | 2015        | (NSERC USRA) Spatialized audio for environmental awareness for the visually impaired  |
| Liu, Bei Chen         | 2015        | (SURE Student) Haptic in-sole design and implementation                               |
| Liu, Shuxuan (Dennis) | 2015        | Multimodal CAVE integration                                                           |
| Chaudhary, Yetesh     | 2014        | Communication in Emergency and Crisis Response                                        |
| Pavlassek, Jana       | 2014        | (NSERC USRA) Natural Interactive Walking                                              |
| Jiang, Mike           | 2014        | (IAESTE student trainee) Graphics Rendering for Multimodal CAVE                       |
| Yin, Guofan           | 2014        | (Mitacs Globalink) Enhanced Remote Viewing Capabilities from a Camera Array           |
| Murgai, Prateek       | 2014        | Acoustic Signal Processing                                                            |
| Sharma, Alok          | 2013-14     | (BITS India Student) rt Emergency Response                                            |

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| <b>Name</b>          | <b>Year</b> | <b>Research project</b>                                                                         |
|----------------------|-------------|-------------------------------------------------------------------------------------------------|
| Gupta, Sakshi        | 2013        | (SURE Student from Indian Institute of Information Technology, Jabalpur) In-Situ Audio Services |
| Brais, Robert        | 2013        | (NSERC USRA) Natural Interactive Walking                                                        |
| Gourdy, Oriane       | 2013        | (Grenoble INP Student) 3DUI Interaction                                                         |
| Jain, Nehil          | 2011-12     | (BITS India Student) In-Situ Audio Services                                                     |
| Sutcliffe, Andrew    | 2011        | Haptically Augmented Steering Wheel                                                             |
| Greencorn, Dan       | 2011        | Food Analysis Simulation                                                                        |
| Redel, Josh          | 2011        | Open Orchestra                                                                                  |
| Varenne, Dylan       | 2011        | (Polytech Nice-Sophia), In-Situ Audio Services                                                  |
| Tomiyoshi, Marcio    | 2011        | (ELAP Scholarship Student) Open Orchestra                                                       |
| Beniak, Stephane     | 2010        | (NSERC USRA) Natural Interactive Walking                                                        |
| Salenikovich, Stepan | 2010        | Natural Interactive Walking                                                                     |
| Chaw, Gary           | 2010        | Natural Interactive Walking                                                                     |
| Redel, Josh          | 2010        | Health Services Virtual Organization                                                            |
| Smith, Severin       | 2009-11     | Natural Interactive Walking                                                                     |
| Rajalingham, Rishi   | 2009        | (NSERC USRA) Natural Interactive Walking                                                        |
| Rener, Farid         | 2009        | (SURE Student) Natural Interactive Walking                                                      |
| Bae, Sung            | 2009        | Optical Tracking for Audio Graffiti                                                             |
| Jathal, Kunal        | 2007        | Haptic and auditory perception in human walking                                                 |
| Lin, Nan*            | 2006        | (NSERC USRA) Interactive navigational control of robotic wheelchair                             |
| Reiter, Philippe     | 2005        | (VP USRA Student) Distributed Video Rendering                                                   |
| Ariane Chan-You      | 2003        | Region-of-Interest Control in Videoconferencing                                                 |
| Ariane Chan-You      | 2002        | Videoconferencing Data Reduction                                                                |
| Gupta, Greeshma      | 2000        | (NSERC Student) Automated slide converter                                                       |
| Cote, Christian      | 2000        | (NSERC Student) Video transformations                                                           |
| Ayatizadeh, Negah    | 2000        | Network communication daemons                                                                   |
| Swartz, Tanya        | 2000        | Speech-based TV-tuner interface                                                                 |
| Cohen, Ouri          | 2000        | Classroom 2000 access control                                                                   |
| Yeong, Jason Aw      | 1999        | (Work Study) Previously Asked Questions system                                                  |

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| <b>Name</b>          | <b>Year</b> | <b>Research project</b>                          |
|----------------------|-------------|--------------------------------------------------|
| Agha, Khurram Zubair | 1999        | (Work Study) URL access tracking                 |
| Lim, Weoi Peng       | 1999        | (Work Study) Graffiti board                      |
| Agha, Haroon Ali     | 1999        | (Work Study) Classroom 2000 minipres. system     |
| Klinger, Zamir       | 2000        | (NSERC Student) Automated Door Attendant         |
| Hooshangi, Sara      | 2000        | (NSERC Student) Intelligent Classroom            |
| Liao, Yuan Mei       | 1999        | Electronic Classroom control interfaces          |
| Luo, Jiexin          | 1999        | PowerPoint C2000 interface and image libraries   |
| Zhao, Changpeng      | 1998-99     | Seamless PowerPoint upload for Classroom 2000    |
| Lakdawalla, Azeem    | 1998-99     | Real-time conjugate-gradient based head-tracking |

\*Co-supervised with Joelle Pineau

## SERVICE

### UNIVERSITY SERVICE

#### Department Committees

|           |                                                                  |
|-----------|------------------------------------------------------------------|
| 2020-2022 | ECE Unit Lab Access Committee                                    |
| 2017-2018 | Undergraduate Recruitment Committee, Chair                       |
| 2017-2020 | Search Committee (Software Engineering, Artificial Intelligence) |
| 2017-2018 | Tenure Committee                                                 |
| 2015-2022 | Safety Committee (Chair in 2015-2017)                            |
| 2014-2016 | Grant Application Support Committee                              |
| 2012-2022 | Graduate Committee                                               |
| 2008-2012 | Undergraduate Recruitment Committee                              |
| 2005-2011 | Scholarships/Graduate Student Financing Committee                |
| 2002      | Ad hoc Committee on Computing Infrastructure for ECE/SOCS        |
| 2000-2008 | College Liaison Committee                                        |
| 2001-2004 | Information Technologies & Undergraduate Lab                     |
| 2000-2002 | Curriculum Committee                                             |
| 2000      | Software Engineering subcommittee                                |
| 2000-2007 | Undergraduate Student Advisor                                    |

#### Other University Service

|           |                                                                                                                                                                                        |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2014-2016 | Elected Member of Council, McGill Association of University Teachers                                                                                                                   |
| 2009-2013 | Member, CIRMMT Executive Committee                                                                                                                                                     |
| 2007-2013 | Co-chair, Multimodal Immersive Systems research axis, CIRMMT                                                                                                                           |
| 2006-2008 | Member, CIRMMT Board of Directors                                                                                                                                                      |
| 2006      | Advisory Committee for Dean of Music                                                                                                                                                   |
| 2004      | Tomlinson University Science Teaching Project adjudication                                                                                                                             |
| 2003-2004 | Royal Bank Teaching and Learning Innovation Fund adjudication                                                                                                                          |
| 2003      | Groupe de travail sur les normes et standards de la formation en ligne. Conférence des recteurs et des principaux des universités du Québec (CREPUQ), McGill University Representative |
| 2002-2003 | SC-IST Workgroup on Research Computing                                                                                                                                                 |
| 2000-2003 | SC-IST Workgroup on Classroom Design                                                                                                                                                   |
| 1999-2004 | Engineering Committee on Teaching and Learning                                                                                                                                         |
| 1999      | SC-IST McGill Machine Project                                                                                                                                                          |
| 1998      | Workgroup on Educational Technology                                                                                                                                                    |

#### Fundraising Activities

|           |                                                                                           |
|-----------|-------------------------------------------------------------------------------------------|
| 2002      | RoboCup demonstration at McCord museum for Dean's Circle                                  |
| 2002      | Corporate fundraising for McGill RoboCup team                                             |
| 2001-2002 | Intelligent Classroom promotion with the Engineering Class of '50; helped raise \$274,000 |
| 2001      | Trottier Building research promotion                                                      |

**Other Activities**

|           |                                                                                            |
|-----------|--------------------------------------------------------------------------------------------|
| 2007-2010 | Promotion of Academic Integrity                                                            |
| 2001-2002 | Design of new Intelligent Classroom systems for ENGM 304                                   |
| 1999-2002 | Maintenance of the Intelligent Classrooms, training other faculty in use of the technology |
| 1999      | Curriculum development of three new courses in software engineering                        |

**PROFESSIONAL ACTIVITIES****Service to the Community**

|              |                                                                                                                                                                       |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2019         | Government of Canada, Network of Canadian Experts on Virtual Reality                                                                                                  |
| 2018         | Consulted by Ordre des ingénieurs du Québec regarding the OIQ's position on AI                                                                                        |
| 2018         | Invited Member, Fonds de recherche, Chantier sur l'intersectorialité et la créativité                                                                                 |
| 2018         | Co-chair, ACM SIGCHI Demonstrations                                                                                                                                   |
| 2017         | External member of academic selection committee, École de technologie supérieure                                                                                      |
| 2016         | Organizing Committee, IEEE International Workshop on Multimedia Signal Processing, Special Session on Multimodal Interaction with Digital Information in Smart Cities |
| 2016, 2019   | Selection Committee, Bill Buxton HCI Thesis Award                                                                                                                     |
| 2016         | Digital Media Program Review, York University                                                                                                                         |
| 2016         | Critique of TCPS CORE Tutorial on Research Ethics (Secretariat agreed to remove problematic question associated with the Zimbardo study)                              |
| 2010-2015    | Theme Leader, Enabling Technologies, Graphics Animation and New Media (GRAND) Networks of Centres of Excellence                                                       |
| 2010-ongoing | Voting Member, IEEE Communication Society Multimedia Communications Technical Committee (IEEE MMTC)                                                                   |
| 2009         | Organizer and Chair, AES Workshop on Network Technologies for Audio over IP                                                                                           |
| 2008         | Tenure Portfolio evaluation, York University                                                                                                                          |
| 2005-2006    | Organizer, AES Tutorial and Workshop on Human Factors in Audio                                                                                                        |
| 2004         | Founder, AES Technical Committee for Human Factors in Audio Systems                                                                                                   |
| 2003         | Organizer, Workshop on LAN Delivery of Audio for AES                                                                                                                  |
| 2002-2003    | Comité Scientifique de Robofolies, Centre Science de Montreal                                                                                                         |
| 2001         | Local Events Organizer, Autonomous Agents Conference, Montreal                                                                                                        |
| 2001-2009    | Chair, AES Technical Committee for Network Audio Systems                                                                                                              |
| 2000-2004    | Scientific Organizer, RoboCup Junior, Montreal                                                                                                                        |
| 2000-2001    | Organizing Committee, Robofesta International Robot Games Festival, Japan                                                                                             |
| 1999-2000    | Member and Webmaster, Canadian Virtualized Reality Working Group                                                                                                      |
| 1998         | Co-organizer, AAAI Symposium on Intelligent Environments                                                                                                              |

**Editorial Service**

|              |                                                                                                   |
|--------------|---------------------------------------------------------------------------------------------------|
| 2021-ongoing | Associate Editor, IEEE Transactions on Haptics                                                    |
| 2021         | Senior Program Committee, International Conference on Multimodal Interaction                      |
| 2021         | Guest Editor, IEEE Transactions on Haptics (WHC track)                                            |
| 2020-ongoing | Associate Editor, Frontiers in Virtual Reality                                                    |
| 2019         | Associate Editor, World Haptics Conference                                                        |
| 2019         | Guest Editor, Multimodal Technologies and Interaction, Special Issue on Multimodal Medical Alarms |
| 2018-2022    | Associate Editor, Program Committee member, Haptics Symposium                                     |
| 2013         | Guest Editor, Journal of the Audio Engineering Society, Special Issue on Audio Networking         |
| 2008-2022    | Associate Editor, Journal of the Audio Engineering Society                                        |

**Journal Referee**

|              |                                                               |
|--------------|---------------------------------------------------------------|
| 2022         | IEEE Multimedia                                               |
| 2021         | ACM Transactions on Human-Computer Interaction                |
| 2020-21      | ACM Transactions on Applied Perception                        |
| 2020         | ACM Interactive, Mobile, Wearable and Ubiquitous Technologies |
| 2019         | Frontiers in Neurobotics                                      |
| 2018         | Peer J–Journal of Life & Environmental Sciences               |
| 2017         | Sensor Review                                                 |
| 2015         | Ambient Intelligence and Smart Environments                   |
| 2010-20      | IEEE Transactions on Haptics                                  |
| 2012         | International Journal on Acoustics                            |
| 2011         | BMC Medical Informatics and Decision Making                   |
| 2011         | IEEE Software                                                 |
| 2010         | IEEE Transactions on Affective Computing                      |
| 2010         | IEEE Transactions on Robotics                                 |
| 2010         | IEEE Signal Processing Magazine                               |
| 2009         | IEEE Transactions on Robotics                                 |
| 2008         | EURASIP Advances in Signal Processing                         |
| 2008         | EURASIP Image and Video Processing                            |
| 2008-ongoing | Audio Engineering Society                                     |
| 2007         | IEEE Transactions on Systems, Man, and Cybernetics            |
| 2006         | International Journal of Human-Computer Interaction           |
| 2006         | Springer Virtual Reality                                      |
| 2005         | Elsevier: Computers and Education                             |
| 2005         | Elsevier: Image and Vision Computing                          |
| 2004, 2019   | IEEE Pervasive Computing                                      |
| 2000, 2003   | Wiley Journal of Robotic Systems                              |
| 1999         | ACM Transactions on Computer-Human Interaction                |
| 1999         | IEEE Transactions on Robotics and Automation                  |
| 1998         | IEEE Personal Communications                                  |

**Conference Review**

|                     |                                                                               |
|---------------------|-------------------------------------------------------------------------------|
| 2020                | IEEE Virtual Reality                                                          |
| 2018, 2020          | ACM SIGCHI User Interface Systems and Techniques                              |
| 2018                | Workshop on Assistive Computer Vision and Robotics                            |
| 2018                | Eurohaptics                                                                   |
| 2017                | International Conference on Auditory Display                                  |
| 2017                | Mobile HCI                                                                    |
| 2017-19             | IEEE World Haptics                                                            |
| 2016                | IEEE International Workshop on Multimedia Signal Processing                   |
| 2015                | ACM Multimedia                                                                |
| 2015                | INTERACT                                                                      |
| 2014                | ACM SIGGRAPH                                                                  |
| 2012, 2013          | Workshop on Context Based Affect Recognition                                  |
| 2012, 2013          | International Society for Presence Research                                   |
| 2012                | IEEE Canadian Conference on Electrical and Computer Engineering               |
| 2011                | AES Conference on Audio Networking                                            |
| 2011                | Intelligent Robots and Systems                                                |
| 2011                | VRIC Wkshop on Haptics for Telepresence, Teleoperation & Collab. Environments |
| 2009                | IEEE Haptics Symposium                                                        |
| 2009                | International Computer Music Conference                                       |
| 2009                | Stereoscopic Displays and Applications                                        |
| 2008-19             | ACM SIGCHI Human Factors in Computing                                         |
| 2008                | Immersive Medical Telepresence                                                |
| 2006                | International Conference on Digital Audio Effects                             |
| 2006, 2007          | IEEE Workshop on Projector-Camera Systems (part of CVPR)                      |
| 2005-2009           | Canadian Conference on Computer and Robot Vision                              |
| 2004, 2009-14, 2016 | Graphics Interface                                                            |
| 2003, 2006          | Audio Engineering Society                                                     |
| 2003                | New Interfaces for Musical Expression                                         |
| 2002                | RoboCup International Symposium                                               |
| 2002, 2015          | IEEE International Conference on Robotics and Automation                      |
| 2001                | ACM UbiComp                                                                   |
| 2001                | IEEE International Conference on Computer Vision                              |

**Grant Review**

|                  |                                                                       |
|------------------|-----------------------------------------------------------------------|
| 2017             | NSERC Strategic Project Grants                                        |
| 2017             | Member of Expert Committee, CFI Innovation Fund                       |
| 2016             | L'Agence Nationale de la Recherche (France)                           |
| 2011             | NSERC Collaborative Research and Training Experience Program (CREATE) |
| 2009, 2011       | Mathematics of Information Technology and Complex Systems (MITACS)    |
| 2009             | NSERC Strategic Networks (Site Visit Chair)                           |
| 2008, 2015, 2017 | Peer review, NSERC Collaborative Research and Development Grants      |
| 2007-2008        | NSERC Industrial Research Chair (Site Visit)                          |
| 2007-2020        | Research Grants Council, Hong Kong                                    |
| 2005             | NSERC Steacie Memorial Fellowship                                     |
| 2002, 2005-2008  | Panel member, NSERC/Canada Council, New Media Initiative              |
| 2001-2017        | Peer review, NSERC Discovery Grants                                   |
| 2001, 2008       | Peer review, CFI (Canada Foundation for Innovation)                   |

**Participation in Academic Fora**

|      |                                                                |
|------|----------------------------------------------------------------|
| 2019 | San Diego Opera – Opera Hack, July 27-28                       |
| 2019 | Dagstuhl Seminar on Ubiquitous Computing Education, June 2-7   |
| 2010 | Participant, NSF/CCC Workshop on Ultra-Large Scale Interaction |

**CONSUMER ADVOCACY**

|              |                                                                                                                             |
|--------------|-----------------------------------------------------------------------------------------------------------------------------|
| 2013         | brought successful appeal ( <a href="#">2013 QCCA 1670</a> ) before Quebec Court of Appeal regarding anti-SLAPP legislation |
| 2013         | initiated petition to <a href="#">improve rights of Canadian airline passengers</a>                                         |
| 2010         | advocating for <a href="#">reliable public transportation</a> in Montreal                                                   |
| 1997-present | created and maintained <a href="#">passenger rights website</a>                                                             |