

Declaration of Jeremy Cooperstock, Ph.D. in Support of
Petition for *Inter Partes* Review of
U.S. Patent No. 10,269,222 B2

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
Petitioner

v.

IMMERSION CORPORATION,
Patent Owner

Case IPR2023-00944
U.S. Patent No. 10,269,222 B2
Issue Date: April 23, 2019

Title: SYSTEM WITH WEARABLE DEVICE AND HAPTIC OUTPUT DEVICE

DECLARATION OF JEREMY COOPERSTOCK, PH.D.

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U.S. Patent No. 10,269,222 B2

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I, Jeremy Cooperstock, declare as follows:

I. INTRODUCTION AND QUALIFICATIONS

A. Qualifications and Experience

1. I am a 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. 10,269,222 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. 10,269,222 B2 (“222 patent”) [EX1001] and its prosecution history. I have cited to the following documents in my analysis below:

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Exhibit No.	Description of Document
1001	U.S. Patent No. 10,269,222 B2 to Allan Visitacion et al. (filed July 24, 2015, issued April 23, 2019) (“ ’222 ” or “ ’222 patent ”)
1003	U.S. Patent Application Publication No. 2009/0289955 A1 to Stephan Douris et al. (filed May 22, 2008, published November 26, 2009) (“ Douris ”)
1004	U.S. Patent Application No. 2012/0028577 A1 to Tony F. Rodriguez and William Y. Conwell (filed June 30, 2011, published February 2, 2012) (“ Rodriguez ”)
1005	Excerpts from <i>Microsoft Computer Dictionary</i> (5th ed. 2002)
1006	Joint Claim Construction Statement, <i>Immersion Corp. v. Meta Platforms, Inc.</i> , No. 6:22-cv-00541-ADA (W.D. Tex.) (dated Jan. 21, 2023)
1007	Prosecution history of the ’222 patent

II. PERSON OF ORDINARY SKILL IN THE ART

10. I understand 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 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 ’222 patent, I have assumed that date to be March 15, 2013, the filing date of the earliest patent application to which the ’222 patent

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claims priority (Appl. Ser. No. 13/841,551). I am also informed that in the related district court litigation, Patent Owner has asserted that the '222 patent is entitled to an April 23, 2012 priority date. I express no opinion on whether the '222 patent is actually entitled to a priority date as early as April 23, 2012. This issue is not relevant here because all of the prior art references relied upon pre-date that date, and my analysis and conclusions (including POSITA definition) would not change if a priority date as early as April 23, 2012 were applied. In the event a priority date before March 15, 2013 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 advised 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 '222 patent states that it relates to “a system with a wearable device, a second device, and a haptic output device that is configured to generate feedback based on an event that occurs in an environment related to the wearable

device and/or the second device.” (’222, 1:14-18.)

13. In my opinion, a person of ordinary skill in the art as of March 2013 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 and for processing images captured by a device (such as detecting objects in digital images captured by a camera). 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.

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 be relevant to an engineer or scientist 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 '222 patent have been based on the perspective of a person of ordinary skill in the art as of March 2013.

III. STATEMENT OF LEGAL PRINCIPLES

A. Claim Construction

16. I understand 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 understand 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 further understand that other claims of the patent in question, both asserted and unasserted, can be valuable sources of information as to the meaning of

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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 understand 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.

20. I understand 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 understand that in the related district court litigation, the parties dispute the meaning of one term appearing in the challenged claims: “**augmented reality.**” Petitioner asserts that “augmented reality” as used in the ’222 patent means “*one or more physical objects in a real-world, physical space are concurrently displayed with one or more virtual objects in a virtual space,*” while Patent Owner asserts that the term should be given its “*plain and ordinary meaning*” but “*to the extent that the Court believes that any further construction is necessary, the plain and ordinary meaning includes ‘an environment comprising a physical space of one or more physical objects and a virtual space of one or more virtual objects that are displayed coincident with or in association with one or more physical objects in the physical space.’*” (EX1006 (Joint Claim Construction Statement), p.003.) The parties also agreed that the word “chain” recited in claim 15 should be “claim.” (*Id.*) For purposes of my analysis here, I do not believe express claim constructions are necessary because the prior art renders the claims obvious under these competing claim constructions or any other reasonable construction.

B. Obviousness

23. I understand 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 understand 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 understand 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 understand 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

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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 understand 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 understand one way that a patent can be found 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

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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 understand 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 understand 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:

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- (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 understand 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 understand 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 '222 PATENT

A. Overview of the Specification

33. The '222 patent, entitled “System with Wearable Device and Haptic Output Device,” states that it “relates to a system with a wearable device, a second device, and a haptic output device that is configured to generate feedback based on an event that occurs in an environment related to the wearable device and/or the second device.” ('222, 1:14-18.)

34. In the “Background” section, the '222 patent acknowledges “[a]ugmented reality devices [that] provide an augmented reality environment in

which physical objects in a physical space are concurrently displayed with virtual objects in a virtual space,” as well as “augmented reality devices [that] can recognize specific, known physical objects using image recognition such as by transmitting images to a server that performs the image recognition.” (’222, 1:22-32.) The ’222 patent asserts that “[d]espite advances in augmented reality systems, the ability to interact with an augmented virtual environment is limited. Providing useful feedback to the user is also limited. In addition, recognizing objects in the virtual reality environment may be computationally intensive and reduce usability in many instances.” (’222, 1:33-38.)

35. The patent purports to describe “a wearable device that is configured to generate feedback based on an event that occurs in an environment related to the wearable device.” (’222, 1:42-44.) The wearable device “may be configured as eyewear” and configured to display an “AR [augmented reality] environment via one or both lenses of the eyewear.” (’222, 5:4-11, 5:60-62.) The wearable device may be in communication with a server and/or another device. (’222, 2:46-49.) The wearable device may include a haptic output device configured to provide haptic feedback based on an event in an environment of the wearable device. (’222, 7:1-9; *see also id.*, 2:20-31 (listing examples of an event).) The wearable device may provide different haptic feedback in response to different events. (’222, 10:30-41.)

36. I discuss additional aspects of the '222 patent as needed in the analysis below.

B. The Challenged Claims

37. This Declaration addresses claims 1, 2, 5, 7, 10, 11, 15, 17, 18, 21, and 23 of the '222 patent. Claims 1, 10 and 17 are independent claims. Independent claim 1 recites:

1. A system comprising:

[a] a wearable device;

[b] a second device remote from and in communication with the wearable device;

[c] a processor configured to generate at least a first control signal and a second control signal representative of a first event and a second event, respectively, occurring in an environment related to the wearable device and/or the second device, the first event and the second event being different events; and

[d] a haptic output device configured to provide a first haptic feedback signal and a second haptic feedback signal based on the first control signal and the second control signal, respectively.

('222, 29-42 (claim 1) (bracketed notations, e.g. “[a],” added).) Independent claim 10 recites:

10. A system comprising:
 - [a] an augmented reality device configured to generate an augmented reality environment comprising an augmented reality space and a physical space, the augmented reality device comprising
 - [b] a processor configured to detect a plurality of events that occur in the environment related to a wearable device, the processor configured to generate the augmented reality space coincident with the physical space,
 - [b][1] recognize at least one physical object in the physical space and augment the at least one physical object with one or more virtual objects in the augmented reality space, and
 - [b][2] determine an event associated with the augmented reality environment, and
 - [b][3] generate a control signal based on the determined event;
 - [c] the wearable device remote from and in communication with the augmented reality device;
 - [d] a remote device remote from and in communication with the wearable device and the augmented reality device; and
 - [e] a haptic output device configured to provide a plurality of haptic feedback signals based on the control signal.

(’222, 29:20-44 (claim 10) (bracketed notations added).) Independent claim 17 recites:

17. A method comprising;
 - [a] detecting an event in an environment, the detecting performed at least in part with a processor,
 - [b] generating a control signal representative of an event occurring in the environment related to a wearable device and/or a second device with the processor, the generated control signal being a first control signal selected from at least first and second available control signals, the first control signal representative of the event, the second control signal representative of a different event; and
 - [c] providing a plurality of haptic feedback signals based on the control signal with a haptic output device.

(’222, 30:3-16 (claim 17) (bracketed notations added).) I address the claims further in my detailed analysis in **Part V** below.

V. APPLICATION OF THE PRIOR ART TO CHALLENGED CLAIMS

38. 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 ’222 patent would have been obvious to a person of ordinary skill in the art based on the following combinations of the prior art.

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Ground	Claims	Basis for Challenge (Obviousness)
1	1, 2, 5, 7, 10, 11, 15, 17, 18, 21, 23	Douris in view of Rodriguez

39. I am informed by counsel that both Douris and Rodriguez qualify as prior art to the challenged claims because they were both filed and published before the '222 patent priority date (March 15, 2013), as well as the April 23, 2012 priority date that Patent Owner has asserted in the related district court litigation.

A. Brief Summary and Overview of the Prior Art

40. The challenged claims of the '222 patent attempt to lay claim to techniques for using haptic feedback in systems providing augmented reality (“AR”) and/or virtual reality (“VR”) interfaces that were already well-known long before March 2013. The patent asserts that “[d]espite advances in augmented reality systems, the ability to interact with an augmented reality environment is limited” as is “providing useful feedback to the user.” ('222, 1:33-35.) In fact, the prior art was rich with techniques to interact with an augmented reality environment and to provide useful feedback to a user, including the prior art I discuss below.

1. Douris [EX1003]

41. **Douris**, U.S. Patent Application Publication No. 2009/0289955 A1 to Stephan Douris et al., is entitled “Reality Overlay Device.” I am informed that

Douris qualifies as prior art because it was filed on May 22, 2008 and published on November 26, 2009, both dates being before the March 15, 2013 priority date of the challenged claims (as well as the April 23, 2012 date that Patent Owner has asserted in the related district court litigation).

42. Douris describes a “reality overlay device” that may take the form of glasses or sunglasses, as shown in Figure 1:

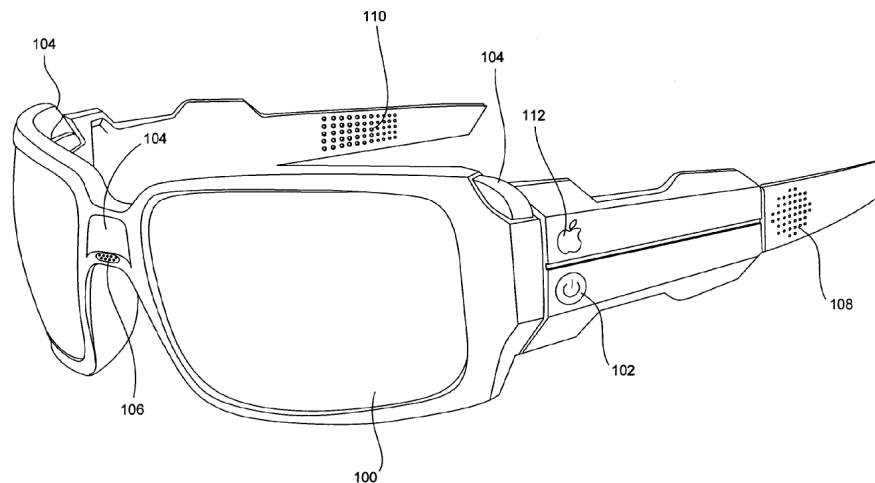


FIG. 1

(Douris, Fig. 1.) Referring to Figure 1, Douris explains that a reality overlay device has the ability to superimpose a transparent overlay of information pertinent to the wearer’s surroundings:

FIG. 1 is a diagram illustrating an example reality overlay device in which various embodiments may be implemented. In one embodiment, the reality overlay device is a device that is wearable by the user of the device. In this example, the reality overlay device is shaped in the form

of glasses or sunglasses that a user may wear. More specifically, the reality overlay device may include one or more transparent lenses **100** that enable a user to view his or her surroundings through the transparent lenses **100**. Specifically, the transparent lenses **100** may function as screens that enable a transparent overlay to be displayed.

(Douris, ¶0022; *see also id.*, ¶¶0005 (“the reality overlay device is a wearable device that may be worn on the face of the user of the device”), 0006 (“transparent overlay provides one or more transparent images that are pertinent to and in correlation with the physical surroundings”), 0021 (“the transparent visual overlay may be displayed such that it overlays the field of vision of the wearer of the overlay device”), 0030 (“The reality overlay device may superimpose the transparent overlay via the device using the overlay information via one or more of the lenses **100**, wherein the transparent overlay provides one or more transparent images (e.g., static or video) that are pertinent to the physical surroundings.”).)

43. Figures 5 and 6 of Douris illustrate examples of transparent overlays superimposed on the wearer’s surroundings, such as overlays for people or businesses that are in the vicinity of the wearer:

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U.S. Patent No. 10,269,222 B2

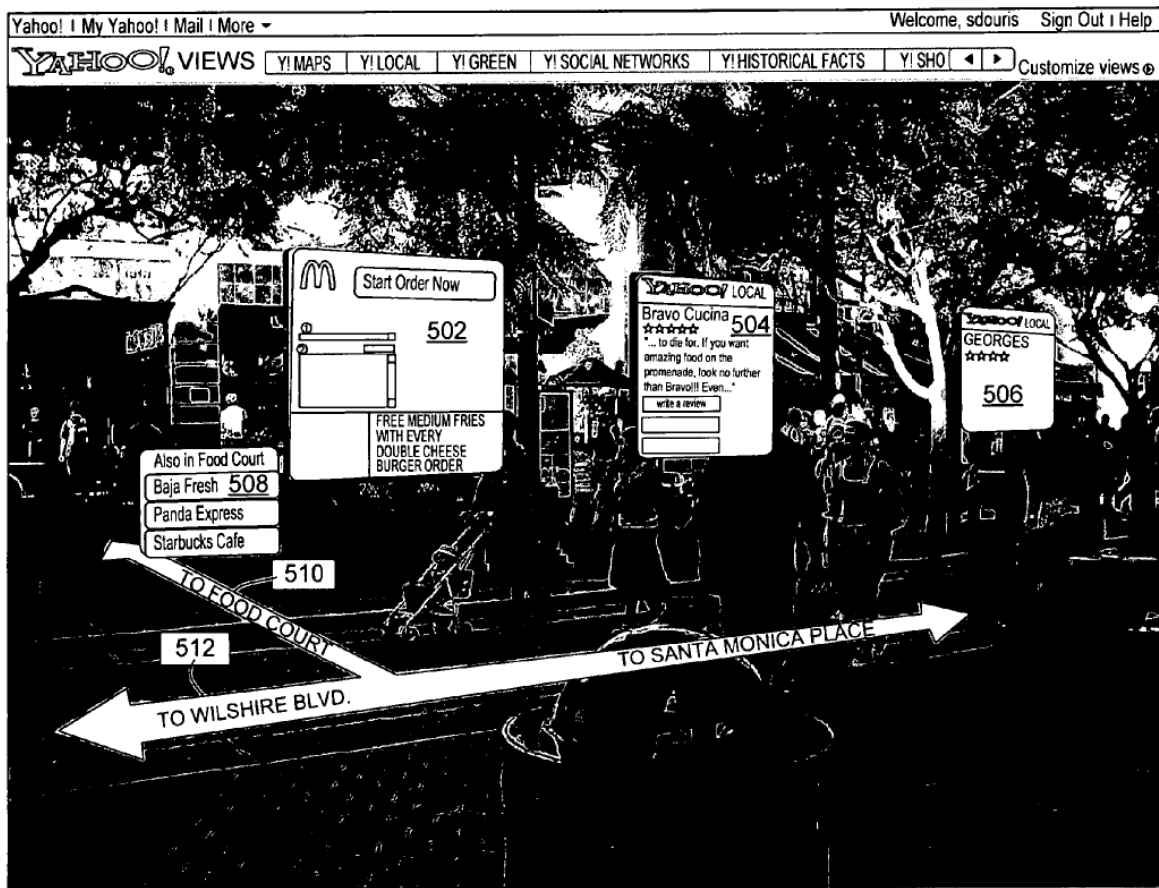


FIG. 5

(Douris, Fig. 5 (showing overlay information for three restaurants in the vicinity of the wearer of the reality overlay device); *see also id.*, ¶¶0051-0053.)

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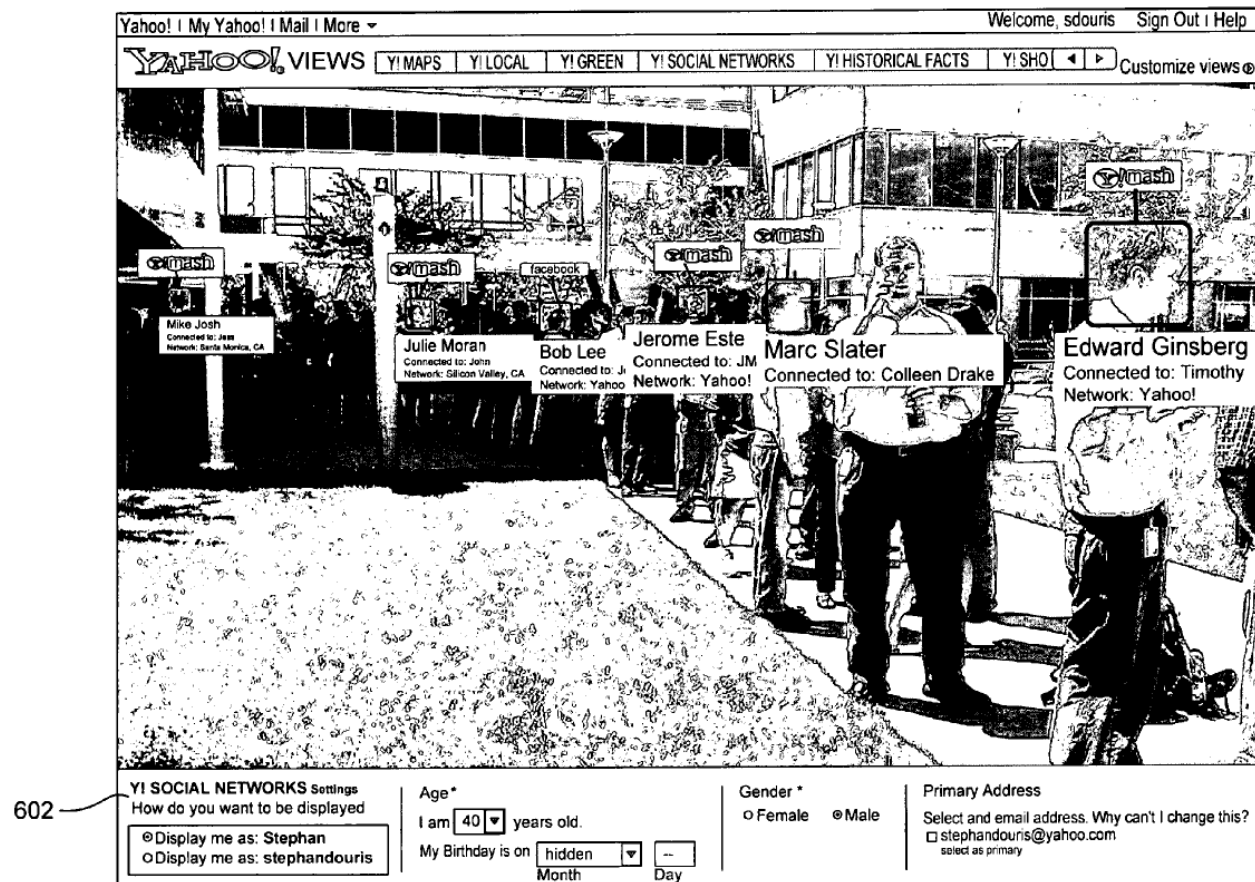


FIG. 6

(Douris, Fig. 6 (showing overlay information for people in the vicinity of the wearer of the reality overlay device); *see also id.*, ¶¶0058-0060 (“The social view may provide information associated with one or more individuals.”).)

44. I will provide more information about Douris in my discussion of the claim limitations below.

2. Rodriguez [EX1004]

45. **Rodriguez**, U.S. Patent Application Publication No. 2012/0028577 A1

to Tony R. Rodriguez and William Y. Conwell, is entitled “Mobile Devices and Methods Employing Haptics.” I am informed that Rodriguez qualifies as prior art because it was filed on June 30, 2011 and published on February 2, 2012, both dates being before the March 15, 2013 priority date of the challenged claims (as well as the April 23, 2012 date that Patent Owner has asserted in the related district court litigation).

46. The challenged claims recite a “**haptic output device**” and associated functionality. Douris identifies at least two ways – video and sound – to provide feedback to a wearer of a reality overlay device in response to events, such as being in the vicinity of a particular restaurant or person, but does not describe providing haptic feedback. (Douris, *e.g.*, ¶¶0031, 0035-0038, 0051-0053, 0058-0060, 0063.) But as I explain in my analysis of the claims below, it would have been obvious to incorporate haptic functionality into Douris’s system.

47. Rodriguez explains that “[h]aptics devices (sometimes termed ‘force feedback’ devices) are becoming more widespread” (Rodriguez, ¶0003), including in augmented reality systems (Rodriguez, ¶¶0009-0010 (describing ARToolKit and applications)). Rodriguez describes techniques using a “haptic signature” to provide specific haptic feedback to a mobile device user in response to recognizing that the user is in the vicinity of a particular person or other entity/object. A haptic signature

can describe, for example, the waveform, amplitude, frequency, and duration of haptic feedback:

A method according to one aspect of the present technology includes using a mobile device to capture image data representing a physical object. This data is then processed (e.g., by the mobile device, and/or by a remote system) so as to obtain metadata that corresponds to the object. This metadata is transmitted to a remote system. In response, data is received indicating a haptic signature that is associated with the object. This haptic signature is presented to a user of the mobile device, e.g., through one or more onboard or linked haptic actuators.

The metadata can indicate one of plural classes to which the physical object belongs. If it belongs to a first class, one haptic signature can be rendered; if it belongs to a second class, a different haptic signature can be rendered. These signatures can differ in one or more of, e.g., waveform, amplitude, frequency, and duration. The classes can be classes such as a class of persons, a class of books, a class of DVDs, a class of barcodes, a class of printed text, a class of landmarks such as buildings, a class of logos, a class of works of art, and a class of product containers. Or each class can comprise a unique physical object.

(Rodriguez, ¶¶0018-0019; *see also id.*, ¶¶0022 (“[W]hen imagery captured by the mobile device includes visual stimulus of that first class, a corresponding type of haptic signal is output to the user.”), 0050 (“Once identification data has been obtained for a nearby object, the phone can determine what haptic signature to

render.”).) For example, a specific haptic signal can be used to “indicat[e] proximity to social network friends.” (Rodriguez, ¶¶0075, 0085 (“haptically indicate the presence of friends with the user’s social network at such location, by a distinctive ‘friend(s) here’ signature when that location of the map is sensed (or when the user approaches that physical location in the festival)”)).) As another example, a haptic signature may “indicate[] (e.g., by amplitude or frequency) the relative popularity of one of the establishments based the number of mobile devices currently inhabiting that location.” (Rodriguez, ¶0085.)

48. Rodriguez also notes that the mobile device that provides haptic feedback can take a variety of forms, including a wearable computer. (Rodriguez, ¶0092 (“For example, while reference has been made to smartphones, it will be recognized that this technology finds utility with all manner of devices—both mobile and fixed. Portable music players, gaming devices, electronic wallets, tablet computers, wearable computers, etc., can all make use of the principles detailed herein.”)).) In fact, Rodriguez expressly identifies positioning haptic feedback devices both on eyewear and by the user’s ears. (Rodriguez, ¶0074 (“A user’s preferred haptic input may be through actuator-equipped earbuds (which also provide audible output). If stimulus is already being applied to the two earbuds (which may be operated independently), new stimulus may be applied to a secondary

site, e.g., the soles of the user's feet, by an actuator device conveyed within the user's shoes. (Again, these may be operated independently.) A tertiary site may be an actuator positioned on the bridge of the user's nose, as by eye wear.")

49. I will provide more information about Rodriguez in my discussion of the claim limitations below.

B. Ground 1: Claims 1, 2, 5, 7, 10, 11, 15, 17, 18, 21, and 23 Are Obvious Over Douris in View of Rodriguez.

1. Claim 1

50. For reference, claim 1 recites:

1. A system comprising:

[a] a wearable device;

[b] a second device remote from and in communication with the wearable device;

[c] a processor configured to generate at least a first control signal and a second control signal representative of a first event and a second event, respectively, occurring in an environment related to the wearable device and/or the second device, the first event and the second event being different events; and

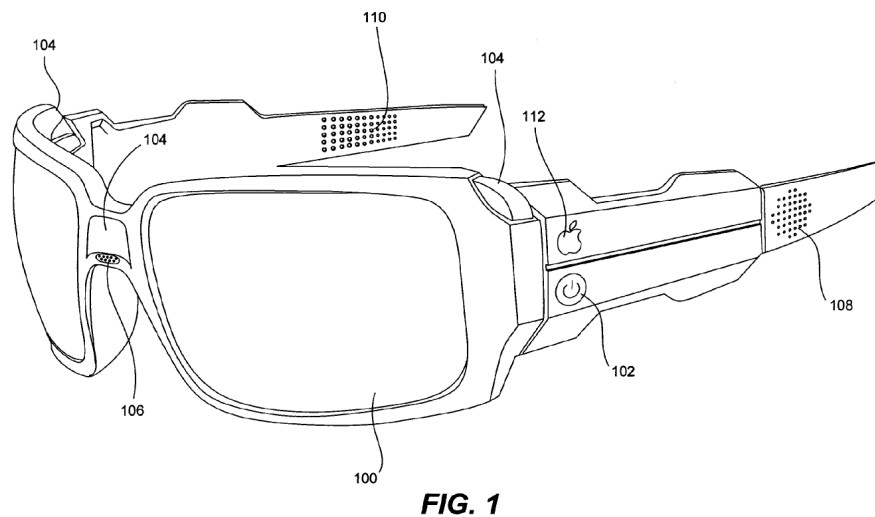
[d] a haptic output device configured to provide a first haptic feedback signal and a second haptic feedback signal based on the first control signal and the second control signal, respectively.

(’222, claim 1 (bracketed notation added).)

51. The preamble of claim 1 recites “[a] **system comprising**” the identified elements, which as explained below, would have been obvious over Douris in view of Rodriguez.

(a) “a wearable device;” (Claim 1[a])

52. Douris’s “reality overlay device” is “**a wearable device.**” Figure 1 of Douris illustrates a reality overlay device:



(Douris, Fig. 1.) Douris explains that the reality overlay device may be shaped in the form of glasses or sunglasses, and has the ability to superimpose a transparent overlay of information pertinent to the wearer’s surroundings:

FIG. 1 is a diagram illustrating an example reality overlay device in which various embodiments may be implemented. In one embodiment, the reality overlay device is a device that is wearable by the user of the

device. In this example, the reality overlay device is shaped in the form of glasses or sunglasses that a user may wear. More specifically, the reality overlay device may include one or more transparent lenses **100** that enable a user to view his or her surroundings through the transparent lenses **100**. Specifically, the transparent lenses **100** may function as screens that enable a transparent overlay to be displayed.

(Douris, ¶0022; *see also id.*, ¶¶0005 (“the reality overlay device is a wearable device that may be worn on the face of the user of the device”), 0006 (“transparent overlay provides one or more transparent images that are pertinent to and in correlation with the physical surroundings”), 0021 (“the transparent visual overlay may be displayed such that it overlays the field of vision of the wearer of the overlay device”), 0030 (“The reality overlay device may superimpose the transparent overlay via the device using the overlay information via one or more of the lenses **100**, wherein the transparent overlay provides one or more transparent images (e.g., static or video) that are pertinent to the physical surroundings.”).) The ’222 patent similarly describes a “wearable device” in the form of eyewear. (’222, e.g., 5:4-24, Fig. 5.)

(b) “a second device remote from and in communication with the wearable device;” (Claim 1[b])

53. The “**second device**” can be mapped in Douris two different ways. Each of these ways independently discloses the claimed second device. I note that

the “**second device**” is not recited in any limitations of claim 1 after claim 1 [b], but is referenced in certain dependent claims, as explained below.

54. Under the first mapping, the “**second device**” is simply a second reality overlay device worn by a different user. *I use this mapping in my analysis of dependent claims 2 and 5 below.* Douris discloses that a second reality overlay device (“**second device**”) may be “**in communication with**” a first reality overlay device (“**the wearable device**”), explaining that “users of different overlay devices may connect to one another for purposes of sharing the same experience (e.g., visiting a city or playing a game).” (Douris, ¶0045.)

55. Douris further makes clear that the second reality overlay device (“**second device**”) may be “**remote from**” the first reality overlay device (“**the wearable device**”), explaining that “implementations are contemplated in which a user implementing a reality overlay device 1000 interacts with a diverse network environment which may include other reality overlay devices... or any other type of device” and states that the network environment includes “for example, TCP/IP-based networks, telecommunications networks, wireless networks, etc.” (Douris, ¶¶0064, 0066; *see also id.*, ¶0023 (“The reality overlay device may support connection to a wireless network such as a cell phone network, localized Bluetooth™ devices, Worldwide Interoperability for Microwave Access (Wi-MAX)

and Wireless Fidelity (Wi-Fi).”).) It therefore would have been obvious that two reality overlay devices could have been remote from, and in communication with, each other. The exemplary communication networks provided in Douris, including TCP/IP-based networks, cellular phone networks, Wi-MAX,¹ among others, provide well-known examples of networks capable of connecting devices that are remote from each other. It therefore would have been obvious that two reality overlay devices at remote locations could have been in communication with each other – for example, to enable a user visiting a city to share their experience with a friend back home, to enable two users who are remote from each other to play a game or exchange messages. (*See also id.*, ¶¶0045 (“[U]sers of different overlay devices may connect to one another for purposes of sharing the same experience (e.g., visiting a city or playing a game.”), 0062 (“[A] user may display a message directed to a specific set of one or more individuals.”).)

56. Turning to the second mapping, *which I use in my analysis of dependent claim 7 below*, the “**second device**” corresponds to a remote network device/server,

¹ WiMAX, an acronym for Worldwide Interoperability for Microwave Access, refers to a number of communications standards (e.g., IEEE 802.16) for providing mobile wireless communications over larger areas such as cities. WiMAX thus provides an example of a communications technology for connecting two or more devices that are remote from each another.

for example server **1008** depicted in Figure 9 of Douris:

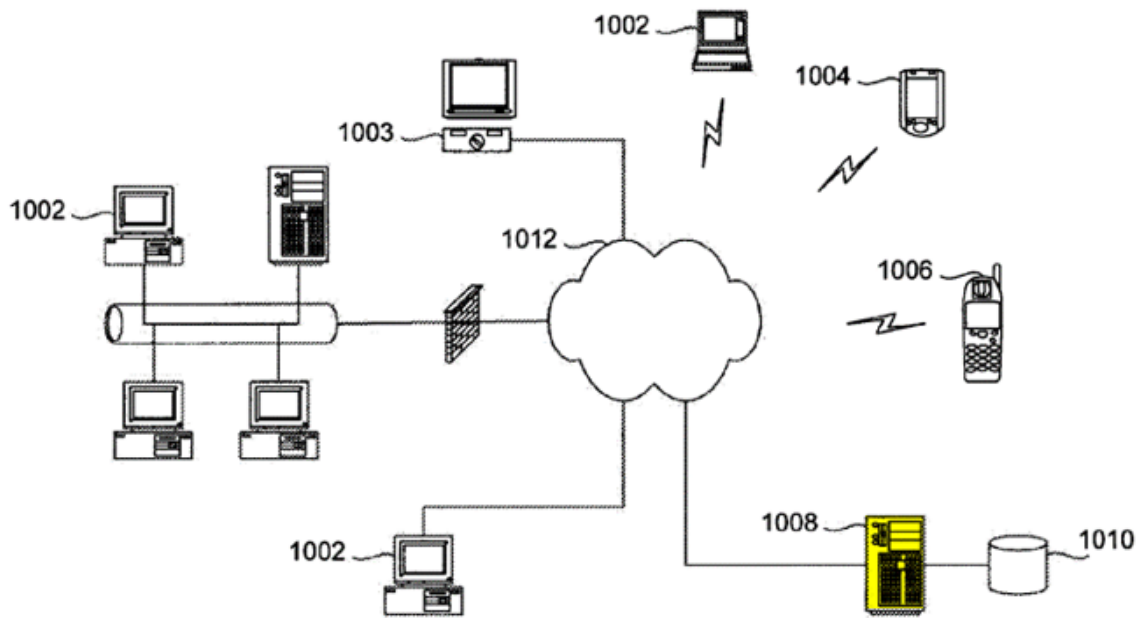


FIG. 9

(Douris, Fig. 9 (highlighting added); *see also id.*, ¶0007 (“the network device may be implemented as a server associated with a web site”).)

57. As I noted above for claim 1[a], Douris explains that a reality overlay device has the ability to superimpose a transparent overlay of information pertinent to the wearer’s surroundings. (Douris, ¶¶0005-0006, 0021-0022, 0030.) Douris further explains that, in order to determine the information to overlay, a remote server and the reality overlay device may be “**in communication with**” each other. More specifically, the server receives information about the user’s surroundings

from the reality overlay device, determines appropriate overlay information, and transmits the overlay information back to the reality overlay device for display.

Douris explains:

The reality overlay device may obtain overlay information for use in generating and providing a transparent visual overlay and/or audio overlay via the device using at least a portion of the information that the reality overlay device has captured. The overlay information may be obtained locally via one or more local memories and/or processors. The overlay information may also be obtained **remotely** from one or more servers using an Internet browser via a wireless connection to the Internet. More specifically, in order to obtain the overlay information, the reality overlay device or a remotely located server may identify one or more entities in the information that the reality overlay device has captured. This may be accomplished by accessing a map of the location in which the reality overlay device is being used, using RFID, and/or by using pattern recognition, as set forth above. Information that is pertinent to the identified entities may then be obtained.

(Douris, ¶0028; *see also id.*, ¶¶0046 (“A server may receive information that is pertinent to physical surroundings with respect to a device from the device at 302.”), 0039 (“The overlay information may be obtained locally via a memory and/or **remotely** from a server via the Internet.”), 0064 (“a user implementing a reality overlay device **1000** interacts with a diverse network environment which may

include ... server **1008**").) Douris therefore describes a server ("**second device**") "**remote from and in communication with**" a reality overlay device ("**the wearable device**"). Figure 3 of Douris illustrates this communication:

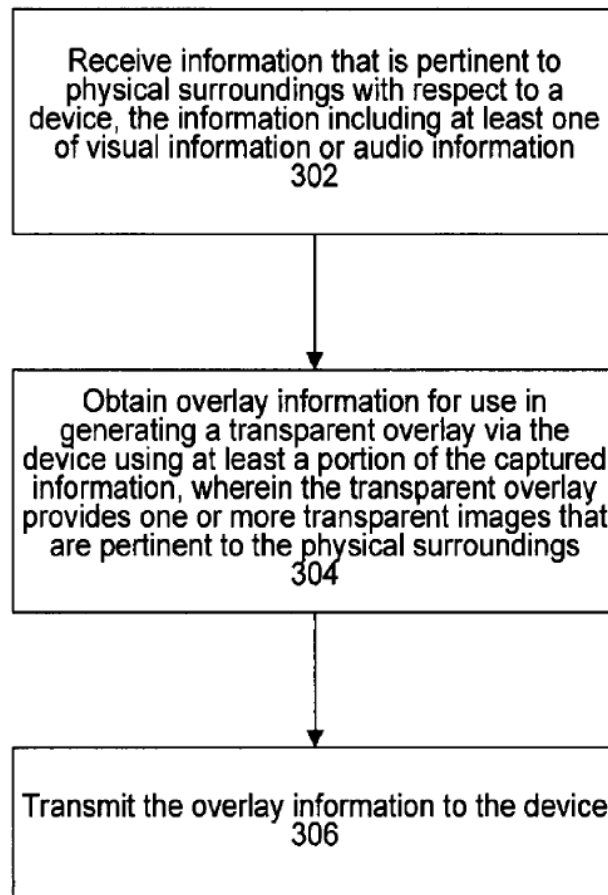


FIG. 3

(Douris, Fig. 3; *see also id.*, ¶¶0013 (“FIG. 3 is a process flow diagram illustrating an example method of providing information to a reality overlay device such as that presented in FIG. 1.”), 0046-0048 (describing Figure 3).)

- (c) “a processor configured to generate at least a first control signal and a second control signal representative of a first event and a second event, respectively, occurring in an environment related to the wearable device and/or the second device, the first event and the second event being different events; and”
(Claim 1[c])

58. As explained below, claim 1[c] would have been obvious to a person of ordinary skill in the art over Douris in view of Rodriguez.

59. Douris makes clear that a reality overlay device includes “a processor.” For example, Douris discloses that a reality overlay device may use “one or more local memories and/or processors” to obtain overlay information for use in generating and providing a transparent visual overlay. (Douris, ¶0028; *see also id.*, ¶0009 (“the invention pertains to a device comprising a processor, memory, and a display”).) Douris further explains that “[t]he reality overlay device or server of this invention may be specially constructed for the required purposes, or may be a general-purpose computer selectively activated or reconfigured by a computer program and/or data structure stored in the computer.” (Douris, ¶0067.) Because a processor is a key component of a general-purpose computer, a person of ordinary skill in the art would have understood and found it obvious that a reality overlay device in Douris includes “a processor.” (*See, e.g.*, EX1005 (Microsoft Computer Dictionary (5th ed. 2002)), pp.338-339 (definition for “microprocessor” stating that

“[m]icroprocessors are at the heart of all personal computers. When memory and power are added to a microprocessor, all the pieces, excluding peripherals, required for a computer are present.”.)

60. Before addressing the claimed **“first control signal”** and **“second control signal,”** I will explain how the prior art discloses a first and second event **“occurring in an environment related to the wearable device and/or the second device.”** The ’222 patent does not provide an express definition of **“event”** but broadly describes it by reference to a number of examples including “an indication of a physical object within a predetermined proximity of the wearable device,” “an interaction between the wearable device and an object in the environment,” “an indication that the wearable device recognizes an object in the environment, a navigation event, and/or another event occurring in an environment related to the wearable device.” (’222, 2:20-31.)

61. Consistent with the ’222 patent, Douris discloses several examples of **“event[s]...occurring in an environment related to the wearable device and/or the second device,”** such as the wearer of the reality overlay device being in proximity of a particular person, business or other entity, which may cause particular overlay information to be displayed by the reality overlay device. For example, Figure 5 of Douris depicts overlay information for three restaurants in the vicinity

of the wearer of the reality overlay device:

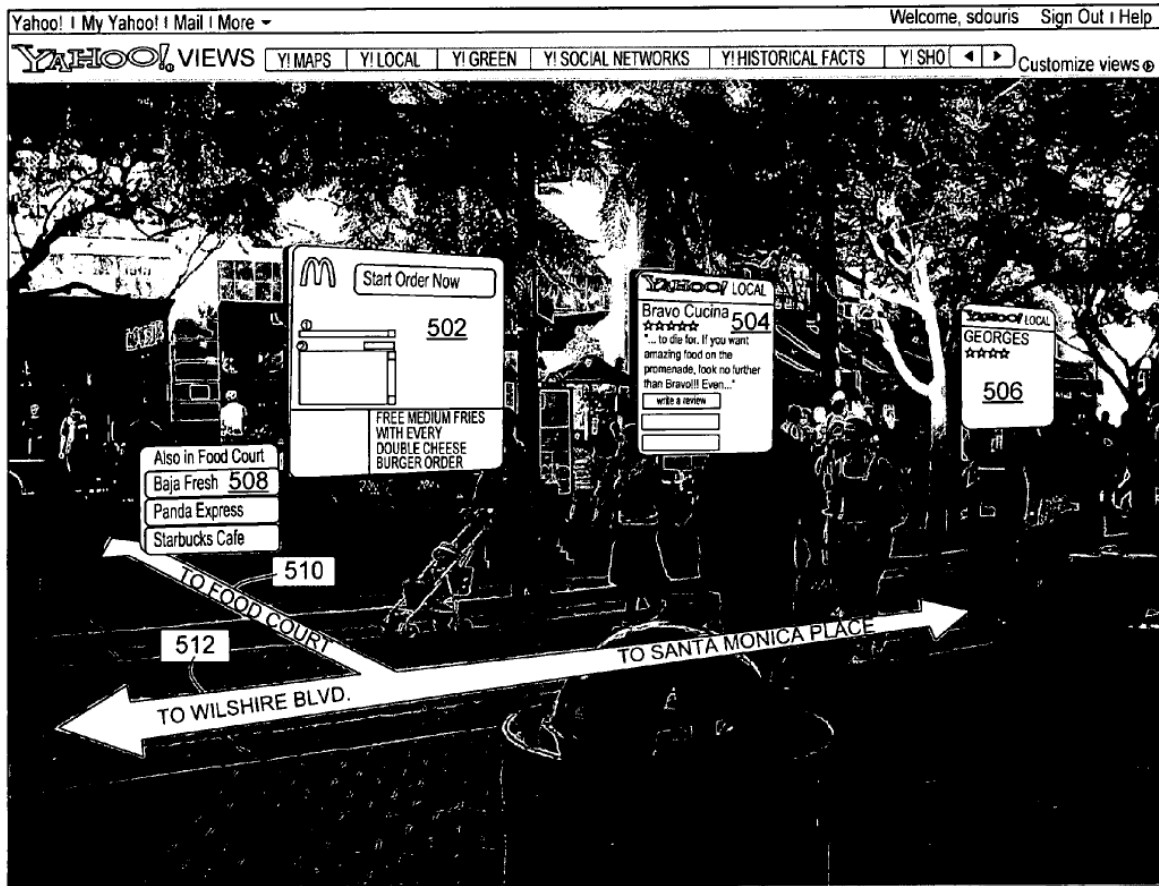


FIG. 5

(Douris, Fig. 5.) “In this example, the transparent overlay includes three different virtual billboards, which are placed in front of a business with which it is associated, such as a restaurant. The first virtual billboard **502** is a billboard associated with a McDonald's restaurant, the second virtual billboard **504** is a billboard associated with Bravo Cucina restaurant, and the third virtual billboard **506** is associated with Georges restaurant **508**.” (Douris, ¶0051; *see also id.*, ¶¶0050-0053 (describing Fig.

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5), 0040 (“the overlay information may identify restaurants that the user may be interested in within the context of the surroundings.”).) As another example, Figure 6 of Douris depicts overlay information for people in the vicinity of the wearer of the reality overlay device:

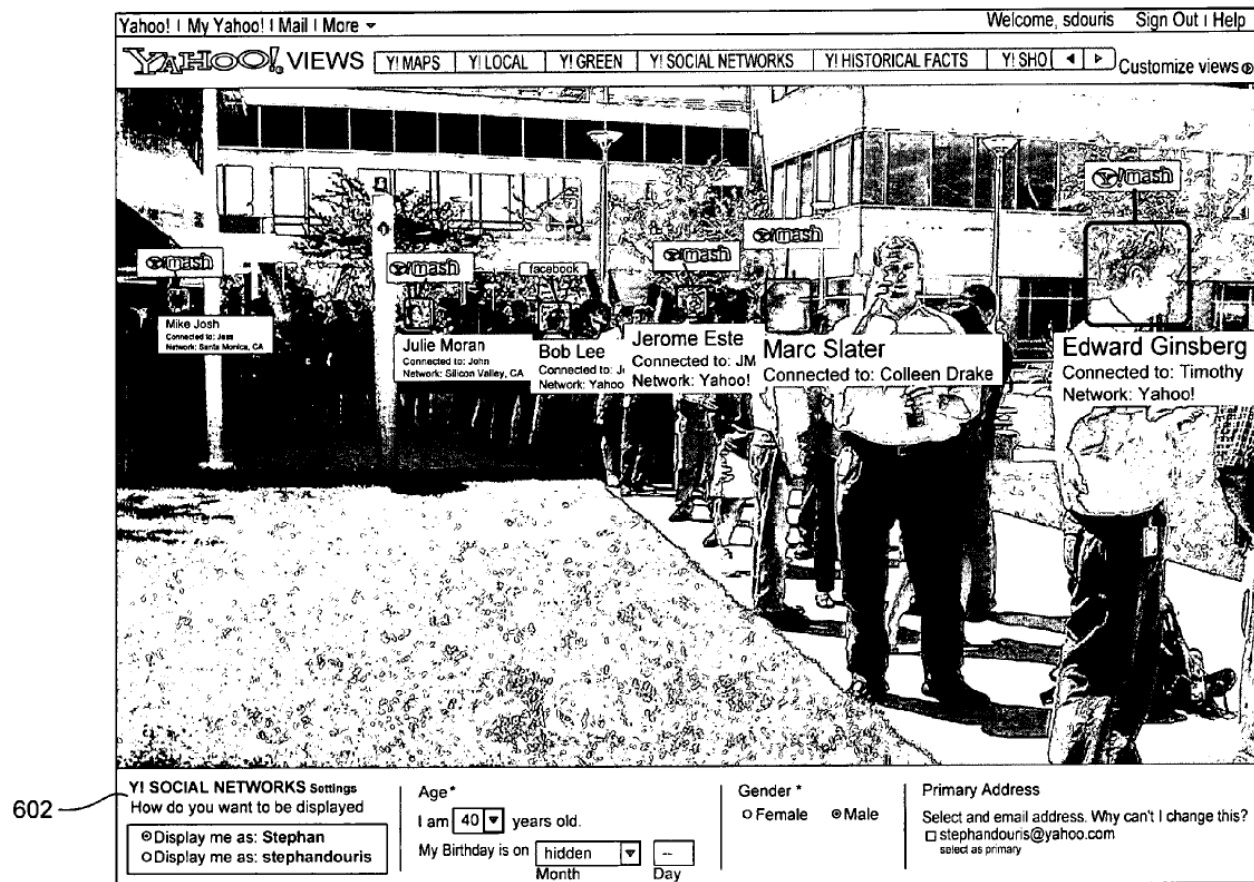


FIG. 6

(Douris, Fig. 6; *see also id.*, ¶¶0058 (“The social view may provide information associated with one or more individuals.”), 0059-0060; *see generally id.*, ¶¶0027 (“[T]he reality overlay device may process at least a portion of the received

information (e.g., one or more images) in order to identify one or more entities using pattern recognition. Such entities may include environmental features such as a mountain, road, building, or sidewalk. Moreover, entities that are recognized may also include people or animals. Pattern recognition may also be used to identify specific buildings by identifying letters, words, or addresses posted in association with a particular building”), 0028-0030, 0035-0036 (“The reality overlay device captures information that is pertinent to physical surroundings with respect to the reality overlay device at **202**, where the information includes at least one of visual information or audio information....In order to obtain the overlay information, one or more entities in the surroundings or in nearby locations may be identified in the captured information.”), 0037-0038.)

62. Douris therefore discloses at least “**a first event and a second event... occurring in an environment related to the wearable device and/or the second device,**” as claimed. In the first example above, the wearer of the reality overlay device was in the vicinity of one or more businesses (“**first event**”), and in the second, in the vicinity of one or more particular persons (“**second event**”). It would have been obvious that these qualify as “**different events**” because they could have occurred at different places and/or different times, and the events involve the wearer being in the vicinity of different types of objects (e.g., businesses vs. persons). Both

of these events occur in an “**environment related to the wearable device and/or the second device**,” because they occur in the augmented reality (AR) environment of the user wearing the reality overlay device (“**the wearable device**”).

63. I will next address how the prior art renders obvious generation of at least a “**first control signal**” and a “**second control signal**” representative of, respectively, the first and second events. I note that the next claim limitation 1[d] requires that the first and second control signals of claim 1[c] be used to provide respective haptic feedback signals using a haptic output device. Because Douris does not expressly disclose the use of haptic feedback controls or a haptic output device, I have relied on Douris in combination with Rodriguez for the claimed first and second control signals.

64. As explained below, the combination of Douris and Rodriguez would have predictably resulted in the processor of Douris’s reality overlay device being configured to generate haptic control signals representative of different events occurring near the reality overlay device (such as being in proximity to particular businesses or people).

65. Rodriguez explains that “[h]aptics devices (sometimes termed ‘force feedback’ devices) are becoming more widespread” (Rodriguez, ¶0003), including in augmented reality systems (Rodriguez, ¶¶0009-0010 (describing ARToolKit and

applications)). Rodriguez describes techniques for using a “haptic signature” to provide specific haptic feedback to a mobile device user in response to recognizing that the user is in the vicinity of a particular person or other entity/object. A haptic signature can describe, for example, the waveform, amplitude, frequency, and duration of haptic feedback:

A method according to one aspect of the present technology includes using a mobile device to capture image data representing a physical object. This data is then processed (e.g., by the mobile device, and/or by a remote system) so as to obtain metadata that corresponds to the object. This metadata is transmitted to a remote system. In response, data is received indicating a haptic signature that is associated with the object. This haptic signature is presented to a user of the mobile device, e.g., through one or more onboard or linked haptic actuators.

The metadata can indicate one of plural classes to which the physical object belongs. If it belongs to a first class, one haptic signature can be rendered; if it belongs to a second class, a different haptic signature can be rendered. These signatures can differ in one or more of, e.g., waveform, amplitude, frequency, and duration. The classes can be classes such as a class of persons, a class of books, a class of DVDs, a class of barcodes, a class of printed text, a class of landmarks such as buildings, a class of logos, a class of works of art, and a class of product containers. Or each class can comprise a unique physical object.

(Rodriguez, ¶¶0018-0019; *see also id.*, ¶¶0022 (“[W]hen imagery captured by the

mobile device includes visual stimulus of that first class, a corresponding type of haptic signal is output to the user.”), 0050 (“Once identification data has been obtained for a nearby object, the phone can determine what haptic signature to render.”).)

66. Rodriguez discloses using specific haptic signatures corresponding to the same types of events described in Douris above (*e.g.*, vicinity to persons or businesses). For example, Rodriguez discloses that a specific haptic signature can be provided to “indicat[e] proximity to social network friends.” (Rodriguez, ¶¶0075, 0085 (“haptically indicate the presence of friends with the user’s social network at such location, by a distinctive ‘friend(s) here’ signature when that location of the map is sensed (or when the user approaches that physical location in the festival)”)).) As another example, a haptic signature may “indicate[] (*e.g.*, by amplitude or frequency) the relative popularity of one of the establishments based [on] the number of mobile devices currently inhabiting that location.” (Rodriguez, ¶0085.)

67. Rodriguez further teaches that, in order to output haptic feedback in accordance with a haptic signature, the mobile device’s processor is configured to generate “**control signals**” that instruct the device’s haptic output device (such as an actuator) to provide feedback in accordance with the haptic signature:

Haptic actuators are responsive to electrical control signals—

commonly governed by a programmable processor (often in conjunction with digital-to-analog converter circuitry). While software instructions to control the haptic actuators may be written from scratch, the artisan will most commonly use one of the existing toolkits designed for this purpose. One popular toolkit is the Immersion for Java SDK. This allows control of the actuators through instantiation of Java objects (e.g., JImmWebAPI objects). Immersion also offers a haptic SDK especially for mobile platforms, the TouchSense Mobile Developer SDK. Another haptic toolkit that is popular with some developers is OpenHaptics by SensAble Technologies.

(Rodriguez, ¶0071; *see also id.*, ¶¶0063 (“Or the actuators **102** may be of a plural-axis variety, configured so that they can move in two or more orthogonal planes, responsive to appropriate control signals.”), 0050 (“Once identification data has been obtained for a nearby object, the phone can determine what haptic signature to render.”).)

68. Although one embodiment in Rodriguez involves a mobile device in the form of a mobile phone, Rodriguez confirms that its haptic feedback techniques can be applied to a variety of different devices, including a “wearable computer.” (Rodriguez, ¶0092 (“For example, while reference has been made to smartphones, it will be recognized that this technology finds utility with all manner of devices—both mobile and fixed. Portable music players, gaming devices, electronic wallets,

tablet computers, wearable computers, etc., can all make use of the principles detailed herein.”.) In fact, Rodriguez expressly identifies positioning haptic feedback devices both on eyewear and by the user’s ears. (Rodriguez, ¶0074 (“A user’s preferred haptic input may be through actuator-equipped earbuds (which also provide audible output). If stimulus is already being applied to the two earbuds (which may be operated independently), new stimulus may be applied to a secondary site, e.g., the soles of the user's feet, by an actuator device conveyed within the user's shoes. (Again, these may be operated independently.) A tertiary site may be an actuator positioned on the bridge of the user’s nose, as by eye wear.”).)

69. ***Manner, Rationale and Motivation to Combine (Douris with Rodriguez):*** It would have been obvious to a person of ordinary skill in the art to combine Douris with Rodriguez’s teachings about haptics in mobile devices and haptic signatures. The combination would have involved incorporating a haptic output device (such as an actuator) and haptic signature functionality, based on the teachings of Rodriguez, into Douris’s reality overlay device. The combination would have predictably resulted in the processor of Douris’s reality overlay device being configured to generate different control signals representing different events occurring in the vicinity of the reality overlay device.

70. For example, under the proposed combination, the processor in

Douris's reality overlay device would have generated "**a first control signal**" when the reality overlay device was in the vicinity of one or more businesses ("**the first event**"), and "**a second control signal**" when the reality overlay device was in the vicinity of one or more persons ("**the second event**").) As explained for claim 1[d] below, these control signals would in turn have resulted in haptic feedback signals being provided to the user via a haptic output device.

71. Douris and Rodriguez are analogous references in the same field of the '222 patent of wearable devices capable of generating feedback for a user based on events occurring in the user's environment. ('222, 1:14-32, 1:42-44 ("The disclosure relates to a wearable device that is configured to generate feedback based on an event that occurs in an environment related to the wearable device.").) Both Douris and Rodriguez disclose wearable devices that augment their wearer's interactions with their environment. As such, these references would also have been reasonably pertinent to a number of problems facing the '222 patent inventors, such as techniques for allowing wearable devices to present feedback information to the user (visually in the case of Douris and haptically in the case of Rodriguez) based on events occurring in the user's environment.

72. An ordinarily skilled artisan would also have recognized that the proposed combination would have provided a clear enhancement to the reality

overlay device of Douris.

73. Douris itself supports this combination by disclosing that, in addition to visual information, the reality overlay device can also present “audio overlay information” to the user pertinent to the user’s environment. (Douris, *e.g.*, ¶¶0031 (“Similarly, in accordance with various embodiments, audio overlay information may be provided via one or more audio outputs (e.g., speakers) of the reality overlay device.”), 0063 (“[I]t is also important to note that information may also be provided audibly as well as visually. Thus, in some embodiments, audio information that is pertinent to the physical surroundings is generated from at least a portion of the captured information and provided via one or more audio inputs of the reality overlay device.”).) Douris further explains that presenting audio overlay information has the benefit of “not impact[ing] the user’s field of vision.” (Douris, ¶0031.) An ordinarily skilled artisan would have appreciated that the same advantage attaches to haptic feedback, as it would have provided a third modality to present information to the user – the sense of touch – without impacting the user’s field of vision. For example, haptic feedback, like audio feedback, can convey information about events occurring in the user’s environment without impacting the user’s field of view. Haptic feedback could also, in some situations, be more effective at getting the attention of the wearer of the reality overlay device when compared to visual

information, and is more useful than audio information when a quiet environment must be observed or when the environment is too noisy to hear audio feedback. Haptic feedback can also be useful for hearing- and vision-impaired users. A person of ordinary skill in the art would have therefore appreciated that Rodriguez's techniques would improve Douris's similar reality overlay device in the same way, and would have been motivated to include haptic functionality into Douris's reality overlay device.

74. A person of ordinary skill in the art would have had at least a reasonable expectation that the combination would have been successful. As Rodriguez itself acknowledges, the use of control signals to provide haptic feedback was well-known before March 2013. Rodriguez acknowledges that, as of its June 2011 filing date, that "[h]aptics devices (sometimes termed 'force feedback' devices) are becoming more widespread" (Rodriguez, ¶0003), including in augmented reality systems (Rodriguez, ¶¶0009-0010 (describing ARToolKit and applications)). Rodriguez also identifies a number of commercially available, off-the-shelf components and toolkits for implementing haptics in mobile devices. (Rodriguez, ¶¶0009-0010 (describing ARToolKit and applications), 0071 (describing "Immersion for Java SDK," "TouchSense Mobile Developer SDK," and "OpenHaptics by SensAble Technologies").) Rodriguez further notes that "[s]oftware instructions for

implementing the detailed functionality can be authored by artisans without undue experimentation from the descriptions provided herein, e.g., written in C, C++, Visual Basic, Java, Python, Tcl, Perl, Scheme, Ruby, etc.” (Rodriguez, ¶0098.) And, as discussed above, Rodriguez makes clear that its haptics functionality and haptic signature techniques are readily applicable to the eyewear/headphone form factor of Douris’s example reality overlay device. (Rodriguez, ¶0074 (“A user’s preferred haptic input may be through actuator-equipped earbuds (which also provide audible output)....A tertiary site may be an actuator positioned on the bridge of the user’s nose, as by eye wear.”); Douris, Fig. 1.) As such, a person of ordinary skill in the art would have found the disclosures of Douris and Rodriguez more than adequate to implement the teachings on which I rely in this Declaration, using conventional programming techniques and without undue experimentation.

(d) **“a haptic output device configured to provide a first haptic feedback signal and a second haptic feedback signal based on the first control signal and the second control signal, respectively.” (Claim 1[d])**

75. I largely addressed claim 1[d] in my analysis of claim 1[c] above. As explained above, it would have been obvious to a person of ordinary skill in the art to include a **“haptic output device,”** such as an actuator, in the reality overlay device, as taught by the combination of Douris and Rodriguez. As I explained in the

discussion of claim 1[c] above, an ordinarily skilled artisan would also have been amply motivated to combine Douris and Rodriguez in this manner.

76. Rodriguez identifies various devices that a person of ordinary skill in the art would have understood to qualify as a claimed **“haptic output device”** – such as “vibratory electric motors using an offset mass,” and actuators “based on electroactive polymers, piezoelectrics, acoustic radiation pressure, and electrostatic surface actuation.” (Rodriguez, ¶0015.) The ’222 patent expressly identifies similar examples as “haptic output devices.” (’222, 3:14-23 (“The haptic output device may include an actuator, for example, an electromagnetic actuator such as an Eccentric Rotating Mass (‘ERM’) in which an eccentric mass is moved by a motor, a Linear Resonant Actuator (‘LRA’) in which a mass attached to a spring is driven back and forth, or a ‘smart material’ such as piezoelectric, electro-active polymers, or shape memory alloys, a macro-composite fiber actuator, an electro-static actuator, an electro-tactile actuator, and/or another type of actuator that provides a physical feedback such as a haptic (e.g., vibrotactile) feedback.”).)

77. Under the proposed combination of Douris and Rodriguez, a haptic output device included in a reality overlay device would have been **“configured to provide a first haptic signal and a second haptic signal [distinct haptic feedback] based on the first control signal and the second control signal, respectively [by**

operating in accordance with different control signals based on distinct haptic signatures as disclosed in Rodriguez].” For example, as discussed above, it would have been obvious for Douris’s reality overlay device to generate distinct haptic feedback using different control signals based on different haptic signatures in response to the user being in the vicinity of businesses versus persons. Thus, when a reality overlay device wearer is in the vicinity of one or more businesses, the device would have provided a distinct haptic feedback signal based the “**first control signal**,” and a different haptic feedback signal based on the “**second control signal**,” as described in my discussion of claim 1 [c] above.

2. **Claim 2: “The system according to claim 1, wherein the second device is a second wearable device.”**

78. As explained above for claim 1, Douris’s reality overlay device is a “**wearable device**” because it can be worn by a user. As I also explained in my discussion of claim 1 [b], the claimed “**second device**” can be mapped to a second reality overlay device that is remote from the “**wearable device**,” with the two reality overlay devices being in communication with each other. Under this mapping, the “**second device**” is a “**second wearable device**.”

3. **Claim 5: “The system according to claim 1, wherein the second device comprises the haptic output device.”**

79. As just explained, the claimed “**second device**” recited in claim 1 can

be mapped to a second reality overlay device. As explained above for claim 1[c]-[d], it would have been obvious for Douris's reality overlay device ("**wearable device**") to include a haptic output device. It would have been obvious that, in an arrangement of the proposed combination in which the "**second device**" was a second reality overlay device, that second device would have had the same functionality as the first reality overlay device ("**wearable device**"), including a haptic output device.

80. Claim 1[c] recites in pertinent part, "**a processor configured to generate at least a first control signal and a second control signal representative of a first event and a second event, respectively, occurring in an environment related to the wearable device and/or the second device,**" and thus, allows the generated control signals to relate to either the wearable device or the second device. I note that claim 1[c] and 1[d] do not specify whether the "**wearable device**" or the "**second device**" comprises the "**processor**" (1[c]) or the "**haptic output device**" (1[d]), and thus, either device could comprise these components. For purposes of claim 5, therefore, the "**second device**" would have comprised both the processor and the haptic output device of claim 1. Under this mapping, the "**processor**" would have generated control signals representative of the claimed first and second events occurring in the environment of the wearer of the second reality overlay device

(“**second device**”), for the same reasons as those provided for the claimed “**wearable device**” as fully described in the discussion of claim 1[c] above. And under this mapping, the “**haptic output device**” would have generated haptic feedback signals based on those control signals, for the second device, as fully described for claim 1[d] above.

4. Claim 7: “The system according to claim 1, further comprising:”

81. As I explained for claim 1[b] above, the “**second device**” could also be mapped to a remote network device/server in communication with a reality overlay device (the “**wearable device**”). I will apply that mapping for claim 7.

(a) “a communication port configured to establish a wireless or wired communication channel between the wearable device and the second device,” (Claim 7[a])

82. A person of ordinary skill in the art would have understood and found it obvious that Douris’s reality overlay device (“**wearable device**”), as well as the network server with which the reality overlay device communicates (“**second device**”), would each include the claimed “**communication port**.”

83. The ’222 patent does not provide an express definition of “**communication port**,” but describes it broadly as including an interface through which communication with another device can be established and maintained.

(’222, *e.g.*, 1:59-61 (“The communication port may include an interface through which a communication channel may be maintained with, for example, a server, and/or other devices.”), 3:48-49 (“The communication port may be configured to establish a communication channel with another device.”).) This description is consistent with the plain and ordinary meaning of the term “**communication port**” to a person of ordinary skill in the art. (*See also Microsoft Computer Dictionary* (5th ed. 2002), EX1005, p.412 (“**port**¹ *n.* An interface through which data is transferred between a computer and other devices (such as a printer, mouse, keyboard, or monitor), a network, or a direct connection to another computer.”).) The ’222 patent also makes clear that both the wearable device and a remote server can each include a communication port. (’222, 7:10-15 (“The wearable device **100** may also comprise, for example... a communication port **140**....”), 22:37-38 (“In some implementations, server **400** may comprise a processor, a storage, and a communication port.”).)

84. As noted above, Douris discloses that a reality overlay device communicates via a network with a remote server. (Douris ¶¶0028 (“The overlay information may also be obtained remotely from one or more servers using an Internet browser via a wireless connection to the Internet.”), 0039 (“The overlay information may be obtained locally via a memory and/or remotely from a server

via the Internet.”).) Douris explains, for example, that the reality overlay device is capable of connecting to and communicating via various types of wireless networks, “such as a cell phone network, localized Bluetooth™ devices, Worldwide Interoperability for Microwave Access (Wi-MAX) and Wireless Fidelity (Wi-Fi).” (Douris, ¶0023; *see also id.*, ¶0066 (“The invention may also be practiced in a wide variety of network environments (represented by network 1012) including, for example, TCP/IP-based networks, telecommunications networks, wireless networks, etc.”).) A person of ordinary skill in the art would have therefore understood and found it obvious that, in order for the reality overlay device and server to communicate with each other via a network, as described in Douris, both the devices would have included a **“communication port”** in the form of an interface including hardware and/or software enabling the reality overlay device and server to communicate over the network. I note that claim 7 only requires a single **“communication port,”** but as described, both devices would have such a port.

85. A person of ordinary skill in the art would have further understood and found it obvious that the **“communication port”** would have been **“configured to establish a wireless or wired communication channel between the wearable device [reality overlay device] and the second device [server].”** The term **“communication channel,”** generally speaking, refers to a path or link through

which information passes between two devices. (*See Microsoft Computer Dictionary* (5th ed. 2002), EX1005, p.94 (“**channel** *n.* **1.** A path or link through which communication passes between two devices.”).) One common example of a “**wireless or wired communication channel**” would have included a TCP/IP network connection between two devices. As noted above, Douris describes a reality overlay device communicating with a remote server via the Internet. (Douris, ¶¶0028 (“The overlay information may also be obtained remotely from one or more servers using an Internet browser via a wireless connection to the Internet.”), 0039 (“The overlay information may be obtained locally via a memory and/or remotely from a server via the Internet.”), 0066 (“The invention may also be practiced in a wide variety of network environments (represented by network **1012**) including, for example, TCP/IP-based networks, telecommunications networks, wireless networks, etc.”).) All of the exemplary network connections in Douris, identified above, would have provided a wireless or wired communication channel between the reality overlay device and the server.

(b) **“wherein the processor is configured to receive a signal representative of the first and second events occurring at the wearable device or the second device via the wireless or wired communication channel and generate the control signal based on the received signal.” (Claim 7[b])**

86. As discussed above for claim 1[c], **“the processor”** refers to the processor in the reality overlay device of Douris which would have been, in this arrangement of the proposed combination, in communication with a remote server (**“second device”**) over the communication channel described in my discussion of claim 7[a] above. As also explained for claim 1[c], **“the first and second events occurring at the wearable device,”** corresponds in Douris to the user being in the vicinity of one or more businesses (**“first event”**) or persons (**“second event”**). As further explained in my discussion of claim 1[c], when the reality overlay device is in the vicinity of a particular business (**“first event”**), the device may generate the **“first control signal”** to haptic feedback based on that event, and when the wearer is in the vicinity of one or more persons (**“second event”**), the device may generate the **“second control signal”** to provide different haptic feedback for that event, based on the combination of Douris and Rodriguez.

87. Now addressing claim 7[b], the processor in the reality overlay device is **“configured to receive a signal representative of the first and second events**

occurring at the wearable device,” when the reality overlay device receives at least the reality overlay information from the remote server, which is representative of the remote server determining that the reality overlay device is in the vicinity of particular businesses (“**first event**”) or persons (“**second event**”). (Douris, *e.g.*, ¶0039 (“The overlay information may be obtained... remotely from a server via the Internet... The overlay information may identify one or more entities such as physical locations, buildings, or individuals, as well as information associated with these entities.”), *see also id.*, ¶¶0028, 0030, 0036-0037, 0040.) It would have been obvious that this information would have been received by the “**processor**” in the reality overlay device because the processor would have been responsible for presenting the overlay information to the user. It would also have been obvious that the information received by the reality overlay device would have qualified as one or more “**signals**,” as the information would have been conveyed over the network using signals. (*E.g.*, *Microsoft Computer Dictionary* (5th ed. 2002) (EX1005), pp.480 (defining “signal” as “1. Any electrical quantity, such as voltage, current, or frequency, that can be used to transmit information.”), 145 (defining “data signal” as “The information transmitted over a line or circuit. It consists of binary digits and can include actual information or messages and other elements such as control characters or error-checking codes.”), 159 (defining “digital signal” as “A signal,

such as one transmitted within or between computers, in which information is represented by discrete states—for example, high and low voltages—rather than by fluctuating levels in a continuous stream, as in an analog signal.”.)

88. It would also have been obvious that the processor in the reality overlay device would have “**generate[d] the control signal based on the received signal,**” as claimed. I note that claim 7[b] refers to “**the control signal**” but does not specify which signal from claim 1[c] (*i.e.*, the claimed first or second control signals) must be generated based on the received signal, but it would have been obvious that both control signals would have been generated based on the received signal. For example, under the proposed combination of Douris and Rodriguez, the processor would have generated the “**first control signal**” if the received overlay information pertained to particular businesses, and generated the “**second control signal**” if the received overlay information pertained to particular persons. The reality overlay device, in turn, would have provided distinct haptic feedback to the user corresponding to those control signals as described for claim 1[d] above.

89. From an implementation standpoint, an ordinarily skilled artisan could have carried out this combination in a number of straightforward ways. In one example, the “**signal**” received by the reality overlay device from the server would have included additional overlay information pertaining to the appropriate haptic

signature to use to provide haptic feedback (*e.g.*, based on whether the device was in the vicinity of businesses or persons). Rodriguez itself expressly suggests such an implementation by disclosing the remote system providing, to the mobile device, data indicating a haptic signature based on the object in the user's vicinity:

A method according to one aspect of the present technology includes using a mobile device to capture image data representing a physical object. This data is then processed (e.g., by the mobile device, and/or by a remote system) so as to obtain metadata that corresponds to the object. This metadata is transmitted to a remote system. In response, data is received indicating a haptic signature that is associated with the object. This haptic signature is presented to a user of the mobile device, e.g., through one or more onboard or linked haptic actuators.

(Rodriguez, ¶0018.) It would have been obvious to incorporate similar functionality into the server of Douris. It would have involved the straightforward combination of Rodriguez's remote system functionality with Douris's server functionality, with no change in their respective functions, and would have predictably resulted in Douris's server both recognizing a person, business or other entity in order to generate overlay imagery as well as for generating an indication of a haptic signature associated with the recognized business or person. An ordinarily skilled artisan would have been motivated to implement the proposed combination in this way in

order to simplify the process by which the processor in the reality overlay device generates the first and second control signals, since the server would have already determined whether businesses or persons were in the vicinity of the device. (Douris, *e.g.*, ¶¶0028 (“More specifically, in order to obtain the overlay information, the reality overlay device or a remotely located server may identify one or more entities in the information that the reality overlay device has captured.”); *see also* Rodriguez, ¶0050 (“Once identification data has been obtained for a nearby object, the phone can determine what haptic signature to render.”).) Such an implementation would have relieved the processor in the overlay device from the burden of further analyzing received visual overlay data in order to determine, for example, whether the data relates to businesses or persons in order to select the appropriate haptic signature.

5. Independent Claim 10

90. For reference, claim 10 recites:

10. A system comprising:

- [a] an augmented reality device configured to generate an augmented reality environment comprising an augmented reality space and a physical space, the augmented reality device comprising
- [b] a processor configured to detect a plurality of events that occur in the

environment related to a wearable device, the processor configured to generate the augmented reality space coincident with the physical space,

[b][1] recognize at least one physical object in the physical space and augment the at least one physical object with one or more virtual objects in the augmented reality space, and

[b][2] determine an event associated with the augmented reality environment, and

[b][3] generate a control signal based on the determined event;

[c] the wearable device remote from and in communication with the augmented reality device;

[d] a remote device remote from and in communication with the wearable device and the augmented reality device; and

[e] a haptic output device configured to provide a plurality of haptic feedback signals based on the control signal.

(’222, claim 10 (bracketed notations added).)

91. The preamble of claim 10 recites “[a] **system comprising**” the identified elements, which as explained below, would have been obvious over Douris in view of Rodriguez.

- (a) **“an augmented reality device configured to generate an augmented reality environment comprising an augmented reality space and a physical space, the augmented reality device comprising” (Claim 10[a])**

92. Douris discloses the claimed **“augmented reality device”** in the form of a remote network device/server that creates transparent overlay information (such as two- and three-dimensional images) that augment the display of physical objects in a physical space. Such a remote network device/server is an **“augmented reality device”** because, as explained below, it is a device that processes information about a physical space to determine augmenting information associated with that physical space to provide to a user and because, more generally speaking, it is a device used to generate an augmented reality space in an augmented reality system.

93. Douris discloses the claimed **“augmented reality device”** in the form of a remote network device/server in communication with a reality overlay device. Such a remote network device/server is an **“augmented reality device”** because, as explained below, it is a device that processes information about a physical space to determine augmenting information associated with that physical space to provide to a user and because, more generally speaking, it is a device used in an augmented reality system.

94. I note that the '222 patent makes clear that a remote server can be an

“**augmented reality device**,” and nothing in the ’222 patent requires that an augmented reality device itself be a wearable device capable of physically displaying the augmented reality environment. This is consistent with the fact that, as recited claim 1[c] below, the ’222 patent recites a “**wearable device remote from and in communication with the augmented reality device**,” thus indicating to a person of ordinary skill in the art that the claimed “**augmented reality device**” need not itself be a wearable device. The claim also only requires that the augmented reality device “**generate an augmented reality environment**” (which the server in Douris does as explained below), but the claim does not require that the augmented reality device itself physically display that environment. And although some embodiments in the ’222 patent describe an augmented reality device as a wearable device capable of display, it also explains that much of a wearable device’s functionality can be implemented “remotely.” For example, the ’222 patent describes a “wearable AR device **200**” that may include “an event handler module **211**, a control signal generation module **212**, a feedback control module **213**, a communication module **214**, an object recognition module **215**, an object generation module **216**.” (’222, 14:46-57; *see also id.*, Fig. 2.) These modules perform key augmented reality functionality including, among other things, detecting whether an event occurs in the augmented reality environment, generating a control signal relating to the event,

recognizing physical objects in the physical space, and generating virtual objects to augment recognized physical objects. ('222, 14:57-15:6.) But the '222 patent further explains that this augmented reality functionality may be implemented “remotely” from the wearable device:

It should be appreciated that although modules **211**, **212**, **213**, **214**, **215**, and **216** are illustrated in FIG. 2 as being implemented within a single processing unit, in implementations in which processor **210** includes multiple processing units, one or more of modules **211**, **212**, **213**, **214**, **215**, and **216** may be implemented remotely from the other modules. The description of the functionality provided by the different modules **211**, **212**, **213**, **214**, **215**, and **216** described below is for illustrative purposes, and is not intended to be limiting, as any of modules **211**, **212**, **213**, **214**, **215**, and **216** may provide more or less functionality than is described. For example, one or more of modules **211**, **212**, **213**, **214**, **215**, and **216** may be eliminated, and some or all of its functionality may be provided by other ones of modules **211**, **212**, **213**, **214**, **215**, and **216**.

('222, 26:43-57; *see also id.*, 23:61-7:1 (broadly disclosing that “the operations of FIG. 6 and other Figures may be implemented in one or more processing devices (e.g., wearable device **100**, wearable AR device **200**, server **400**, and/or other devices)”.) A person of ordinary skill in the art would have understood a remote device that included functionality provided by these modules to be an “**augmented**

reality device.” Notably, claim 11 does not require that the augmented reality device itself display or otherwise output an augmented reality environment, nor does it require that the augmented reality device itself capture images of a physical space or otherwise directly detect or sense the physical space.

95. A remote network device/server in Douris is “**configured to generate an augmented reality environment**” because the server generates transparent overlay information comprising imagery and associated position information based on recognized objects in the physical surroundings to transmit to a reality overlay device so that the wearer “may view real world images through the lenses **100** while simultaneously viewing the transparent overlay.” (Douris, ¶¶0028-0030; *see also id.*, ¶¶0013, 0039, 0041 (“the transparent images may be two-dimensional or three-dimensional images”), 0046-0048, 0064, Fig. 3.) “For example, where one of the [identified] entities is a restaurant, the visual overlay information associated with the restaurant may be placed immediately next to or in front of the restaurant.” (Douris, ¶0029.) Douris explains:

The reality overlay device may obtain overlay information for use in generating and providing a transparent visual overlay and/or audio overlay via the device using at least a portion of the information that the reality overlay device has captured.... The overlay information may also be obtained remotely from one or more servers using an Internet

browser via a wireless connection to the Internet. More specifically, in order to obtain the overlay information, the reality overlay device or a remotely located server may identify one or more entities in the information that the reality overlay device has captured. This may be accomplished by accessing a map of the location in which the reality overlay device is being used, using RFID, and/or by using pattern recognition, as set forth above. Information that is pertinent to the identified entities may then be obtained.

The overlay information may also specify placement of visual overlay information within the transparent visual overlay (e.g., with respect to identified entities). More specifically, the location of the entities in the visual information may be used to determine an optimum placement of the visual overlay information within the transparent visual overlay. For example, where one of the entities is a restaurant, the visual overlay information associated with the restaurant may be placed immediately next to or in front of the restaurant. As another example, where one of the entities is a road, directions or a map may be placed such that the road in the user's field of vision is not obstructed.

The reality overlay device may superimpose the transparent overlay via the device using the overlay information via one or more of the lenses 100, wherein the transparent overlay provides one or more transparent images (e.g., static or video) that are pertinent to the physical surroundings. The positioning of the transparent images may depend upon the location of any identified entities in the user's field of vision (e.g., to reduce obstruction of the user's field of vision). The transparent

images that are produced may include text, symbols, etc. The transparent images may be generated locally or remotely. In this manner, a user of the reality overlay device may view real world images through the lenses **100** while simultaneously viewing the transparent overlay.

(Douris, ¶¶0028-0030.) The augmented reality environment generated by a server in Douris is then transmitted to a reality overlay device where it is displayed, as I explained in connection with claim 1[c] above. Figures 5 and 6 of Douris illustrate exemplary displays of an augmented reality environment:

Declaration of Jeremy Cooperstock, Ph.D. in Support of
Petition for *Inter Partes* Review of
U.S. Patent No. 10,269,222 B2

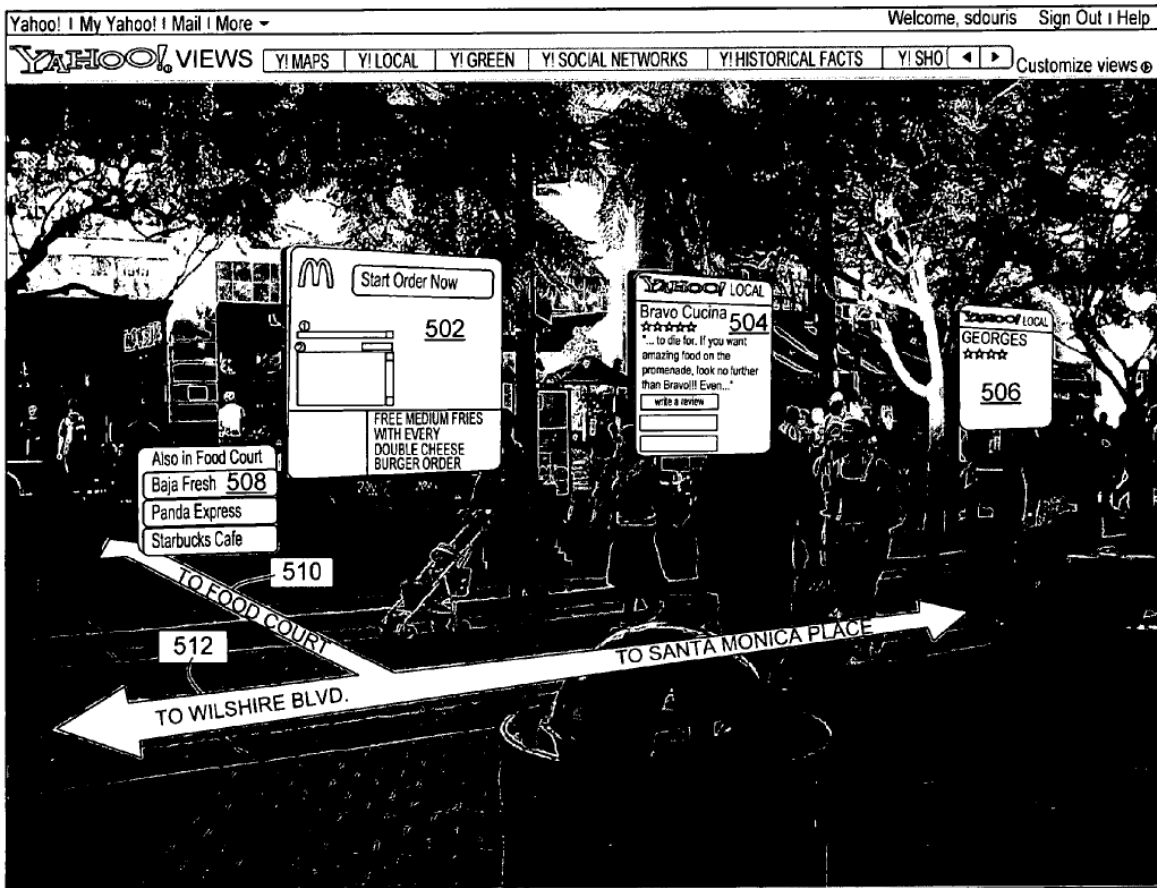


FIG. 5

Declaration of Jeremy Cooperstock, Ph.D. in Support of
Petition for *Inter Partes* Review of
U.S. Patent No. 10,269,222 B2

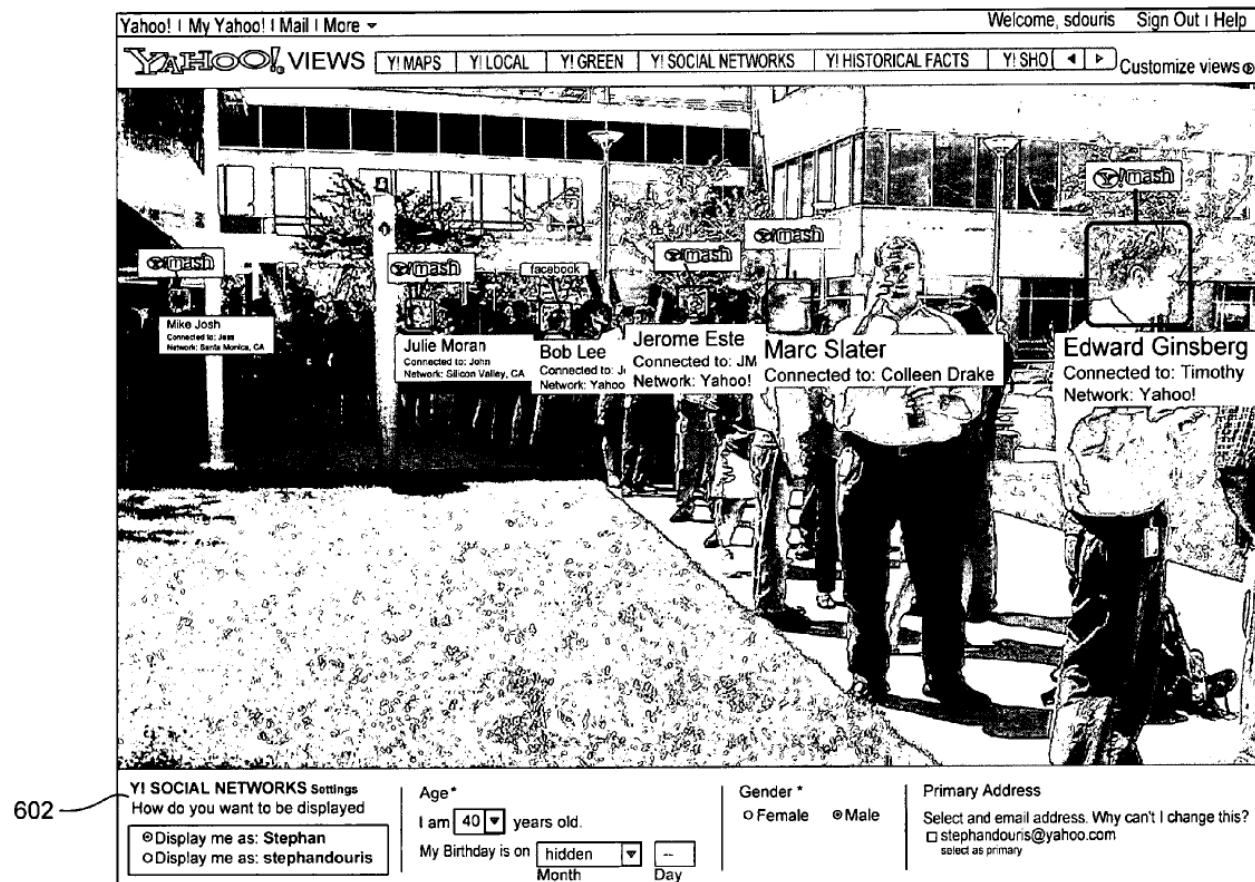


FIG. 6

(Douris, Figs. 5 & 6; *see also id.*, ¶¶0051-0052 (describing Figure 5), 0058 (describing Figure 6).)

96. The “**augmented reality environment**” in Douris thus corresponds to the transparent overlay information for a reality overlay device generated by the server. That information, as discussed, includes “**an augmented reality space**,” *i.e.*, additional information associated with entities identified in the user’s physical surroundings. Douris explains “[t]he overlay information may also specify

placement of visual overlay information within the transparent visual overlay (e.g., with respect to identified entities).” (Douris, ¶0029; *see also id.*, ¶0047 (“... the overlay information indicates the desired placement of visual overlay information within the transparent overlay.”).) The server in Douris therefore generates an “**augmented reality environment**” that also comprises “**a physical space**” because the overlay information specifies where the additional information about the identified entities will be displayed within the transparent overlay. These identified entities, for which additional information is displayed (such as businesses or persons), will of course also be visible (at least in part) to the user within the augmented reality environment. (Douris, *e.g.*, Figs. 5-6.) Additionally, in one embodiment, the overlay information can also include “transparent images” that will be presented to the user on the transparent overlay. (Douris, ¶0006; *see also id.*, ¶¶0036 (“[T]he overlay information may include, but need not include, the actual transparent image(s) to be displayed in order to superimpose the transparent overlay.”), 0037 (“Moreover, the overlay information may indicate a placement of one or more transparent images (e.g., advertisements, menus, maps, directions, reviews) with respect to and in correlation with the identified entities in the captured information (e.g., visual information), as perceived by the user of the reality overlay device.”); 0041 (“The transparent images may be static images or video images.

Moreover, the transparent images may be two-dimensional or three-dimensional images.”).) Under this further embodiment, the “**augmented reality environment**” generated by the server further comprises “**a physical space**” because the overlay information would also have included actual images displayed to the user, placed “with respect to and in correlation with the identified entities in the captured information (e.g., visual information), as perceived by the user of the reality overlay device” (Douris, ¶0037), thus further defining a physical space.

97. I note that the augmented reality environment in Douris closely tracks the one described in the ’222 patent. The ’222 patent discusses “AR environment **500**,” which like Douris, “may include the physical space **520** and the AR space **510**” in which “the display is configured as an at least partially transparent display (e.g., a lens) through which the physical space **520** may be viewed” so that one or more virtual objects **510a**, **510b**, . . . **510n** may be displayed coincident with or in association with one or more physical objects **520a**, **520b**, . . . **520n** that exist in the physical space **520**, thereby augmenting the one or more physical objects **520a**, **520b**, . . . **520n** in the AR environment **500**.” (’222, 18:18-33.)

98. Douris’s “**augmented reality device**” and “**augmented reality environment**” are also consistent with both parties’ proposed constructions of “**augmented reality**” in the related district court litigation. As noted in **Section**

III.A above, Petitioner asserts that “augmented reality” as used in the ’222 patent means “*one or more physical objects in a real-world, physical space are concurrently displayed with one or more virtual objects in a virtual space*” while Patent Owner asserts that the term should be given is “*plain and ordinary meaning*” but “*to the extent that the Court believes that any further construction is necessary, the plain and ordinary meaning includes ‘an environment comprising a physical space of one or more physical objects and a virtual space of one or more virtual objects that are displayed coincident with or in association with one or more physical objects in the physical space.’*” (EX1006 (Joint Claim Construction Statement), p.003.) Douris’s augmented reality device and augmented reality environment are consistent with both parties’ proposed constructions because the transparent overlay information for a reality overlay device (“**augmented reality environment**”) generated by the server (“**augmented reality device**”) provides an environment where physical objects in a user’s physical surroundings (“*one or more physical objects in a real-world, physical space*” / “*a physical space of one or more physical objects*”) are displayed simultaneously with overlay imagery that is positioned in space from the device wearer’s perspective based on associated physical objects (“*concurrently displayed with one or more virtual objects in a virtual space*” / “*a virtual space of one or more virtual objects that are displayed*

coincident with or in association with one or more physical objects in the physical space”).

99. As explained below, Douris’s remote server that generates transparent overlay information comprises the following components (“**augmented reality device comprising...**”).

- (b) “**a processor configured to detect a plurality of events that occur in the environment related to a wearable device, the processor configured to generate the augmented reality space coincident with the physical space,**” (Claim 10[b])

100. A person of ordinary skill in the art would have understood that a server in Douris that generates an augmented reality environment includes “**a processor.**” For example, Douris explains that “[t]he reality overlay device or server of this invention may be specially constructed for the required purposes, or may be a general-purpose computer selectively activated or reconfigured by a computer program and/or data structure stored in the computer.” (Douris, ¶0067; *see also id.*, ¶0066 (describing computer program instructions at server for performing described operations).) Because a processor is a key component of a computer, a person of ordinary skill in the art would have understood that the server includes “**a processor.**” (*See, e.g.*, EX1005 (Microsoft Computer Dictionary (5th ed. 2002)), pp.338-339 (definition for “microprocessor” stating that “[m]icroprocessors are at

the heart of all personal computers. When memory and power are added to a microprocessor, all the pieces, excluding peripherals, required for a computer are present.”.)

101. The processor in the server in Douris also “**detect[s] a plurality of events that occur in the environment related to a wearable device.**” As explained above for claim 1[c], Douris discloses various events occurring in the environment related to a reality overlay device (“**wearable device**”), such as the wearer of the reality overlay device being in physical proximity to a particular person, business or other entity, which may cause particular overlay information to be displayed by the reality overlay device. (Douris, *e.g.*, Figs. 5 & 6, ¶¶ 0051-0053, 0058-0060, 0027-0030, 0035-0038.) Douris explains that a server may detect such events by using information received from the reality overlay device:

The server may obtain (e.g., retrieve and/or generate) overlay information for use in generating a transparent overlay via the device using at least a portion of the captured information and/or at least a portion of any user information that has been received at **304**, wherein the transparent overlay provides one or more transparent images that are pertinent to the physical surroundings. For instance, the server may identify one or more entities in the visual information using at least a portion of the received information. Thus, the server may support pattern recognition, as well as other features. The server may obtain

information that is pertinent to the identified entities (e.g., from one or more databases) and/or ascertain a desired placement of the overlay information with respect to the identified entities, where the overlay information indicates the desired placement of visual overlay information within the transparent overlay. The server may then transmit the overlay information to the device at **306**.

(Douris, ¶0047; *see also id.*, ¶¶0028 (“[I]n order to obtain the overlay information, the reality overlay device or a remotely located server may identify one or more entities in the information that the reality overlay device has captured.”).) A person of ordinary skill in the art would have further understood and found it obvious that the server’s **processor**, as the component that executes instructions to perform operations specified in computer programs, would have been “**configured to detect a plurality of events that occur in the environment related to a wearable device.**” (*E.g.*, Douris, ¶0067 (“The reality overlay device or server of this invention may be specially constructed for the required purposes, or may be a general-purpose computer selectively activated or reconfigured by a computer program and/or data structure stored in the computer.”).)

102. Douris discloses that the server “**generate[s] the augmented reality space coincident with the physical space.**” As discussed above, Douris explains that the server “ascertain[s] a desired placement of the overlay information with

respect to the identified entities, where the overlay information indicates the desired placement of visual overlay information within the transparent overlay.” (Douris, ¶0047; *see also id.*, ¶¶0029 (“the location of the entities in the visual information may be used to determine an optimum placement of the visual overlay information within the transparent visual overlay”), 0030 (“The positioning of the transparent images may depend upon the location of any identified entities in the user’s field of vision (e.g., to reduce obstruction of the user’s field of vision).”).) Thus, by positioning imagery of the transparent overlay information so that the imagery is displayed in association with identified physical objects, Douris discloses that the server **“generates the augmented reality space coincident with the physical space.”** Figure 6 of Douris, for example, illustrates augmented reality space coincident with the physical space:

Declaration of Jeremy Cooperstock, Ph.D. in Support of
 Petition for *Inter Partes* Review of
 U.S. Patent No. 10,269,222 B2

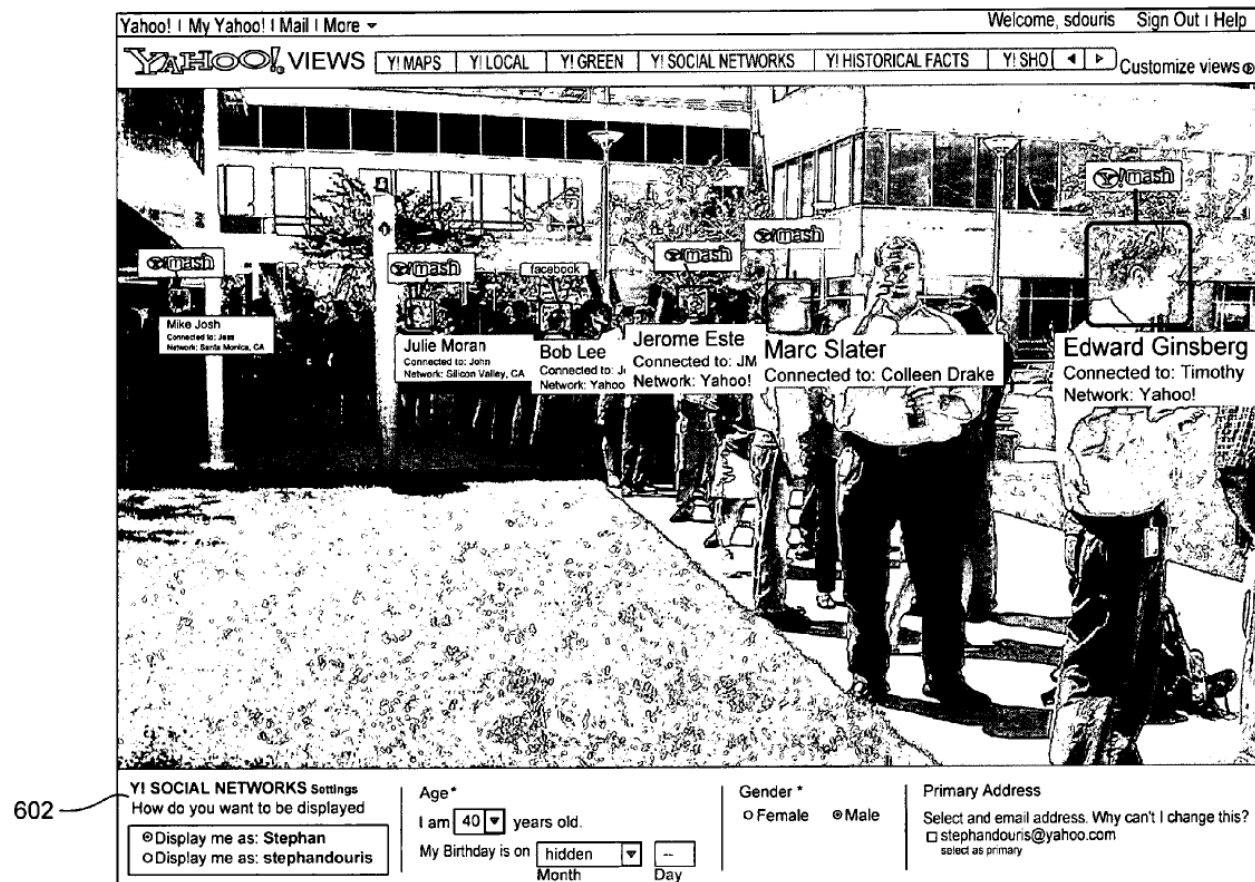


FIG. 6

(Douris, Fig. 6; *see also id.*, Fig. 5.) A person of ordinary skill in the art would have also understood and found it obvious that, in Douris, the server's processor would be configured to perform this step. (*E.g.*, Douris, ¶¶0066-0067; EX1005 (Microsoft Computer Dictionary (5th ed. 2002)), pp.338-339 (definition of “microprocessor”).)

- (1) **“recognize at least one physical object in the physical space and augment the at least one physical object with one or more virtual objects in the augmented reality space, and” (Claim 10[b][1])**

103. As discussed above, Douris explains that a server can **“recognize at least one physical object in the physical space”** of a reality overlay device, using for example, processing images of device’s surroundings using pattern recognition. (Douris, ¶¶0028 (“... the reality overlay device or a remotely located server may identify one or more entities in the information that the reality overlay device has captured.”), 0036, 0039 (“For instance, pattern recognition capabilities may be supported locally or remotely at a remotely located server.”), 0047; *see also id.*, ¶0027 (“process at least a portion of the received information (e.g., one or more images) in order to identify one or more entities using pattern recognition”).) And, as discussed, Douris discloses that the server **“augment[s] the at least one physical object with one or more virtual objects in the augmented reality space”** by generating transparent overlay information that a reality overlay device displays in association with the identified physical objects. (Douris, ¶¶0029, 0030, 0041 (“transparent images may be two-dimensional or three-dimensional images”), 0047, Figs. 5 & 6.) The **“one or more virtual objects”** in Douris corresponds to the additional information and/or transparent images included in the overlay information

generated by the server to augment one or more identified entities (“**at least one physical object**”), as fully explained for claim 10[a] above. (Douris, *e.g.*, ¶¶0036 (“Thus, the overlay information may include... the actual transparent image(s) to be displayed in order to superimpose the transparent overlay.”), 0037 (“[T]he overlay information may indicate a placement of one or more transparent images (e.g., advertisements, menus, maps, directions, reviews) with respect to and in correlation with the identified entities in the captured information (e.g., visual information), as perceived by the user of the reality overlay device.”).)

104. A person of ordinary skill in the art would have also understood and found it obvious that, in Douris, the server’s processor would have been configured to perform this step. (*E.g.*, Douris, ¶¶0066-0067; EX1005 (Microsoft Computer Dictionary (5th ed. 2002)), pp.338-339 (definition of “microprocessor”).)

(2) “determine an event associated with the augmented reality environment, and” (Claim 10[b][2])

105. As explained above, the server in Douris detects various events, such as the wearer of the reality overlay device being in physical proximity to a particular business or person. The server further determines that such an event is “**associated with the augmented reality environment**” by identifying overlay information to provide in response to detecting the event, as explained. (Douris, *e.g.*, ¶¶0028-0030,

0036-0037, 0047.) It would have been obvious that, in order for the server in Douris to produce the transparent overlay information (“**the augmented reality environment**”) associated with the overlay device being, for example, in the vicinity a particular business or person (“**an event**”), the server would have to determine that that event had occurred. (Douris, *e.g.*, ¶¶0028 (“[I]n order to obtain the overlay information, the reality overlay device or a remotely located server may identify one or more entities in the information that the reality overlay device has captured.”), 0029 (“For example, where one of the entities is a restaurant, the visual overlay information associated with the restaurant may be placed immediately next to or in front of the restaurant.”), 0036 (“The reality overlay device obtains overlay information for use in generating a transparent overlay via the device using at least a portion of the captured information at 204... In order to obtain the overlay information, one or more entities in the surroundings or in nearby locations may be identified in the captured information. For example, entities such as businesses, other buildings or physical landmarks may be identified using pattern recognition software, RFID and/or GPS location.”).) A person of ordinary skill in the art would have also understood and found it obvious that, in Douris, the server’s processor would have been configured to perform this step. (*E.g.*, Douris, ¶¶0066-0067; EX1005 (Microsoft Computer Dictionary (5th ed. 2002)), pp.338-339 (definition of

86

“microprocessor”).)

(3) **“generate a control signal based on the determined event;” (Claim 10[b][3])**

106. **“Generat[ing] a control signal based on the determined event”** would have been obvious over Douris in view of **Rodriguez**. As explained above in connection with claim 1[c] and 1[d], it would have been obvious to a person of ordinary skill in the art to combine Douris with Rodriguez’s teachings about haptics in mobile devices and haptic signatures. And as explained for claim 7[b], it would have further been obvious for Douris’s server, under the proposed combination, to generate and transmit overlay information that would be used, at the reality overlay device, to generate the haptic feedback for the user. The **“control signal”** under the proposed combination thus corresponds to the signal conveying the overlay information in Douris that is generated and transmitted by the server, and under the combination with Rodriguez as explained for claim 7[b], that information would have included additional information indicating the haptic signature to use based on whether a business or entity was in the vicinity of the wearer of the reality overlay device. (E.g., Rodriguez, ¶¶0018-0019.) The control signal is thus generated by the server **“based on the determined event.”**

107. As explained for claim 7[b], it would have been obvious that the

information generated and transmitted by the server in Douris would have taken the form of a “**signal**” as claimed. A person of ordinary skill in the art would have also regarded the signal as a “**control signal**” because it would have been used to control the receiving reality overlay device by directing it to display visual overlay information and provide haptic feedback in accordance with the signal. (*E.g.*, Rodriguez, ¶¶0018-0019.) This is consistent with the broad understanding of “control signal” in the computing context, where the term is generally understood to refer to an electronic signal used to control devices or processes. (EX1005 (Microsoft Computer Dictionary (5th ed. 2002)), p.128 (defining “control signal” as “[a]n electronic signal used to control internal or external devices or processes”).)

108. A person of ordinary skill in the art would have also understood and found it obvious that, in Douris, the server’s processor would be configured to perform this step. (*E.g.*, Douris, ¶¶0066-0067; EX1005 (Microsoft Computer Dictionary (5th ed. 2002)), pp.338-339 (definition of “microprocessor”).)

(c) **“the wearable device remote from and in communication with the augmented reality device;”**
(Claim 10[c])

109. As discussed above for claim 1[b], Douris discloses that a reality overlay device (“**the wearable device**”) is “**remote from and in communication with**” the server providing transparent overlay information (“**augmented reality**”).

device”). (Douris, *e.g.*, Figs. 3 & 9, ¶¶0005-0007, 0013, 0028, 0046-0048, 0064.)

(d) **“a remote device remote from and in communication with the wearable device and the augmented reality device; and” (Claim 10[d])**

110. As discussed above for claim 1[b], Douris discloses that, in addition to communicating with a remote server, a reality overlay device can also communicate with another reality overlay device, and makes clear that the devices can be remote from each other. (*See* Douris, ¶¶0045 (“[U]sers of different overlay devices may connect to one another for purposes of sharing the same experience (*e.g.*, visiting a city or playing a game).”), 0022-0023, 0062, 0064, 0066.) The claimed **“remote device”** therefore corresponds in Douris to a second reality overlay device that is **“remote from and communication with”** a first reality overlay device (**“the wearable device”**) and the server (**“the augmented reality device”**).

(e) **“a haptic output device configured to provide a plurality of haptic feedback signals based on the control signal.” (Claim 10[e])**

111. As explained for claim 1[c] and 1[d], it would have been obvious in view of Rodriguez for Douris’s reality overlay device to include a **“haptic output device”** (such as an actuator) configured to provide distinct haptic feedback based on different events and their associated haptic signatures (such as different haptic signatures associated with different businesses, or different people, or to have

different haptic signatures for businesses versus people). (Rodriguez, ¶¶0018-0019, 0022, 0050, 0075, 0085.) Thus, under the proposed combination, the haptic output device of Douris’s reality overlay device would have been **“configured to provide a plurality of haptic feedback signals.”** For example, when a reality overlay device wearer is in the vicinity of a particular person, the device may provide distinct haptic feedback, and when the wearer is in the vicinity of a particular business, the device may provide different haptic feedback. As explained above for claim 7[b] and 10[b][3], the particular haptic feedback to provide is based on the haptic signature indication received from, under the proposed combination, the Douris server (**“based on the control signal”**).

6. **Claim 11: “The system according to claim 10, wherein the remote device is a second wearable device.”**

112. As discussed, the **“remote device”** corresponds to another reality overlay device. A reality overlay device, as explained, is a **“wearable device.”**

7. **Claim 15: “The system according to chain [sic; claim] 10, wherein the wearable device comprises the haptic output device.”**

113. As discussed above for claim 10[c] and 10[e], it would have been obvious in view of Rodriguez for the reality overlay device (**“the wearable device”**) to have included **“the haptic output device”** in order to provide haptic feedback to

the device wearer regarding people, businesses, and other entities in their vicinity.

8. Independent Claim 17

114. For reference, claim 17 recites:

17. A method comprising;

- [a] detecting an event in an environment, the detecting performed at least in part with a processor,
- [b] generating a control signal representative of an event occurring in the environment related to a wearable device and/or a second device with the processor, the generated control signal being a first control signal selected from at least first and second available control signals, the first control signal representative of the event, the second control signal representative of a different event; and
- [c] providing a plurality of haptic feedback signals based on the control signal with a haptic output device.

(’222, claim 17 (bracketed notations added).)

115. The preamble of claim 17 recites “[a] **method comprising**” the identified steps, which as explained below, would have been obvious over Douris in view of Rodriguez.

(a) **“detecting an event in an environment, the detecting performed at least in part with a processor,” (Claim 17[a])**

116. As explained for claim 1[c], Douris discloses various “**event[s] in an environment,**” such as the wearer of the reality overlay device being in proximity of businesses or persons, which may cause particular overlay information to be displayed by the reality overlay device. (Douris, ¶¶0027-0030, 0035-0038, 0040 (“the overlay information may identify restaurants that the user may be interested in within the context of the surroundings.”), 0051-0053 (describing Fig. 5), 0058-0060 (describing Fig. 6), Figs. 5 & 6.)

117. Douris discloses that a reality overlay device “**detect[s] an event in an environment... with a processor.**” For purposes of claim 17[a], “**a processor**” corresponds to a processor in the reality overlay device. As explained for claim 1[c], Douris makes clear that a reality overlay device in fact includes a processor. (See Douris, ¶0028; *see also id.*, ¶¶0009, 0067.) With respect to the claimed detecting step, Douris explains that a reality overlay device itself may analyze information about the device’s physical surroundings to detect that a person or business is in the vicinity of the device (“**an event in an environment**”):

[I]n order to obtain the overlay information, the reality overlay device or a remotely located server may identify one or more entities in the

information that the reality overlay device has captured. This may be accomplished by accessing a map of the location in which the reality overlay device is being used, using RFID, and/or by using pattern recognition, as set forth above. Information that is pertinent to the identified entities may then be obtained.

(Douris, ¶0028; *see also id.*, ¶0039 (“For instance, pattern recognition capabilities may be supported locally or remotely at a remotely located server.”).) A person of ordinary skill in the art would have understood and found it obvious that this functionality of the reality overlay device would have been carried out with its processor.

118. I note that for purposes of this claim limitation, I have mapped the claimed “**processor**” to the processor included with the reality overlay device that performs the detecting step, whereas for claim 10[b], the “**processor**” that performs event detection corresponds to a processor of a remote server. This difference does not impact the proposed combination in any way because, as noted, Douris makes clear that the detecting step can be performed either by the reality overlay device or the remote server. Moreover, nothing in combination with Rodriguez depends on where the detection step physically occurs. Rodriguez, for its part, similarly discloses that the user device itself may perform processing as an alternative to relying on a remote system. (Rodriguez, ¶¶0018-0019 (“This data is then processed

(e.g., by the mobile device, and/or by a remote system) so as to obtain metadata that corresponds to the object.”.) Finally, my mapping also does not preclude the reality overlay device of Douris, after it detects an event from the environment, from obtaining overlay information from a remote server over a network. (Douris, e.g., ¶¶0028, 0030, 0039, 0060.)

(b) “generating a control signal representative of an event occurring in the environment related to a wearable device and/or a second device with the processor, the generated control signal being a first control signal selected from at least first and second available control signals, the first control signal representative of the event, the second control signal representative of a different event; and” (Claim 17[b])

119. I largely addressed the limitations of claim 17[b] in my analysis of claim 1[c] and 1[d] above.

120. As explained, under the proposed combination of Douris and Rodriguez, the reality overlay device would have “**generat[ed] a control signal**” to instruct the device’s haptic output device (such as an actuator) to provide feedback in accordance with the haptic signature associated with a detected event – such as being in proximity to a particular person or business. (E.g., Rodriguez, ¶¶0071 (describing “control signals”), 0063, 0050.)

121. Under the proposed combination, the control signal would also have

been “**representative of an event occurring in the environment related to a wearable device and/or a second device.**” For purposes of my analysis, the “**wearable device**” corresponds to a reality overlay device in Douris.

122. I note that claim 17[b] recites “**a second device,**” which is not referenced later in this claim. But in order to account for recitations of “**the second device**” in dependent claims 18, 21, and 23 addressed below, as with my analysis for claim 1[b], it can be mapped in Douris two different ways. Under the first mapping, the “**second device**” is simply a second reality overlay device worn by a different user. *I use this mapping in my analysis of dependent claims 18 and 21 below.* Under the second mapping, the “**second device**” corresponds to a remote network device/server. *I use this mapping in my analysis of dependent claim 23 below.*

123. Turning back to the other limitations of claim 17[b], as explained in my discussion of claim 1[c], the combination of Douris and Rodriguez would have predictably resulted in the processor of Douris’s reality overlay device being configured to generate different “**control signal[s] representative of**” different events occurring in the vicinity of the reality overlay device – for example, when a reality overlay device wearer is in the vicinity of a particular person (“**an event in the environment related to a wearable device and/or a second device**”), the

device may provide distinct haptic feedback. (*E.g.*, Rodriguez, ¶¶0018-0019, 0022, 0050, 0075, 0085.)

124. For the same reasons discussed above, a person of ordinary skill in the art would have understood and found it obvious that the control signal would have been generated “**with the processor**” of the reality overlay device. (*E.g.*, Douris, ¶¶0066-0067; EX1005 (Microsoft Computer Dictionary (5th ed. 2002)), pp.338-339 (definition of “microprocessor”).)

125. Under the proposed combination of Douris and Rodriguez, the generated control signal would also have been “**a first control signal selected from at least first and second available control signals, the first control signal representative of the event, the second control signal representative of a different event.**” As discussed for claim 1[c], Rodriguez discloses that multiple different haptic signatures can each be associated with being in the vicinity of businesses versus being in the vicinity of persons. (Rodriguez, ¶¶0018-0019, 0022, 0050, 0075, 0085.) Thus, for example, when a reality overlay device wearer was in the vicinity of a particular business (“**the event**”), the device would have selected a distinct haptic signature, having a particular control signal, and when the wearer was in the vicinity of a particular person (“**a different event**”), the device would have selected a second haptic signature having a different control signal.

(c) **“providing a plurality of haptic feedback signals based on the control signal with a haptic output device.”
(Claim 17[c])**

126. I largely addressed claim 17[c] in my analysis of claim 17[b] and 1[d] above. As above, it would have been obvious to a person of ordinary skill in the art to include a **“haptic output device,”** such as an actuator, in a reality overlay device, as taught by the combination of Douris and Rodriguez. As explained, the haptic output device of a reality overlay device (either as the claimed **“wearable device”** or as the claimed **“second device”**), by using a control signal of a particular haptic signature, would **“provid[e] a plurality of haptic feedback signals based on the control signal.”**

9. **Claim 18: “The method according to claim 17, wherein the second device is a second wearable device.”**

127. This claim is substantially similar to claim 2, addressed above. As discussed, under a first mapping in which **“the second device”** is another reality overlay device, the second device would have been **“a second wearable device.”**

10. **Claim 21: “The method according to claim 17, wherein the second device comprises the haptic output device and the haptic feedback is provided at the second device.”**

128. As discussed above, under a first mapping in which **“the second device”** is another reality overlay device, the second device, under the proposed

combination, would have comprised **“the haptic output device,”** and the haptic feedback would have been **“provided at the second device.”** For example, haptic feedback would have been provided in response to detecting that the wearer of the second reality overlay device was in proximity to a particular person.

11. Claim 23: “The method according to claim 17, further comprising:”

129. Claim 23 is similar in many respects to claim 7. As explained below, claim 23 would have been obvious over Douris in view of Rodriguez. My analysis of claim 23, as I noted above, relies on my alternative mapping where the claimed **“second device”** corresponds to a remote network device/server in communication with a reality overlay device (the **“wearable device”**).

(a) “establishing a wireless or wired communication channel between the wearable device and the second device with a communication port; and” (Claim 23[a])

130. As explained for claim 7[a], a person of ordinary skill in the art would have understood and found it obvious that Douris’s reality overlay device (**“wearable device”**), as well as the network server with which the reality overlay device communicates (**“second device”**), would each include the claimed **“communication port.”** (Douris, ¶¶0023, 0028, 0039, 0066; EX1005 (Microsoft Computer Dictionary (5th ed. 2002)), p.363 (defining “network interface card”).)

As discussed, a person of ordinary skill would have further understood and found it obvious to “**establish[] a wireless or wired communication channel between the wearable device [reality overlay device] and the second device [server]**” using the communication ports of those devices (“**with a communication port**”). (Douris ¶¶0028, 0039, 0066, EX1005 (Microsoft Computer Dictionary (5th ed. 2002)), pp.94 (definition of “channel”), 281 (definition of “Internet”), 287 (definition of “IP”), 513 (definition of “TCP”).)

(b) “**receiving a signal representative of at least one of the event and the different event occurring at the wearable device or the second device via the wireless or wired communication channel and generate the control signal based on the received signal with the processor.**”
(Claim 23[b])

131. For purposes of my analysis, claim 23[b] is not meaningfully different from claim 7[b], which similarly recites:

wherein the processor is configured to receive a signal representative of the first and second events occurring at the wearable device or the second device via the wireless or wired communication channel and generate the control signal based on the received signal.

(’222, Claim 7[b].) Therefore, for the reasons discussed above for claim 7[b], claim 23[b] would have been obvious over Douris in view of Rodriguez.

VI. NO SECONDARY CONSIDERATIONS OF NONOBVIOUSNESS

132. 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, 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

133. 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.

134. 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 23, 2023

. Respectfully submitted,

A handwritten signature in black ink, appearing to read 'Jeremy Cooperstock', written in a cursive style.

Jeremy Cooperstock
Paris, France

EXHIBIT A

CURRICULUM VITAE

Jeremy R. Cooperstock
Version as of December 22, 2022

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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, Augmented Reality for Improved Training of First Responders
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 Real-Time Emergency Response
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 Wide Screen Window on the World: Life Size HD Videoconferencing
2001	Audio Engineering Society Citation Award for pioneering the technology enabling collaborative multichannel performance over the broadband internet

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

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

INDUSTRIAL AND CONSULTING EXPERIENCE

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

Sep 2022–ongoing	Apple* v. Taction Technologies, Inc 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	Westwood One, LLC v. Local Radio Networks, LLC* 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	iFIT Inc. f/k/a ICON Health & Fitness* v. Peloton Interactive United States District Court, District of Delaware, Civil Action No. 20-cv-1386-RGA
Sep 2021–ongoing	Brazos* v. Google 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	AmLaw 100 Firm* 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	GUI Global Products, Ltd. v. Apple* 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	Expert consultation re possible litigation in IT-related matter Work done on behalf of Sheridan Ross P.C.
Nov 2020–ongoing	Koss v. Apple* 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	ByteDance* and TikTok* v. Triller <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	Content Square v. Quantum Metric* and Decibel Insight* 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).

Sep 2020–ongoing	Wiesel v. Apple* 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	Finish Time* v. Garmin 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	Pinn v. Apple* 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	Apple* v. Qualcomm <i>Inter Partes</i> Review, Case no. IPR2018-01279. Deposition testimony on expert witness declaration related to multimedia messaging.
Mar 2019–Feb 2022	Cruz Hernandez* v. Air Canada and Lufthansa Canadian Transportation Agency Case no. 20-01712, Petitioner before the Agency regarding passengers' rights to compensation under EC 261/2014
May 2018–May 2019	Samsung* v. Immersion 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	Cooperstock* v. Air Canada 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 (otc-cta.gc.ca/eng/ruling/105-c-a-2017)
Jan–May 2014	St. Lewis v. Rancourt* Provided expert report on web server location, Ontario Superior Court File No. 11-51657
Mar–Sep 2013	Cooperstock* v. United Airlines Brought and argued successful appeal regarding anti-SLAPP legislation before the Quebec Court of Appeal, Decision 2013 QCCA 1670 (goo.gl/pgz301). Argued appeal in person (September 26, 2013)
Nov 2012–Aug 2017	United Airlines v. Cooperstock* Pro se litigant, Federal Court File No. T-2084-12. Deposition as litigant (August 2013) and testified at trial (December 2016).

Nov 2012–Jan 2017	United Airlines v. Cooperstock* Pro se litigant, Quebec Superior Court File No. 500-17-074743-124. Deposition as litigant (October 2014) and testified at trial (April 2016).
Sep 2012	Lukács* v. Air Canada Provided expert report on database query and execution times, Canadian Transportation Agency File No. M4120-3/11-06673, Decision No. 204-C-A-2013
May 2007–Jan 2008	Market Maker c. Brim Solutions* 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.
Feb–Oct 2004	Crawford Adjusters Canada Provided analysis of artifacts in high definition video
Jul 2002–May 2016	Court of Quebec, Small Claims Division 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.
- [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.
- [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. 🏆 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.
- [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>.
- [J26] J. R. Cooperstock. “Multimodal Telepresence Systems: Supporting Demanding Collaborative Human Activities.” In: *IEEE Signal Processing* 28.1 (Jan. 2011). special issue on Immersive Communications, pp. 77–86. DOI: [10.1109/MSP.2010.939040](https://doi.org/10.1109/MSP.2010.939040).
- [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>.
- [J31] **G. Wang**, L. Mercier, D. L. Collins, and J. R. Cooperstock. “A Comparative Study of Monoscopic and Stereoscopic Display for a Probe-Positioning Task.” 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. 417–419. URL: <http://srl.mcgill.ca/publications/2009-MMVR-Wang.pdf>.
- [J32] V. N. Salimpoor, **M. Benovoy**, G. Longo, J. R. Cooperstock, and R. J. Zatorre. “The Rewarding Aspects of Music Listening are Related to Degree of Emotional Arousal.” In: *PLoS ONE* 4.10:e7487 (2009). DOI: [10.1371/journal.pone.0007487](https://doi.org/10.1371/journal.pone.0007487). URL: <http://dx.plos.org/10.1371/journal.pone.0007487>.
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- [J34] **W. Sun** and J. R. Cooperstock. “An Empirical Evaluation of Factors Influencing Camera Calibration Accuracy Using Three Publicly Available Techniques.” In: *Machine Vision and Applications Journal* 17.1 (Feb. 2006), pp. 51–67. DOI: [10.1007/s00138-006-0014-6](https://doi.org/10.1007/s00138-006-0014-6). URL: <http://www.springerlink.com/content/5824738r1w66v6w1/>.
- [J35] W. Woszczyk, J. R. Cooperstock, J. Roston, and W. Martens. “Shake, Rattle and Roll: Getting Immersed in Multisensory, Interactive Music via Broadband Networks.” In: *Journal of the Audio Engineering Society* 53.4 (Apr. 2005), pp. 336–344. URL: <http://www.aes.org/e-lib/browse.cfm?elib=13416>.
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- [J37] L. R. Winer and J. R. Cooperstock. “The “Intelligent Classroom”: Changing teaching and learning with an evolving technological environment.” In: *Journal of Computers and Education* 38 (2002), pp. 253–266. URL: <http://srl.mcgill.ca/publications/2002-CAE.pdf>.
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REFEREED CONFERENCE PUBLICATIONS

- [C1] **D. Marino, M. Henry, P. Fortin, R. Bhayana,** and J. R. Cooperstock. “I See What You’re Hearing: Facilitating The Effect of Environment on Perceived Emotion While Teleconferencing.” In: *Computer-Supported Cooperative Work and Social Computing (to appear)*. Minneapolis, MN: ACM, Oct. 2023.
- [C2] **H. Lee, R. Jiang, Y. Yoo, M. Henry,** and J. R. Cooperstock. “The Sound of Hallucinations: Toward a more convincing emulation of internalized voices.” In: *Human Factors in Computing Systems (CHI)*. New Orleans, LA: ACM, Apr. 2022. DOI: [10.1145/3491102.3501871](https://doi.org/10.1145/3491102.3501871). URL: <https://dl.acm.org/doi/10.1145/3491102.3501871>. 🏆 Honorable Mention.
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- [C162] J. R. Cooperstock and E. Milios. “Self-Supervised Learning for Docking and Target Reaching.” In: *Intelligent Autonomous Systems*. Pittsburgh, 1993, pp. 582–591.
- [C163] J. R. Cooperstock and E. Milios. “Adaptive Neural Networks for Vision-Guided Position Control of a Robot Arm.” In: *IEEE Intelligent Control*. Glasgow, UK, 1992, pp. 397–403. DOI: [10.1109/ISIC.1992.225124](https://doi.org/10.1109/ISIC.1992.225124). URL: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=225124.
- [C164] J. R. Cooperstock and E. Milios. “Neural Network Control for a Vision-Guided Mobile Robot Arm.” In: *IASTED Control and Robotics*. Vancouver, BC, Canada, 1992, pp. 278–281.

REFEREED CONFERENCE PUBLICATIONS (POSTERS)

- [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%.
- [CP5] **F. Al-Taha, P. Fortin, A. Weill–Duflos**, and J. R. Cooperstock. “Reversing Voice-Related Biases Through Haptic Feedback.” In: *User Interface Software and Technology (UIST)*. Berlin, Germany: ACM, Oct. 2018. URL: <http://dl.acm.org/authorize?N682233>.
- [CP6] **F. Tordini**, A. Bregman, and J. R. Cooperstock. “Effects of global brightness on salience and auditory foreground perception.” In: *Speech in Noise Workshop*. Glasgow, Scotland, Jan. 2018. URL: <https://spin2018.eu/?p=program&id=66>.
- [CP7] **J. Blum** and J. R. Cooperstock. “Exploring the Limits of Vibrotactile Numeric Information Delivery.” In: *Ubicomp*. Singapore: ACM, Oct. 2018. URL: <http://dl.acm.org/authorize?N682245>.
- [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>.
- [CP9] **T. Kim** and J. R. Cooperstock. “Enhanced Pressure-Based Multimodal Immersive Experiences.” In: *Augmented Human*. Seoul, Korea: ACM, Feb. 2018. URL: <http://dl.acm.org/authorize?N682247>. 🏆 Best poster presentation award, Acceptance rate: 34%.
- [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%.
- [CP11] **J. Anlauff**, J. Fung, and J. R. Cooperstock. “Modular Haptic Belt for Augmented Balance Feedback.” In: *Intl. Society for Posture and Gait Research*. Seville, Spain, June 2015.
- [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.

- [CP14] **D. Glessner**, F. Bérard, and J. R. Cooperstock. “Overcoming Limitations of the Trackpad for 3D Docking Operations.” In: *Human Factors in Computing Systems (CHI), Extended Abstracts*. Paris, France: ACM, Apr. 2013. URL: <http://dl.acm.org/authorize?N06273>. Acceptance rate: 20%.
- [CP15] **C. Côté**, **S. Arseneau**, and J. R. Cooperstock. “Telepresence with no Strings Attached: An Architecture for a Shared Reality Environment.” In: *Second International Symposium on Mixed Reality (ISMR)*. Yokohama, Japan, Mar. 2001. URL: <http://srl.mcgill.ca/publications/2001-ISMR.pdf>.
- [CP16] **S. Arseneau** and J. R. Cooperstock. “Automated Camera Tracking in a Real-World Environment.” In: Montreal, QC, Canada, 2000.
- [CP17] J. R. Cooperstock. “Rethinking the Remote Control.” In: *HCI International, Conference on Human-Computer Interaction*. San Francisco, CA, USA, Aug. 1997, p. 116.

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. URL: https://link.springer.com/chapter/10.1007/978-3-319-93491-4_16.
- [B2] **M. Wozniowski**, Z. Settel, and J. R. Cooperstock. “Sonic Interaction via Spatial Arrangement in Mixed Reality Environments.” In: *Sonic Interaction Design*. Ed. by K. Franinovic and S. Serafin. MIT Press, 2013, pp. 329–340. URL: <http://xplorebcapaz.ieee.org/xpl/login.jsp?tp=&arnumber=6504636>.
- [B3] M. Marchal, **G. Cirio**, **Y. Visell**, F. Fontana, S. Serafin, J. R. Cooperstock, and A. Lécuyer. “Multimodal Rendering of Walking over Virtual Grounds.” In: *Human Walking in Virtual Environments*. Ed. by Y. Visell, A. Lécuyer, F. Steinicke, and J. Campos. Springer Verlag, 2013, pp. 263–295. URL: <http://www.springer.com/engineering/robotics/book/978-1-4419-8431-9>.
- [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>.
- [B5] **Y. Visell**, **R. Rajalingham**, and J. R. Cooperstock. “A review of nonvisual signatures of human walking with applications to person tracking in augmented environments.” In: *Walking with the senses: Perceptual techniques for walking in virtual environments*. Ed. by Y. Visell and F. Fontana. Logos Verlag, 2012, pp. 33–68.
- [B6] **Y. Visell**, **S. Smith**, and J. R. Cooperstock. “Distributed human-computer interaction with augmented floor surface.” In: *Walking with the senses: Perceptual techniques for walking in virtual environments*. Ed. by Y. Visell and F. Fontana. Logos Verlag, 2012, pp. 15–32.

- [B7] J. R. Cooperstock. “Human-Computer Interaction.” In: *Wiley Encyclopedia of Computer Science and Engineering*. Ed. by B. W. Wah. Vol. 3. Wiley-Interscience, Mar. 2009, pp. 1529–1542. DOI: [10.1002/9780470050118.ecse524](https://doi.org/10.1002/9780470050118.ecse524). URL: <http://onlinelibrary.wiley.com/doi/10.1002/9780470050118.ecse524/abstract>.
- [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.

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.
- [N3] J. R. Cooperstock and G. Lukács. *How to complain to airlines*. CBC Marketplace blog. Mar. 2014. URL: <http://www.cbc.ca/marketplace/blog/plane-wrong-how-to-complain-to-airlines>.
- [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.
- [N12] J. Cooperstock. “Integrating Communication with Interaction: Computer Vision Challenges for Interactive and Intelligent Environments.” In: *Workshop on Computer Vision for Interactive and Intelligent Environments (invited)*. Lexington, KY, USA, Nov. 2005. URL: <http://srl.mcgill.ca/publications/2005-CV4IIE.pdf>.
- [N13] J. Cooperstock, J. Roston, and Woszczyk. “Broadband Networked Audio: Entering the Era of Multisensory Data Distribution.” In: *18th International Congress on Acoustics (invited)*. Kyoto, Apr. 2004.
- [N14] **Cayouette, F.**, **Sud, D.**, **Patel, K.**, **Sarikaya, D.**, and J. Cooperstock. “McGill Reddogs Final Report.” In: *Robocup*. 2002.
- [N15] J. Cooperstock. “Classroom of the Future: Enhancing Education through Augmented Reality.” In: *HCI International, Conference on Human-Computer Interaction (invited)*. New Orleans, 2001.
- [N16] **Sud, D.**, **Cayouette, F.**, **Gu, J.**, and J. Cooperstock. “McGill Reddogs Final Report.” In: *Robocup*. 2001.
- [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” Beiham 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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Name	Period	Project title	Present Position
Olmos, Adriana	Sep 2008 – July 2012	user interface engineer under Canarie NEP	Interaction designer, Google/YouTube
Sun, Haijian	Sep 2008 – Oct 2010	computer engineer under Canarie NEP	programmer, Des- jardins
Soukhodolski, I.	Oct 2005 – Dec 2007	web services programmer under Ca- narie IIP	Owner, W4 Tech- nology
Kiewe, Howard	Oct 2005 – Dec 2007	user interface developer under Canarie IIP	consultant
Spackman, S.	2000–2006	research associate on Canarie and VRQ projects	Google, Mountain View
Sarikaya, Deniz	2003–2004	research assistant on VRQ projects	deceased
Soucy, Gilbert	1999	research associate on CFI project	Imaging Specialist, 36pix Inc., Mon- 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

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

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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. ^p	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. [†]	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

^g Graphics Animation and New Media (GRAND) Scholarship recipient

^p 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, 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 [◊]	Sep 2021–	Wearable sensor deployment for pandemic mitigation	
Henry, Max	Sep 2021–	Spatial-aware audio rendering for immersive telepresence	
Lewis-Lane, 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 – 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 – 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 [‡]	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. [†]	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 [†]	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 [†]	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 Detection 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

Continued on next page

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/ 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/ 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- 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- 2021	NSERC/ 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- 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 (75%)	<i>Avatar Care Provider for Seniors Residences</i> Mitacs Accelerate (with K. Moffatt)
2022-2025	CRIAQ	\$800,000 (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 (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 (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 (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 (90%)	* <i>Augmented Reality Tools for Improved Training of First Responders</i> Mozilla Gigabit Community Fund (with R. Dearden)
2011	CIRMMT	\$10,000 (90%)	* <i>Acoustic Sculptures</i> CIRMMT Strategic Innovation Fund Award (with A. Olmos and 3 others)
2010-2011	NSERC	\$49,815 (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 (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 (?%)	<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 (4%)	<i>*Digitally Merged Environments</i> California-Canada Strategic Initiatives Program (with S. Brown, UCSD and 20 co-applicants)
2009-2011	Canarie	\$927,648 (40%)	<i>†Open Orchestra</i> Network-Enabled Platforms 2 (with J. Roston and W. Woszczyk)
2010-2014	NCE	\$23,000,000 (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 (90%)	<i>*Novel Portable Treatment Device for Lazy Eye</i> Idea to Innovation (I2I) (with R. Hess)
2008-2010	Canarie	\$1,397,758 (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 (18%)	<i>Health Services Virtual Organization</i> Network-Enabled Platforms (with R. Ellaway and 8 others)
2008-2010	NSERC	\$196,000 (50%)	<i>*3-D Visualization and gestural interaction with multimodal neurological data</i> Strategic Projects (with 5 others)
2006-2009	FRQNT	\$146,550 (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 (50%)	<i>Undersea Window–High Definition Video Online</i> Intelligent Infrastructure Program. (with J. Roston)
2005-2006	SAT	\$1,276,000 (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 (33%)	<i>Shared Spaces – High Definition Ultra-Videoconferencing</i> Advanced Applications Program. (with J. Roston)
2003-2004	SAT	\$792,082 (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 (25%)	<i>*Parallel Distributed Camera Arrays for Intelligent Environments</i> (with J. Clark, S. Fels, R. Vertegaal)
2002-2005	VRQ	\$2,180,000 (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 (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 (35%)	<i>McGill Advanced Learnware Project.</i> Advanced Networking Applications Services and Technologies. (with B. Pennycook)
2000-2003	LUB	\$150,000 (50%)	<i>*Distributed Shared Visualization Environment.</i> Laboratoire universitaire Bell. (with B. Ozell)
2000-2001	Royal Bank	\$2,000 (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 (50%)	<i>†The Shared Reality Environment.</i> New Opportunities Award. (with J. Clark)
1999-2000	Royal Bank	\$10,000 (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/ 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/ 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 <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 <i>Embedded Systems</i>	Undergraduate course dealing with both the theory and practice of design for embedded systems	2018–present
ECSE-526 <i>Artificial Intelligence</i>	Graduate level course in artificial intelligence with emphasis on machine learning and autonomous agents	1998–present
*ECSE-683 <i>Topics in Vision and Robotics</i>	Graduate level laboratory course for RoboCup projects	Fall 2000 Fall 2002
*ECSE-424/542 <i>Human-Computer Interaction</i> [†]	Undergraduate (424) and graduate (542) course in human-computer interaction with emphasis on new interface paradigms	2000–present
ECSE-487 <i>Computer Architecture Laboratory</i>	Undergraduate laboratory course	1999–2018
ECSE-427 <i>Operating Systems</i>	Undergraduate course (core for Computer Engineering students)	1998
CSC-270 <i>Introduction to Modelling and Optimization</i>	Computer Science undergraduate course, University of Toronto	1993–1994
CEE 1714Y <i>Digital Systems and Computers</i>	Continuing Engineering Education course for the Association of Professional Engineers of Ontario	1993–1994
CSC-228 <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)

Name	Year	Research topic
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)

Name	Year	Research topic
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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Name	Year	Research topic
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 tex
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

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Name	Year	Research topic
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

Name	Year	Research project
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
Resznetnik, 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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Name	Year	Research project
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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Name	Year	Research project
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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Name	Year	Research project
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 (2013 QCCA 1670) before Quebec Court of Appeal regarding anti-SLAPP legislation
2013	initiated petition to improve rights of Canadian airline passengers
2010	advocating for reliable public transportation in Montreal
1997-present	created and maintained passenger rights website