

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner

v.

IMMERSION CORPORATION,
Patent Owner

U.S. Patent No. 8,581,710
Filing Date: September 5, 2012
Issue Date: November 12, 2013
Title: System and Methods For Haptic Confirmation of Commands

Inter Partes Review No.: (Unassigned)

DECLARATION OF DR. TONY GIVARGIS

TABLE OF CONTENTS

	Page
I. INTRODUCTION	1
A. Background and Qualifications	1
B. Information Considered.....	3
II. LEGAL STANDARDS	4
A. Legal Standards for Prior Art	4
B. Legal Standards for Anticipation	5
C. Legal Standards for Obviousness.....	5
III. OVERVIEW OF THE '710 PATENT	9
A. Summary of the '710 Patent.....	9
B. Person of Ordinary Skill in the Art	12
C. Claim Construction	12
D. The '710 Patent Claims	14
IV. THE PRIOR ART	15
A. U.S. Patent No. 7,336,260 to Martin et al. ("Martin").....	15
B. U.S. Patent Application Publication No. 2009/0164207 to Makela et al. ("Makela").....	18
C. Detailed Analysis	20
1. Limitation 13.a : "A computer-implemented method comprising the steps of:"	20
2. Limitation 13.b: "receiving, from a sensor, a sensor signal associated with a user input"	21
3. Limitation 13.c: "recognizing the user input and determining a command associated with the speech information"	25
4. Limitation 13.d: "if the user input is recognized and the command is determined: generating a first actuator signal configured to cause an actuator to output a first haptic effect; and ..."	28

TABLE OF CONTENTS

(continued)

	Page
5. Limitation 13.e: “if the user input is recognized and the command is determined: ... transmitting the first actuator signal to the actuator;”	29
6. Limitation 13.f: “otherwise: generating a second actuator signal configured to cause the actuator to output a second haptic effect; and ...”	30
7. Limitation 13.g: “otherwise: ... transmitting the second actuator signal to the actuator.”	33
8. Claim 19: “The computer-implemented method of claim 13, further comprising: generating a display signal configured to cause a display to display an image; and transmitting the display signal to the display.”	34
9. Claim 20: “The computer-implemented method of claim 13, wherein the first haptic effect is configured to emulate the command.”	37
D. U.S. Patent No. 6,505,159 to Theodore (“Theodore”).....	38
E. U.S. Pat. App. Pub. No. 2002/0033795 (“Shahoian”)	41
F. Detailed Analysis	41
1. Limitation 13.a: A computer-implemented method comprising the steps of:”	41
2. Limitation 13.b: “receiving, from a sensor, a sensor signal associated with a user input”	42
3. Limitation 13.c: “recognizing the user input and determining a command associated with the speech information”	44
4. Limitation 13.d: “if the user input is recognized and the command is determined: generating a first actuator signal configured to cause an actuator to output a first haptic effect; and”	46
5. Limitation 13.e: “if the user input is recognized and the command is determined: ... transmitting the first actuator signal to the actuator.”	48

TABLE OF CONTENTS
(continued)

	Page
6. Limitation 13.f: “otherwise: generating a second actuator signal configured to cause the actuator to output a second haptic effect;”	49
7. Limitation 13.g: “otherwise: ... transmitting the second actuator signal to the actuator.”	50
8. Claim 18: “The computer-implemented method of claim 13, further comprising: generating an audio signal configured to cause a speaker to output a sound; and transmitting the audio signal to the speaker.”	51
9. Claim 19: “The computer-implemented method of claim 13, further comprising: generating a display signal configured to cause a display to display an image; and transmitting the display signal to the display.”	52
V. CONCLUSION.....	53

EXHIBIT LIST

Exhibit No.	Description
1101	U.S. Patent No. 8,581,710.
1102	Reserved.
1103	Microsoft Computer Dictionary (5th ed. 2002).
1104	U.S. Patent No. 6,505,159 to Theodore (“Theodore”).
1105	U.S. Pat. App. Pub. No. 2002/0033795 (“Shahoian”).
1106	U.S. Patent No. 7,336,260 to Martin et al. (“Martin”).
1107	U.S. Patent Application Publication No. 2009/0164207 to Makela et al. (“Makela”).
1108	MSC1200, MSC1201, MSC1202 Datasheet.
1109	U.S. Patent No. 7,496,481 to Kovacevich.
1110	Patent Owner Immersion’s claim chart regarding alleged infringement of the ’710 patent by certain Apple iPhone products (Exhibit 23 to Immersion’s ITC Complaint in ITC Investigation No. 337-TA-1004).
1111	Immersion’s Complaint in ITC Investigation No. 337-TA-1004 (the “Complaint”).
1112	File History of U.S. Patent No. 8,581,710.
1113	Merriam-Webster’s Collegiate Dictionary (11th ed. 2003).
1114	World Intellectual Property Organization’s publication of PCT/US2010/054967
1115	U.S. Patent No. 5,999,168 to Rosenberg, et al. (“Rosenberg”)

I. INTRODUCTION

1. I have been retained by counsel for Apple Inc. as an expert witness in the above-captioned proceeding. I have been asked to provide my opinion about the patentability of claims 13, 18, 19, and 20 of U.S. Patent No. 8,581,710 (the “’710 patent”).

2. I have been retained at my normal hourly rate of \$400 per hour. No part of my compensation is dependent upon the outcome of this proceeding or the specifics of my testimony.

A. Background and Qualifications

3. A copy of my current curriculum vitae (“CV”) is attached as Appendix A. As detailed in my CV, I received a Bachelor of Science degree in Computer Science from the University of California, Riverside, in 1997. In 2001, I received my Ph.D. degree in Computer Science, also from the University of California, Riverside.

4. My doctoral thesis, completed under the supervision of Professor Frank Vahid, was titled “Design Space Exploration of Parameterized System-on-a-Chip Architectures” and related to computer-aided design optimization of highly integrated circuits on chip.

5. I have been a member of the Department of Computer Science faculty at the University of California, Irvine (“UC-Irvine”) since 2001. From 2001-2007,

I held the title Assistant Professor of Computer Science. I was promoted to Associate Professor, with tenure, in 2007, and to full Professor in 2011. From 2011-2016, I also served as Associate Dean for Student Affairs in the Donald Bren School of Information & Computer Sciences at UC-Irvine.

6. I have done extensive research in the area of embedded systems design. Embedded systems are devices that, in addition to having mechanical and electrical parts, make use of an embedded computing element, comprised of one or more processors, electronic circuitry, and system software. My research is focused on software design for embedded systems, real-time operating systems, sensors and actuators, interfacing circuitry, sensor networks, embedded processor architectures, multi-core processors, flash memory systems, low power design, and general system optimization algorithms.

7. I have graduated six Ph.D. students and am currently supervising and advising a group of two Ph.D., a post-doctoral researcher, and multiple M.S./B.S. students. As a professor, I regularly teach both at the graduate and undergraduate levels. At UC-Irvine, among computer science and engineering students, I am probably best known for routinely teaching the upper division as well as graduate-level embedded systems courses (CS 145 and CS 245). These courses cover the design cycle of a typical embedded device, including all aspects of hardware and software integration. Additionally, I have taught courses in the areas of

programming, logic design, modeling and simulation, ubiquitous computing, and compilers.

8. I have published over 91 peer-reviewed conference and journal papers, four of which have been recognized by Best Paper Awards. My papers are published in highly ranked and archived journals. I am a co-inventor on 11 issued US patents.

9. I have co-authored two popular textbooks on embedded system design that are widely used at top institutions in the US as well as around the globe. I received the prestigious 2011 Frederick Emmons Terman Award for my textbook entitled Embedded System Design: A Unified Hardware/Software Introduction.

10. Additional details regarding my qualifications and background can be found in my CV.

B. Information Considered

11. My opinions are based on my years of education, research, and experience, as well as my study of relevant materials. In forming my opinions, I have considered the materials identified in this declaration and in the Petition.

12. I may rely upon these materials and/or additional materials to respond to arguments raised by Immersion. I may also consider additional documents and information in forming any necessary opinions, including documents that may have not yet been provided to me.

13. My analysis of the materials produced in this proceeding is ongoing and I will continue to review any new material as it is provided. This declaration represents only those opinions I have formed to date. I reserve the right to revise, supplement, or amend my opinions stated herein based on new information and on my continuing analysis of the materials already provided.

II. LEGAL STANDARDS

A. Legal Standards for Prior Art

14. I understand that a patent or other publication must first qualify as prior art before it can be used to invalidate a patent claim.

15. I understand that a U.S. or foreign patent qualifies as prior art to an asserted patent if the date of issuance of the patent is prior to the invention of the asserted patent. I further understand that a printed publication, such as an article published in a magazine or trade publication, qualifies as prior art to an asserted patent if the date of publication is prior to the invention of the asserted patent.

16. I understand that a U.S. or foreign patent also qualifies as prior art to an asserted patent if the date of issuance of the patent is more than one year before the filing date of the asserted patent. I further understand that a printed publication, such as an article published in a magazine or trade publication, constitutes prior art to an asserted patent if the publication occurs more than one year before the filing date of the asserted patent.

17. I understand that a U.S. patent qualifies as prior art to the asserted patent if the application for that patent was filed in the United States before the invention of the asserted patent.

B. Legal Standards for Anticipation

18. I understand that documents and materials that qualify as prior art can be used to invalidate a patent claim via anticipation or obviousness.

19. I understand that, once the claims of a patent have been properly construed, the second step in determining anticipation of a patent claim requires a comparison of the properly construed claim language to the prior art on a limitation-by-limitation basis.

20. I understand that a prior art reference “anticipates” an asserted claim, and thus renders the claim invalid, if all elements of the claim are disclosed in that prior art reference, either explicitly or inherently (i.e., necessarily present).

21. I understand that anticipation in an *inter partes* review must be shown by a preponderance of the evidence.

C. Legal Standards for Obviousness

22. I understand that even if a patent is not anticipated, it is still invalid if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person of ordinary skill in the pertinent art.

23. I understand that a person of ordinary skill in the art provides a reference point from which the prior art and claimed invention should be viewed. This reference point prevents one from using his or her own insight or hindsight in deciding whether a claim is obvious.

24. I also understand that an obviousness determination includes the consideration of various factors such as (1) the scope and content of the prior art, (2) the differences between the prior art and the asserted claims, (3) the level of ordinary skill in the pertinent art, and (4) the existence of secondary considerations such as commercial success, long-felt but unresolved needs, failure of others, etc.

25. I understand that an obviousness evaluation can be based on a combination of multiple prior art references. I understand that the prior art references themselves may provide a suggestion, motivation, or reason to combine, but other times the nexus linking two or more prior art references is simple common sense. I further understand that obviousness analysis recognizes that market demand, rather than scientific literature, often drives innovation, and that a motivation to combine references may be supplied by the direction of the marketplace.

26. I understand that if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve

similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill.

27. I also understand that practical and common sense considerations should guide a proper obviousness analysis, because familiar items may have obvious uses beyond their primary purposes. I further understand that a person of ordinary skill in the art looking to overcome a problem will often be able to fit together the teachings of multiple publications. I understand that obviousness analysis therefore takes into account the inferences and creative steps that a person of ordinary skill in the art would employ under the circumstances.

28. I understand that a particular combination may be proven obvious merely by showing that it was obvious to try the combination. For example, 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 because the result is likely the product not of innovation but of ordinary skill and common sense.

29. The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. When a work is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a

person of ordinary skill can implement a predictable variation, the patent claim is likely obvious.

30. It is further my understanding that a proper obviousness analysis focuses on what was known or obvious to a person of ordinary skill in the art, not just the patentee. Accordingly, I understand that any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.

31. I understand that a claim can be obvious in light of a single reference, without the need to combine references, if the elements of the claim that are not found explicitly or inherently in the reference can be supplied by the common sense of one of skill in the art.

32. I understand that secondary indicia of non-obviousness may include (1) a long felt but unmet need in the prior art that was satisfied by the invention of the patent; (2) commercial success of processes covered by the patent; (3) unexpected results achieved by the invention; (4) praise of the invention by others skilled in the art; (5) taking of licenses under the patent by others; (6) deliberate copying of the invention; (7) failure of others to find a solution to the long felt need; and (8) skepticism by experts.

33. I also understand that there must be a relationship between any such secondary considerations and the invention. I further understand that

contemporaneous and independent invention by others is a secondary consideration supporting an obviousness determination.

34. In sum, my understanding is that prior art teachings are properly combined where a person of ordinary skill in the art having the understanding and knowledge reflected in the prior art and motivated by the general problem facing the inventor, would have been led to make the combination of elements recited in the claims. Under this analysis, the prior art references themselves, or any need or problem known in the field of endeavor at the time of the invention, can provide a reason for combining the elements of multiple prior art references in the claimed manner.

35. I understand that obviousness in an *inter partes* review must be shown by a preponderance of the evidence.

III. OVERVIEW OF THE '710 PATENT

A. Summary of the '710 Patent

36. The '710 patent is titled "Systems and Methods for Haptic Confirmation of Commands." Ex. 1101, cover. The '710 patent explains that "[c]ommands to electronic devices have typically been issued by pressing a button or flipping a switch. However, voice and other types of commands are becoming more prevalent in user interfaces, such as voice-commanded dialing of cell phones." Ex. 1101, 1:21-25. The '710 patent further explains that audio and

visual cues may not always be possible in electronic devices such as smart phones. *Id.*, 1:25-32. “Thus, it may be desirable to provide other mechanisms for providing responses to the user.” *Id.*, 1:32-33.

37. The '710 patent discloses embodiments in which a user speaks commands into a microphone, such as the PDA shown in the block diagram of Fig. 1 reproduced below:

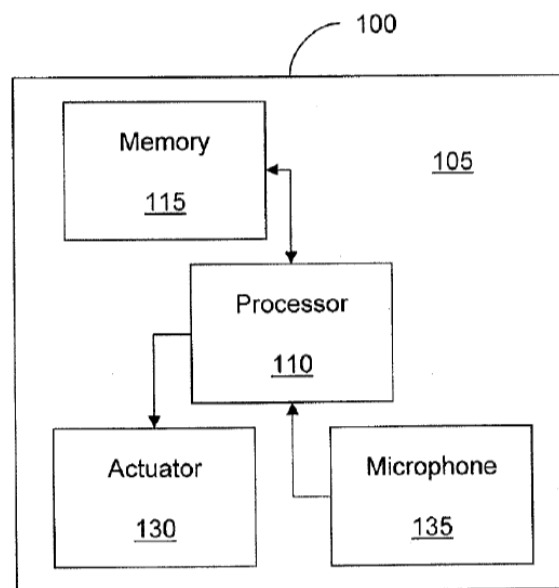
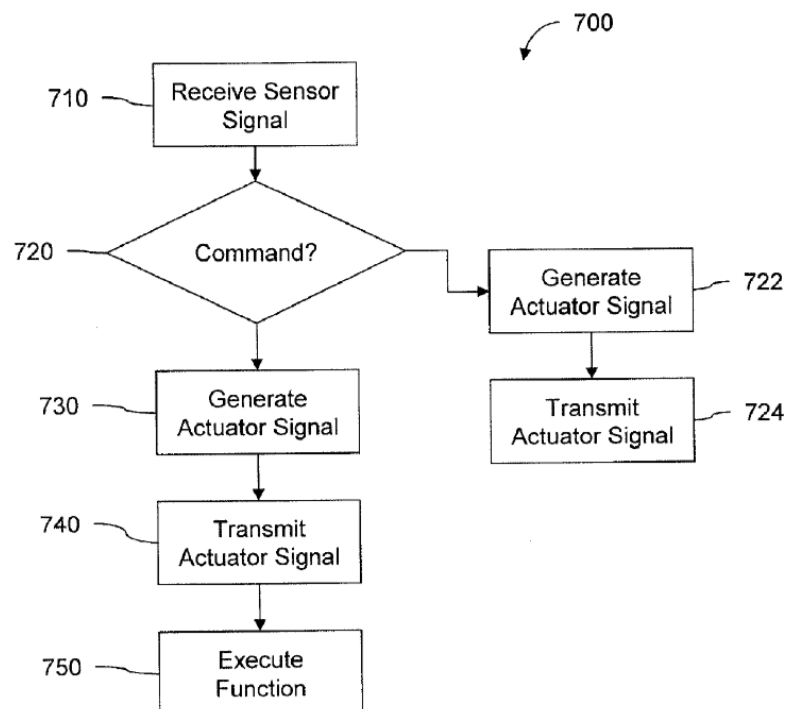


Figure 1

Ex. 1101, 4:47-50. Other embodiments involving voice recognition include desktop computers (*id.*, 5:17-20) and Bluetooth headsets attached to cell phones (*id.*, 6:9-10). Also disclosed in the '710 patent are embodiments comprising a haptically-enabled medical alert device in communication with a communications device (*id.*, 7:4-11), a display worn by a user such as goggles with an integrated

display and a sensor that detects the orientation of a user's eye to select a command on the display that allows a user to control a wheelchair (*id.*, 11:27-41 and 12:6-24), and a user device with a touchscreen in which a user selects commands by touching locations on the touchscreen (*id.*, 7:25-34).

38. An example of processing associated with confirmation of commands is shown in Fig. 7, reproduced below, in which the path from the bottom of decision diamond 720 indicates that the command was determined, and the path leading from the right of the decision diamond 720 indicates that a command was not determined:



Id., 12:38-45. The '710 patent discloses generating and transmitting an actuator signal for a haptic effect that indicates that the command is recognized if the

command is recognized, and “otherwise” generating and transmitting an acuator signal for another haptic effect that indicates that the command was not recognized. *Id.*, 12:38-52.

B. Person of Ordinary Skill in the Art

39. A person of ordinary skill in the art (“POSITA”) at the time of the alleged invention of the ’710 patent would have had a Bachelors’ degree in computer science, electrical engineering, or a comparable field of study, plus approximately two to three years of professional experience with software engineering, haptics programming, or other relevant industry experience. Additional graduate education could substitute for professional experience and significant experience in the field could substitute for formal education.

C. Claim Construction

40. I understand from Apple counsel that in an *inter partes* review, claims are to be given their broadest reasonable interpretation in view of the specification.

41. I also understand that in the ITC investigation involving Immersion and Apple, Immersion has submitted to the ITC claim charts showing how Immersion believes that the ’710 patent’s claims allegedly encompass certain of Apple’s products. Ex. 1110. I understand from Apple counsel that for purposes of this proceeding, it is proper to request that Immersion be held to claim constructions that are as broad as those that Immersion has publicly set forth in its

claim charts from the ITC investigation. I therefore have considered those infringement claim charts in reaching my conclusions about what the claim terms mean.

42. I understand that the standards used in the ITC and in a district court to interpret patent claims are different than those used by the PTO in this proceeding. I understand that the main difference is that in this proceeding, the claims are to be read as broad as is reasonable based on the specification. I understand that this may cause the claims to cover certain things in this proceeding that a court might find are not within the scope of the claims in the court proceeding.

43. In the table below, I provide a scope of construction for certain claim terms based on their broadest reasonable interpretation in view of the specification and based on the Immersion's apparent belief about the scope of the claim terms from its infringement contentions in the ITC investigation.

Claim Term	Scope of Construction	Citation(s)
“signal” (all challenged claims)	Based on the plain and ordinary meaning, the claim term should encompass “any electrical quantity, such as voltage, current or frequency that can be used to transmit information.” One skilled in the art would understand that this definition would encompass either digital or analog signals.	Ex. 1103 at 3 (Microsoft Computer Dictionary).

“haptic effect configured to emulate the command” (claim 20)	Based on Immersion’s public contentions, this term should encompass a short vibration used to emulate the command to display a menu.	Ex. 1111 at 19, Table 1 and 21 (Immersion contending that Apple iPhone 6s and 6s Plus infringe claim 8); Ex. 1110 at 28-29, 32 (Immersion contending that Quick Action feature in accused Apple products display a menu); <i>id.</i> at 39-40 (Immersion contending that haptic effect in the form of a tap of duration of less than 10 ms is associated with Quick Action menu display).
“otherwise...” (claim 13)	In the first IPR petition relating to the ’710 patent, the PTAB determined that the prior art does not need to teach the steps recited in the similar “otherwise” limitations claim 1 to render the claim obvious. I understand from Apple counsel that applying the same rationale, a prior art reference need not practice the “otherwise” limitation of claim 13 to render the claim obvious.	IPR2016-01603, Paper 7 at 19.

D. The ’710 Patent Claims

44. For reference, claims 13, 18, 19, and 20 of the ’710 patent are recreated below.

	Claim Language
13.a	A computer-implemented method comprising the steps of:

13.b	receiving, from a sensor, a sensor signal associated with a user input
13.c	recognizing the user input and determining a command associated with the speech information
13.d	if the user input is recognized and the command is determined: generating a first actuator signal configured to cause an actuator to output a first haptic effect; and ...
13.e	if the user input is recognized and the command is determined: ... transmitting the first actuator signal to the actuator;
13.f	otherwise: generating a second actuator signal configured to cause the actuator to output a second haptic effect; and ...
13.g	otherwise: ... transmitting the second actuator signal to the actuator.
18	The computer-implemented method of claim 13, further comprising: generating an audio signal configured to cause a speaker to output a sound; and transmitting the audio signal to the speaker.
19	The computer-implemented method of claim 13, further comprising: generating a display signal configured to cause a display to display an image; and transmitting the display signal to the display.
20	The computer-implemented method of claim 13, wherein the first haptic effect is configured to emulate the command.

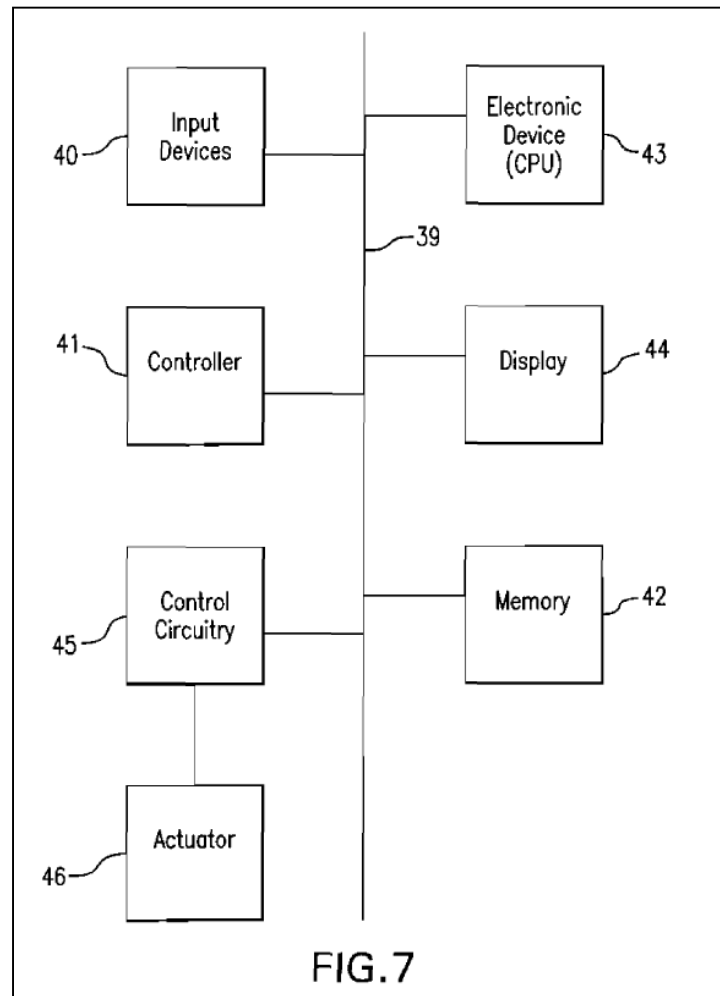
IV. THE PRIOR ART

A. U.S. Patent No. 7,336,260 to Martin et al. (“Martin”)

45. Martin was issued on February 26, 2008 (Ex. 1106, cover), which is more than one year before the earliest possible priority date of the ’710 patent (November 4, 2009). I understand from Apple counsel that Martin is therefore prior art to the ’710 patent under 35 U.S.C. § 102 (b) (pre-AIA).

46. Martin is titled “Method and Apparatus for Providing Tactile Sensations.” Ex. 1106, Cover. More particularly, Martin discloses providing tactile feedback associated with user input on devices such as smartphones and PDAs (personal digital assistants). *Id.*, 2:16-35. In one embodiment, Martin

discloses an electronic device including a CPU 43, a display 44, input devices 40, a controller 41, and an actuator 46 controlled by control circuitry 45 as shown in block diagram form in Fig. 7 reproduced below:



47. Martin discloses that the “input devices 40 produce input signals in accordance with the present invention, and the input signals are communicated to the controller 41 across the communication bus 39.” Ex. 1106, 13:28-31. “In some embodiments, the input signal includes pressure data, or data from which the pressure applied to the input device can be calculated, position data, or a

combination of pressure and position data.” *Id.*, 14:17-21. “Based upon the received input signal, pressure and position data, the controller accesses a memory 42 to obtain the necessary data regarding the functionality and tactile feedback associated with the received input signal.” *Id.*, 13:33-37. “Based upon the received functionality, the controller delivers a function signal to the electronic device 43 to which the apparatus is connected. In addition, the controller 41 modifies the output on the display 44 in particular where the display is part of the input device, such as when a touchpad is used.” *Id.*, 13:41-46. “The controller uses the tactile feedback information received from the memory to provide the necessary input to control circuitry 45 to drive the actuator 46 to produce the desired tactile sensation in the appropriate input device.” *Id.* 13:54-58.

48. In one embodiment, the information stored in the memory “is in the form of associations among the detected input data, the functions of the electronic device or apparatus, and the tactile sensations.” *Id.*, 14:28-31. An example of such associations is represented in tabular form in Fig. 9 shown below:

INPUT DEVICE	INPUT SIGNAL	POSITION DATA	PRESSURE DATA	FUNCTION	TACTILE SENSATION
1	--	Location 1	< Pressure 1	Search	Sensation 1
	Input 1	Location 1	Pressure 1 <=	Select	Sensation 2
2	--	Position 1	--	On	Sensation 3
	--	Position 2	--	Off	Sensation 4
3	Input 2A	--	Pressure 1	9	Sensation 5
	Input 2B	--	Pressure 2	W	Sensation 6
	Input 2C	--	Pressure 3	X	Sensation 7
	Input 2D	--	Pressure 4	Y	Sensation 8
	Input 2E	--	Pressure 5	Z	Sensation 9
4	Input 3	--	Pressure 1	Menu 1	Sensation 10
		--	Pressure 2	Menu 2	Sensation 11
		--	Pressure 3	Menu 3	Sensation 12
5	--	--	Pressure 1	2	Sensation 13
		--	Pressure 2	A	Sensation 14
		--	Pressure 3	B	Sensation 15
		--	Pressure 4	C	Sensation 16
6	Input 4	Position 1	Pressure 1	Function 1	Sensation 17
	Input 5	Position 2	Pressure 2	Function 2	Sensation 18
	Input 6	Position 3	Pressure 3	Function 3	Sensation 19
7	Input 7	Location 1	Pressure 1	Function 1	Sensation 20
	Input 8	Location 2	Pressure 2	Function 2	Sensation 21
--	AMBIGUOUS	--	--	--	Sensation 22
--	Function Failure	--	--	--	Sensation 23

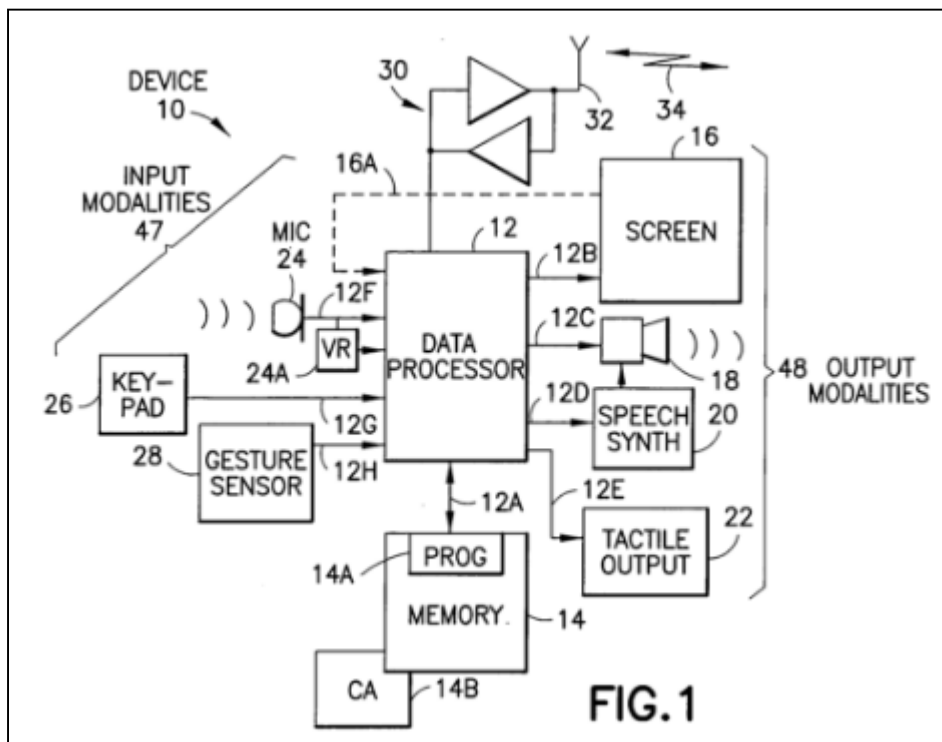
FIG. 9

B. U.S. Patent Application Publication No. 2009/0164207 to Makela et al. (“Makela”)

49. Makela was filed on December 20, 2007 and published on June 25, 2009 (Ex. 1107, cover), which is before the earliest possible priority date of the ’710 patent (November 4, 2009). I understand from Apple counsel that Makela is therefore prior art to the ’710 patent under 35 U.S.C. §§ 102 (a) and (e) (pre-AIA).

50. Makela is titled “User Device Having Sequential Multimodal Output User Interface.” Ex. 1107, Cover. Specifically, Makela discloses “a user interface that contains a plurality of input modalities and a plurality of output modalities, and a data processor coupled with the user interface and configurable to present a user with a content item that includes a plurality of attributes.” Ex. 1107, Abstract. The input modalities can include one or more of a microphone, keypad, keyboard,

and gesture sensor. *Id.*, ¶ 17. Output modalities can include display screen, speaker, and tactile output device. *Id.* Fig. 1, reproduced below, is a block diagram depicting the various input and output modalities.



* * *

51. For the reasons set forth below, it is my opinion that this and other information in Martin and Makela renders each of the challenged claims obvious. With respect to any particular feature required by the challenged claims of the '710 patent that is not expressly disclosed in Martin with respect to the embodiment of Fig. 7 and 9 but is disclosed in connection with another embodiment of Martin, the disclosure in Martin at 20:26-30 (emphasis added) that “variations and modifications of each of the disclosed embodiments, including combinations

thereof, can be made within the scope of this invention” in combination with the knowledge and skill of a POSITA would have rendered obvious modification of the embodiment of Figs. 7 and 9 to include such features. Such modifications would be nothing more than a combination of familiar elements according to known methods, and a POSITA would recognize the desirability of such a modification. Such modifications would also be within the skill of a POSITA.

52. For the reasons set forth below, it is my opinion that Martin in view of Makela renders claims 13, 19, and 20 obvious.

C. Detailed Analysis

1. Limitation 13.a : “A computer-implemented method comprising the steps of:”

53. I understand from counsel that the preamble of claim 1 is not a claim limitation, because the body of the claim defines a complete and operative system, and nothing in the body of the claim relies on the preamble for antecedent basis. Nevertheless, Martin discloses the preamble.

54. For example, Martin discloses “methods and systems for providing tactile sensations.” Ex. 1106, 2:66-67. These methods and systems can include “for example soft-keys that are computer generated and displayed on a screen.” *Id.*, 3:2-4. Martin further discloses that its invention can be implemented in “wide variety of electronic devices including telephones, mobile telephones, remote controls, gamepads, joystick handles, automotive controls (radios, Compact Disc

(CD) players, automobile functions, etc.), consumer electronics devices, Personal Digital Assistants (PDAs), personal computers, laptop computers, portable gaming devices, pagers, I-pagers, audio equipment, televisions, security or alarm systems, Automated Teller Machines (ATM), calculators, home appliances, and white goods.” Ex. 1106, 3:4-13. Thus, one skilled in the art would understand that the methods disclosed by Martin are “computer-implemented.”

2. Limitation 13.b: “receiving, from a sensor, a sensor signal associated with a user input”

55. Martin discloses sensors, including input devices 40 depicted in Fig. 7. *See* Ex. 1106, Fig. 7. Martin teaches that an input device “can be any device capable of transmitting an input signal.” *Id.*, 3:17-18. Martin discloses that input signals produced by the input device 40 (the sensor) “are communicated to the controller 41 across the communication bus 39.” *Id.*, 13:28-31. Accordingly, Martin discloses that the controller 41 receives sensor signals from input devices 40 (sensors) associated with the user input.

56. Martin does not expressly disclose the input device (sensor) as comprising a sensor for sensing user inputs comprising speech information, as recited in limitation 13.c (emphasis added): “recognizing the user input and determining a command associated with the speech information.” However, Martin contemplates that the electronic device may include a wide variety of potential input devices. For example, Martin discloses that input devices “may

include an analog switch, a force sending resistor, a strain gauge based sensor, a capacitive touch switch, a scroll wheel, a mini-joystick, a touchpad, a touch screen, a 3-way switch, a 4-way switch, a 5-way switch, or other input device.” *Id.*, 3:27-31.

57. Makela likewise discloses a variety of input devices for use in an electronic device such as a mobile phone or PDA, including specifically input devices for sensing speech input. For example, Makela discloses input devices including “one or more of an acoustic input transducer such as a microphone 24, an associated speech or voice recognition function (VR) 24A, a keypad or keyboard 26 and a gesture sensor 28...” Ex. 1107, ¶ 17 (emphasis added). A POSITA would appreciate that an acoustic input transducer such as a microphone is a sensor that senses audible signals, such as speech.

58. It would have been obvious for a POSITA at the time of the alleged invention of the ’710 patent to combine these teachings of Makela with Martin. Specifically, a POSITA would have found it obvious to use an acoustic input transducer such as a microphone as described by Makela as the input device of Martin. In this regard, Martin contemplates an electronic device, such as a mobile phone or PDA, that includes a number of different types of input devices. *See, e.g.*, Ex. 1106, 3:27-31 (the input device “may include an analog switch, a force sending resistor, a strain gauge based sensor, a capacitive touch switch, a scroll

wheel, a mini-joystick, a touchpad, a touch screen, a 3-way switch, a 4-way switch, a 5-way switch, or other input device.”) (emphasis added); *id.*, 1:19-21 (describing the inventive system as including electronic devices such as “mobile telephones and Personal Digital Assistants (PDAs)”). Makela similarly discloses an electronic device, such as a mobile phone or PDA, with multiple input modalities, specifically including a microphone. *See, e.g.*, Ex. 1107, ¶ 28 (“...the user may activate one of the input modalities 47, such as the microphone 24, the keypad or keyboard 26, the gesture sensor 28 or the touch screen 16...”); *id.*, ¶ 1 (describing the inventive system as including “mobile devices suitable for use in a wireless communication system”); Because both references disclose the use and desirability of various types of input modalities in similar types of devices (*i.e.* mobile phones and PDAs), it would have been obvious to a POSITA to consider the teachings of Makela in designing a system according to the teachings of Martin.

59. Furthermore, Makela provides express motivation for using a microphone as an input device in an electronic device, such as a mobile phone or PDA. For example, Makela discloses the benefits of using a microphone for input in a mobile device, noting that “[a]s it is typically the case that a mobile device used in a certain context cannot continuously be attended by the user, those modalities that enable eyes-free reception and hands-free interaction can be particularly useful.” Ex. 1107, ¶ 3. As such, Makela provides the motivation that

would have led a POSITA to modify Martin's device to use an acoustic sensor, such as a microphone, for speech input. In this regard, Martin teaches that the embodiment of Figures 7 and 9 may be implemented in a mobile device with the capability to place and receive phone calls. Ex. 1106, 16:33-37 (describing Function 1 in the Table of Fig. 9 being associated with various operating modes including "missed phone calls"); 16:59-61 ("In an embodiment of the apparatus of the present invention, for example, the apparatus is incorporated into a mobile phone..."). A POSITA would appreciate that a mobile phone capable of placing and receiving calls would include a microphone. And, it would have been obvious to a POSITA that the same microphone could be used as an input device for spoken commands, as taught by Makela.

60. A POSITA would have been further motivated to combine the teachings of Martin and Makela, because applying a known technique (*i.e.*, Makela's microphone as an input device) to a known device (*i.e.*, the one disclosed by Martin) that was ready for improvement (as taught by Makela) would yield predictable results (*i.e.*, to provide the user with another input method). In addition, combining Martin with Makela in this manner would have been obvious to try because it amounts to merely choosing from a finite number of identified, predictable solutions for providing input to a mobile device, such as a mobile phone or PDA, with a reasonable expectation of success. This combination would

have been well within the skill of a POSITA, could have been accomplished with minimal effort, and would have led to predictable results.

3. **Limitation 13.c: “recognizing the user input and determining a command associated with the speech information”**

61. As discussed above in claim limitation 13.b, the combination of Martin and Makela results in the system of Martin having an acoustic sensor, such as a microphone.

62. Makela discloses speech recognition software for recognizing speech input from the microphone and determining an associated command. For example, Makela explains that “[t]he microphone 24 may be coupled with the speech recognition functionality of the device 10 (the VR 24A) whereby a word or words spoken by the user can be interpreted by the data processor 12 as representing a command.” Ex. 1107, ¶ 17. Makela further discloses an exemplary use case in the context of incoming phone call: “In this case assume the user receives a call in a mobile context via the transceiver 30, and the incoming call is indicated with a ringing tone. To hear the caller name via the speech synthesizer 20 the user triggers a voice output token with a speech command: ‘who’. If the user does not speak the voice command, then the caller's name is not enunciated, and the device remains quiet.” *Id.*, ¶ 38.

63. Martin likewise discloses recognizing user input and determining a command associated with the user input. For example, in one embodiment, Martin discloses a memory storing associations between user input and functions and tactile sensations associated with the user input. *Id.*, 14:28-31 (the information in memory “is in the form of associations among the detected input data, the functions of the electronic device or apparatus, and the tactile sensations.”). An example of such associations is represented in tabular form in Fig. 9 shown below:

INPUT DEVICE	INPUT SIGNAL	POSITION DATA	PRESSURE DATA	FUNCTION	TACTILE SENSATION
1	--	Location 1	< Pressure 1	Search	Sensation 1
	Input 1	Location 1	Pressure 1 <=	Select	Sensation 2
2	--	Position 1	--	On	Sensation 3
	--	Position 2	--	Off	Sensation 4
3	Input 2A	--	Pressure 1	9	Sensation 5
	Input 2B	--	Pressure 2	W	Sensation 6
	Input 2C	--	Pressure 3	X	Sensation 7
	Input 2D	--	Pressure 4	Y	Sensation 8
	Input 2E	--	Pressure 5	Z	Sensation 9
4	Input 3	--	Pressure 1	Menu 1	Sensation 10
		--	Pressure 2	Menu 2	Sensation 11
		--	Pressure 3	Menu 3	Sensation 12
5	--	--	Pressure 1	2	Sensation 13
		--	Pressure 2	A	Sensation 14
		--	Pressure 3	B	Sensation 15
		--	Pressure 4	C	Sensation 16
6	Input 4	Position 1	Pressure 1	Function 1	Sensation 17
	Input 5	Position 2	Pressure 2	Function 2	Sensation 18
	Input 6	Position 3	Pressure 3	Function 3	Sensation 19
7	Input 7	Location 1	Pressure 1	Function 1	Sensation 20
	Input 8	Location 2	Pressure 2	Function 2	Sensation 21
--	AMBIGUOUS	--	--	--	Sensation 22
--	Function Failure	--	--	--	Sensation 23

FIG. 9

64. Martin further explains that “[h]aving obtained the input data from the input device, or from a plurality of input devices, the controller then accesses a memory device 54 in which is stored at least one database containing information necessary to produce the desired function in the electronic device and the

predetermined tactile sensation.” Ex. 1106, 14:22-27. From this disclosure, a POSITA would understand or at least have found obvious that Martin’s controller would be configured to recognize that an input signal (*e.g.* “Input 3”) from an input device (*e.g.* Input Device 4) is associated with a user input intended to invoke a command in the form of “Menu 1” and associated with a “Sensation 10” as shown in the middle of Fig. 9 above. Invoking a set of menus should be found to constitute a command in light of Immersion’s infringement contentions in the ITC (Ex. 1110 at 35-38) alleging that displaying a menu as a result of a user pressing an icon on a touchscreen satisfies this claim element.

65. Moreover, a POSITA would understand and found obvious that to implement the Martin system with a microphone input device, by modifying the table depicted in Figure 9 to include a microphone as an input device. For the reasons discussed above in connection with claim element 13.b, A POSITA would have been motivated to utilize a microphone as an input device.

66. Furthermore, a POSITA would appreciate that input signals from the microphone corresponding to spoken commands likewise could be associated with corresponding Functions and Tactile Sensations in the table of Figure 9, in the same way that input signals from other input devices are associated with corresponding Functions and Tactile Sensations in the table of Figure 9. Such a modification would have been well within the skill of a POSITA, as it would

simply involve applying Martin's teachings regarding the use of a table to associate user input from an input device with corresponding functions and tactile sensations with a particular type of input device, *i.e.* a microphone. And, such a modification could have been accomplished with minimal effort, and would have led to predictable results.

4. **Limitation 13.d: “if the user input is recognized and the command is determined: generating a first actuator signal configured to cause an actuator to output a first haptic effect; and ...”**

67. As discussed in the preceding section, a POSITA would understand or at least have found obvious that Martin's controller 41 would be configured to recognize that an input signal “Input 3” from an input device 4 was associated with a user input intended to invoke a command in the form of “Menu 1” and associated with a “Sensation 10” as shown in the middle of Fig. 9 above.

68. Martin further discloses that the information from the table in the memory is used by the controller 41 to generate a signal to be transmitted to the control circuitry 45 via the communications bus 39 that will cause the actuator 46 to generate “Sensation 10.” Ex. 1106 at 13:54-58 (the controller 41 “uses tactile feedback control information received from the memory to provide the necessary input to the control circuitry 45 to drive the actuator 46 to produce the desired tactile sensation”) and at 14:22-27 (“[h]aving obtained the input data from the input device, or from a plurality of input devices, the controller then accesses a

memory device 54 in which is stored at least one database containing information necessary to produce the desired function in the electronic device and the predetermined tactile sensation.") (emphasis added). Martin then discloses that the function information is delivered to the electronic device and that the controller 41 then causes the actuator to produce the predetermined tactile sensation. *Id.* at 14:50-57. Thus, a POSITA would understand or at least find obvious that Martin discloses a controller that generates a first actuator signal when the user input is recognized and command is determined.

5. **Limitation 13.e: "if the user input is recognized and the command is determined: ... transmitting the first actuator signal to the actuator;"**

69. As discussed above in element 13.d, the controller generates and transmits a signal that causes the actuator to produce the desired haptic effect (*e.g.*, "Sensation 10"). Although Martin does not disclose that the signal generated by the controller is transmitted to the actuator, Martin does disclose that the signal generated by the controller is transmitted to control circuitry 45, which in turn generates an actuator signal for driving actuator 46. Ex. 1106, 13:54-58 and 14:22-27. Thus, to the extent the broadest reasonable interpretation of this limitation encompasses transmitting the first actuator signal to control circuitry, which in turn generates an actuator signal for driving the actuator, Martin discloses or at least renders obvious this limitation.

70. To the extent this limitation is construed as requiring generating a first actuator signal and transmitting this generated signal to the actuator, a POSITA would have found it obvious to employ an actuator 46 that could accept a digital control signal directly from the controller 41 via the bus 39. Alternatively, a POSITA would have found it obvious to utilize a controller such as one selected from the MSC120x family that includes a digital-to-analog converter (*see* Ex. 1108 at 1) and connect the actuator 46 to the output of that digital-to-analog converter.¹ In both cases, a POSITA would have been motivated to do so in order to reduce the number of components and save space in the electronic device of Fig. 7.

6. Limitation 13.f: “otherwise: generating a second actuator signal configured to cause the actuator to output a second haptic effect; and ...”

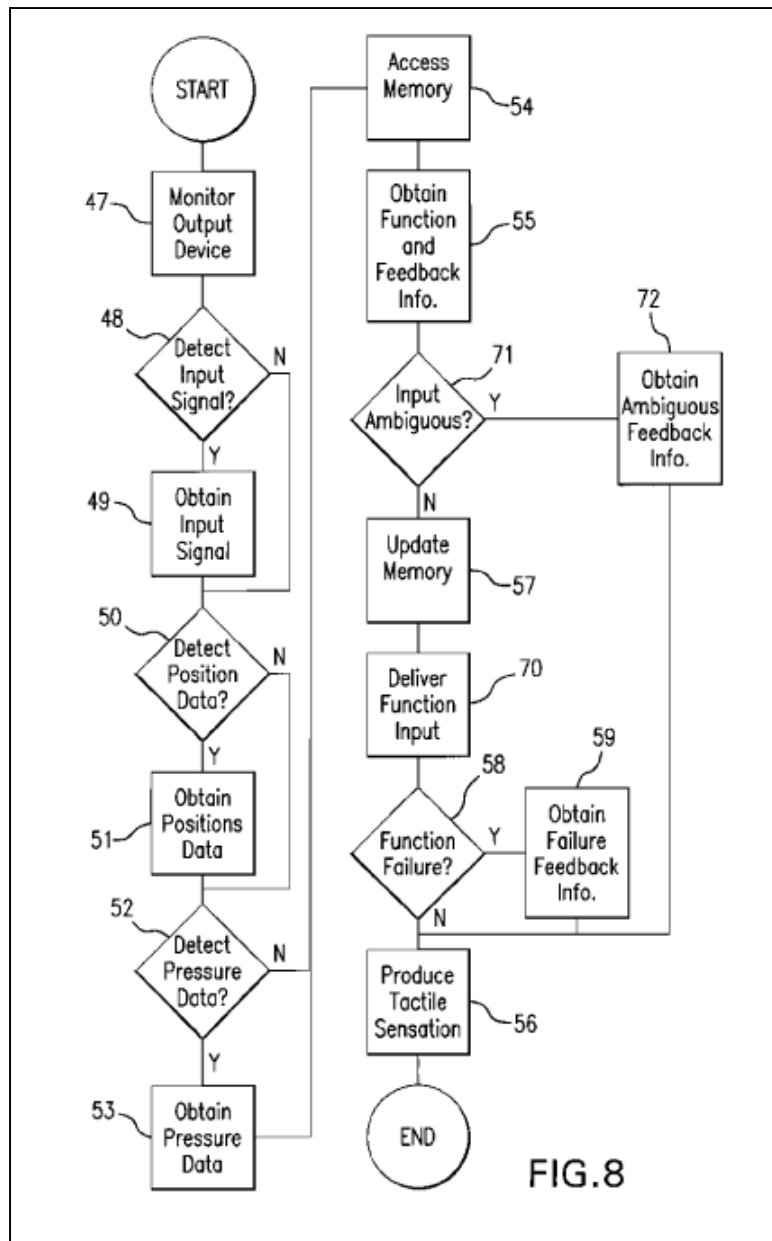
71. As discussed above in Section III.C, the PTAB previously determined in IPR2016-01603 that a prior art reference does not need to teach the steps recited in the similar “otherwise” limitations of claim 1 in order to render the claim

¹ Literature for products in the MSC120X family were available at least as early as February 24, 2009, and earlier, as evidenced by the citation of such literature in Ex. 1109, front cover. To the extent that the limitation 13.e is construed as requiring generating the signal to drive the actuator and transmitting this generated signal to the actuator, Petitioner respectfully requests consideration of Ground 1 as including Martin, Makela and Ex. 1108.

obvious. IPR2016-01603, Paper 7 at 19. And, I understand from Apple counsel that applying the same rationale, a prior art reference need not teach the “otherwise” limitations of claim 13 to render the claim obvious.

72. Regardless, Martin discloses this limitation. For example, Martin discloses that the “controller can also determine if [] an ambiguous input is received.” Ex. 1106, 16:3-4. “The ambiguous input can represent ... an input... that is not associated with an input device.” *Id.*, 16:4-10. “In response to receiving an ambiguous input signal, the controller obtains the associated ambiguous tactile sensation, Sensation 22, in one or more input devices associated with the ambiguous input.” *Id.* at 16:10-14. Thus, as discussed above, a POSITA would understand or at least find obvious that when the user input is recognized as an input listed in the table of Fig. 9 and a command (i.e. the associated function listed in the table of Fig. 9) is determined, then the associated tactile sensation is provided. Otherwise, the input is considered ambiguous and the associated ambiguous tactile sensation is provided.

73. The “if... otherwise...” conditional structure of claim 13 is further illustrated in Figure 8, reproduced below.



Ex. 1106, Fig. 8, 13:59-16:21.

74. In the left-hand column of the flowchart, the device first obtains signals from the input device. *Id.* at 14:1-21. Then, at blocks 54 and 55, the device accesses memory (e.g., the table of Figure 9), to determine whether the user input is associated with a corresponding function and tactile sensation. *Id.* at

14:22-32. At block 71, the device determines whether the input is ambiguous. *Id.* at 16:3-21. If the input is not ambiguous (*i.e.*, the user input is recognized and a corresponding function determined in the table of Figure 9), the device proceeds downward and eventually produces the tactile sensation associated with the user input at block 56. Ex. 1106, 14:47-57. Otherwise (*i.e.*, the input is ambiguous), the flowchart proceeds to the right to block 72. *Id.* At block 72, there is a second access to the table to obtain the tactile sensation associated with an ambiguous input in the row labeled “AMBIGUOUS,” and the ambiguous tactile sensation is generated. Ex. 1106, 16:3-14, Fig. 9.

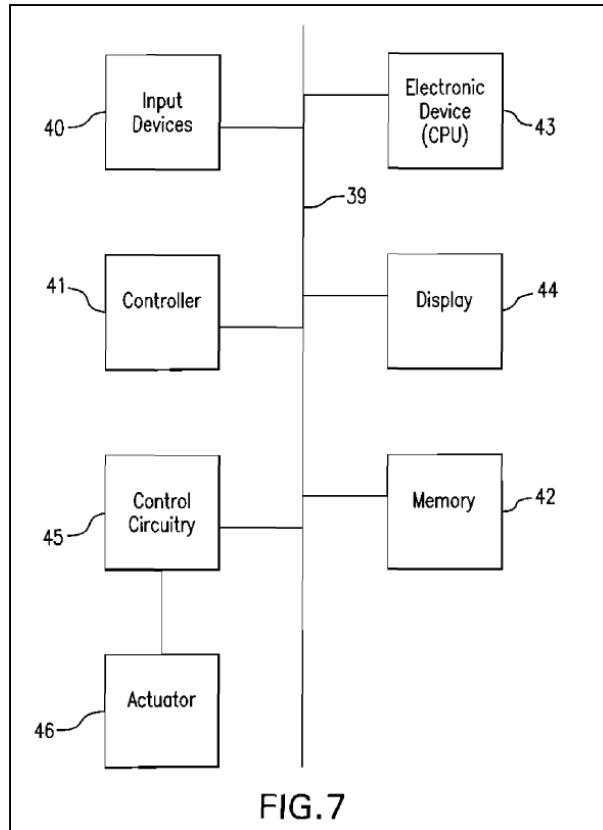
7. Limitation 13.g: “otherwise: ... transmitting the second actuator signal to the actuator.”

75. As discussed above in element 13.f, the controller generates and transmits a signal that causes the actuator to produce the AMBIGUOUS haptic effect (*e.g.*, “Sensation 22”). Although Martin does not disclose that the signal generated by the controller is transmitted to the actuator, Martin does disclose that the signal generated by the controller is transmitted to control circuitry 45, which in turn generates an actuator signal for driving actuator 46. Ex. 1106, 13:54-58 and 14:22-27. Thus, to the extent the broadest reasonable interpretation of this limitation encompasses transmitting the first actuator signal to control circuitry, which in turn generates an actuator signal for driving the actuator, Martin discloses or at least renders obvious this limitation.

76. To the extent this limitation is construed as requiring generating a first actuator signal and transmitting this generated signal to the actuator, it would have been obvious to modify the Martin system to do so for the same reasons discussed above in connection with claim element 13.e. For example, a POSITA would have found it obvious to employ an actuator that could accept a digital signal, or alternatively utilize a controller that generates an analog signal. See discussion of claim element 13.e, above. In both cases, a POSITA would have been motivated to do so in order to reduce the number of components and save space in the electronic device of Fig. 7.

8. **Claim 19: “The computer-implemented method of claim 13, further comprising: generating a display signal configured to cause a display to display an image; and transmitting the display signal to the display.”**

77. Martin discloses a display 44 in communication with the controller 41 via the communications bus 39 as shown in Fig. 7 below:



Ex. 1106, 13:26-28.

78. Martin discloses that the controller is in communication with the display 44 as Martin discloses that “[i]n addition, the controller 41 modifies the output on the display 44 in particular where the display is part of the input device, such as when a touchpad is used.” *Id.*, 13:43-46.

79. Martin does not expressly disclose that the embodiment of Figs. 7 and 9 generates a display signal that causes the display to generate an image.

However, Martin discloses that:

In addition, the controller 41 modifies the output on the display 44 in particular where the display is part of the input device, such as when a

touchpad is used. Alternatively, the electronic device controls and updates the display. In addition, the controller can be the CPU associated with the electronic device and the memory can be the memory associated with the electronic device. The arrangement of the controller, memory and display depends on whether or not the apparatus is constructed as a standalone device that can be retrofitted into an existing electronic device or is incorporated into the electronic device itself.

Id., 13:46-50.

80. The first part of this passage appears confusing at first blush because Martin uses “electronic device” in this passage to refer to both the CPU 43 individually and the device that incorporates the CPU 43 as a whole. Nonetheless, a POSITA would understand this passage. In particular, the statement that “alternatively, the electronic device controls and updates the display” would be understood by a POSITA to mean that, in the non-alternative embodiment, the display is both controlled and updated by the controller 41, and that the Electronic Device (CPU) 43 instead of the controller 41 controls and updates the display in the alternate embodiment.

81. To the extent this is found not to be disclosed in Martin, a POSITA would have found it obvious. A POSITA would further understand, or at least would have found obvious, that the controller 41 would control the display by

generating and transmitting to the display a display signal configured to cause the display to generate an image, such as an icon or graphical menu as discussed above in connection with element 13.c, as graphical user interfaces were well known in the art at the time of the '710 patent.

9. **Claim 20: “The computer-implemented method of claim 13, wherein the first haptic effect is configured to emulate the command.”**

82. As discussed above in Section III.C, based on Immersion’s infringement allegations in the ITC action, the term “haptic effect is configured to emulate the command” should be broadly construed such that a haptic effect in the form of a short vibration is found to emulate a command to display a menu. As further discussed above in connection with limitation 13.c, Martin discloses that the command associated with the user input “can represent one set of menus from a list of menus or one operating mode out of a plurality of operating modes.” See Ex. 1106, 16:33-35. Martin further discloses a haptic effect in the form of a “pop.” *Id.*, 18:33-34. Although not explicitly disclosed in Martin, a POSITA would understand that a “pop” is of generally short duration based on the plain and ordinary meaning of this word, and based on experience in haptics would understand that a vibration of, *e.g.*, 10 milliseconds could constitute a haptic “pop.” In determining what type of haptic effect should accompany a command that results in the display of a menu, a POSITA would find it obvious to select a “pop”

haptic effect when “popping up” a menu, to, for example, avoid the intermingling of haptic effects if the user quickly makes a menu selection associated with another command that results in the generation of another haptic effect.

83. Martin also discloses in another embodiment that “the number of occurrences of a distinct vibrotactile sensation, such as a pop, corresponds to the index number of the menu option within a list of options. In such an embodiment, one pop signifies the first option, two pops signifies the second option.” Ex. 1106, 18:33-37. It would have been obvious to a POSITA to incorporate this disclosure of Martin into embodiments which display menus with lists of multiple options. In such an embodiment, the number of pops emulates the command because the number of pops corresponds to the position of the command in the menu.

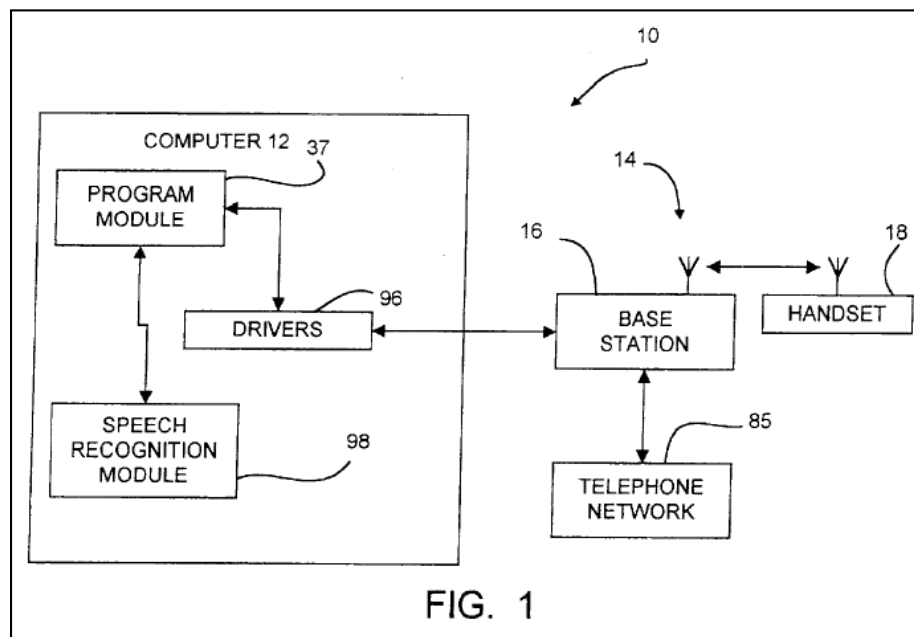
D. U.S. Patent No. 6,505,159 to Theodore (“Theodore”)

84. Theodore issued on January 7, 2003 (Ex. 1104, cover), which is more than one year before the earliest possible priority date of the ’710 patent (November 4, 2009). I understand from Apple counsel that Theodore is therefore prior art to the ’710 patent under 35 U.S.C. § 102 (b) (pre-AIA).

85. Theodore is titled “Apparatus and Method for Providing Speech Input to a Speech Recognition System.” Ex. 1104, Cover. Theodore is generally directed to an apparatus and method for providing speech input to a computer with speech recognition capabilities. *Id.*, Abstract. More particularly, Theodore

discloses that the apparatus is “programmed to carry out voice recognition based on voice data produced from sounds spoken by a user” through an input device such as cordless phone or portable handset. *Id.*, 2:20-26.

86. One embodiment of the Theodore system is depicted in Figure 1, reproduced below.



Ex. 1104, Fig. 1.

87. In the embodiment depicted in Fig. 1, Theodore discloses an apparatus 10 comprising a computer 12 and an input device 14. *Id.*, 1:18-23. The input device 14 may consist of a cordless phone with a base station 16 and a handset 18. *Id.*, 2:23-26. The input device includes a switch which allows the user to indicate to the computer when input speech is going to be provided by the user. *Id.*, 2:37-40; 5:53-55. When activated by the user, an “Activation Signal” is sent from the

input device to the computer and the computer transmits a “Computer Waiting Signal” to the handset. Ex. 1104, 5:56-67. The computer also prepares a speech recognition module and transmits a “Speech Recognition Ready Signal” to the input device which indicates that the computer is ready to accept speech input. *Id.*, 6:33-38. The user can then enter voice instruction. *Id.*, 6:44-46.

88. Upon receiving voice input, the speech recognition module evaluates the input. *Id.*, 6:62-7:4. If the voice input is recognized, then the speech module transmits a “Recognized Signal” to the handset, which provides an indication to the user that the voice input has been recognized. *Id.*, 7:11-18. Otherwise, if the voice input is not recognized, a “Not Recognized Signal” is transmitted to the handset, which provides an indication to the user that the voice input was not recognized. *Id.*, 6:62-7:4.

89. Theodore discloses that the input device 14 provides indications of whether the voice input was “Recognized” or “Not recognized” in the form of audible tones. Ex. 1104, 6:62-7:18. However, Theodore also contemplates various other means for providing these indications to the user in place of or in addition to audible tones, including, for example, lights or tactile buzzers. *Id.*, 7:30-36 (“other types of indications can be used in addition or in place of the audible tones described above for the Activation Signal, the Speech Recognition Ready Signal, the Computer Error Signal, the Recognized Signal and the Not Recognized Signal.

For example, each of these signals can initiate visual indicators such as lights, or tactile indicators such as buzzers.") (emphasis added).

E. U.S. Pat. App. Pub. No. 2002/0033795 ("Shahoian")

90. I understand from counsel that U.S. Patent Application Publication No. 2002/0033795 ("Shahoian") qualifies as prior art under 35 U.S.C. § 102(a) and (b) (pre-AIA) because it was published on March 21, 2002, more than one year before the priority date of the '710 patent (Nov. 4, 2009). Ex. 1105, Cover.

91. Shahoian relates to touch sensitive input devices that "output haptic feedback such as tactile sensations" to users. Ex. 1105, ¶ 43. The disclosure of Shahoian is applicable to a range of input devices "such as gamepads, joysticks, steering wheels, touchpads, spherical controllers, finger pads, knobs, track balls, remote control device, cell phone, personal digital assistant, etc." *Id.*, ¶ 74.

* * *

92. As demonstrated below, this and other information in Theodore and Shahoian renders each of the challenged claims obvious.

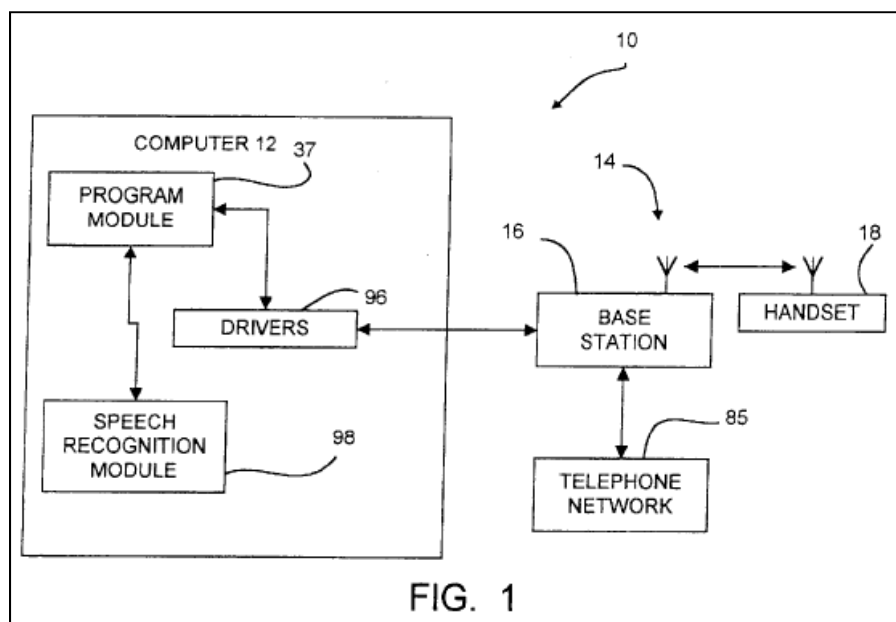
F. Detailed Analysis

1. Limitation 13.a: A computer-implemented method comprising the steps of:"

93. I understand from counsel that the preamble of claim 1 is not a claim limitation, because the body of the claim defines a complete and operative system,

and nothing in the body of the claim relies on the preamble for antecedent basis. Nevertheless, Theodore discloses the preamble.

94. Specifically, Theodore discloses “[a]n apparatus and a method for providing speech input into a computer having a speech recognition system and an input device remote from the computer.” Ex. 1104, 1:53-54. Further, Fig. 1 of Theodore depicts an embodiment of the invention using a computer:



Ex. 1104, Fig. 1.

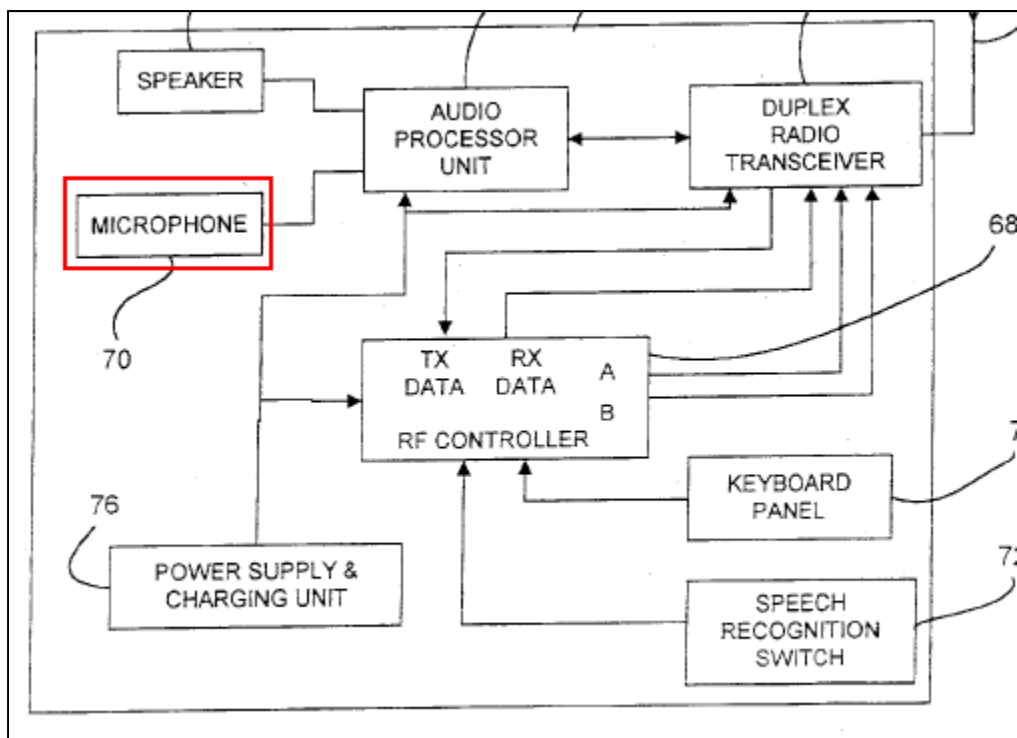
95. Thus, one skilled in the art would understand that the methods disclosed by Theodore are “computer-implemented.”

2. **Limitation 13.b: “receiving, from a sensor, a sensor signal associated with a user input”**

96. Theodore discloses a sensor in the form of a microphone. For example, Theodore discloses that “[a] user may enter commands and information

into the personal computer 12 through devices such as a keyboard 40, a pointing device 42 and a microphone 43 located at the site of the personal computer 12, as well as through the input device 14 (FIG. 2B), discussed in detail below, which allows the user to input speech from a location remote from the computer 12.” Ex. 1104, 3:40-46 (emphasis added).

97. A microphone in input device 14 is depicted in Figure 2B, reproduced below.



Ex. 1104, Fig. 2b (annotated); see also 1:55-59 (“[t]he input device includes a microphone, an indicator and a user operated switch.”).

98. Theodore does not expressly disclose that the microphone generates signals. However, a POSITA would understand or at least have found obvious that

a microphone is a transducer that converts sound into electrical signals. *See, e.g.,* Ex. 1103 (Microsoft Computer Dictionary) (“microphone n. 1. A device that converts sound waves into analog electrical signals.”).

99. Theodore further discloses receiving inputs from the microphone associated with user input, in the form of voice commands. For example, Theodore discloses that computer 12 is “programmed to carry out voice recognition based on voice data produced from sound spoken by a user through an input device 14.” Ex. 1104, 2:20-23.

100. Accordingly, Theodore discloses receiving from the sensor (microphone) sensor signals associated with the user input (voice command).

3. Limitation 13.c: “recognizing the user input and determining a command associated with the speech information”

101. Theodore discloses recognizing the user input and determining a command associated with the speech information. For example, Theodore “[a] user may enter commands and information into the personal computer 12 through devices such as a keyboard 40, a pointing device 42 and a microphone...” and that when a microphone is used “the speech recognition module 98 evaluates the input voice instruction against the set of valid instructions.” Ex. 1104, 3:40-46; 6:62-64.

102. Theodore further discloses that “[i]f the voice instruction received from the user does not correspond with any of the expected instructions in the set

of valid instructions, program flow continues to step 122 whereat a ‘Not Recognized Signal’ is transmitted to the user indicating that the voice instruction received was not recognized.” *Id.*, 6:64-7:2. However, if the voice command matches a set of valid voice instructions, then “the system generates a ‘Recognized Signal’ that is transmitted to the user...” *Id.*, 7:9-15.

103. After determining that a valid voice command was received, “[s]ystem operation is then transferred to the program module 37 at step 126 where instructions are provided to components of the computer 12 necessary to complete the task in accordance with the voice instructions received.” Ex. 1104, 7:18-22. In response to the valid speech input, the system can carry out various commands associated with the input: “For example, the computer 12 may open, close or transfer files requested by the user. In another application, the program module 37 may begin recording a message from the user, or play a selected message to the user. At the completion of the task, the system awaits reactivation of the speech recognition switch 72 at step 102 indicating that another voice instruction is to be provided by the user.” Ex. 1104, 7:18-29.

104. Accordingly, Theodore discloses recognizing the user input (voice command) using the speech recognition module and determining a command (valid instruction) associated with the speech information.

4. **Limitation 13.d:** “if the user input is recognized and the command is determined: generating a first actuator signal configured to cause an actuator to output a first haptic effect; and”

105. As discussed above in connection with the preceding claim limitation, Theodore discloses that if the user input is recognized and the command is determined, then “the system generates a ‘Recognized Signal’ that is transmitted to the user...” *Id.*, 7:9-15. Theodore teaches that this “Recognized Signal” is sent to the user in the form of “an audible tone provided to the user.” *Id.*, 7:15-18. However, Theodore does not limit its disclosure to audible tones. Rather, Theodore discloses that “it is worth noting, that other types of indications can be used in addition or in place of the audible tones described above for the Activation Signal, the Speech Recognition Ready Signal, the Computer Error Signal, the Recognized Signal and the Not Recognized Signal. For example, each of these signals can initiate visual indicators such as lights, or tactile indicators such as buzzers.” *Id.*, 7:30-36 (emphasis added).

106. A POSITA would understand or at least find obvious that a “buzzer” which provides a “tactile indication” inherently comprises or includes an actuator. See Ex. 1105, ¶ 106 (describing a buzzer for generating tactile sensations as an actuator). Indeed, a POSITA would appreciate that while there are many types of actuators that may be used to generate vibration feedback (*e.g.* an LRA, ERM or piezo-electric actuator), some type of actuator is required to convert electrical

energy into mechanical energy in order to generate tactile feedback in an electronic device, such as the device disclosed by Theodore. At a minimum, it would have been obvious to a POSITA that the buzzer could be implemented using an actuator. Indeed, it was well known in the art that actuators were components capable of, and typically used when generating haptic effects. *See, e.g.*, Ex. 1115 (U.S. Patent No. 5,999,168 to Rosenberg, et al.) at 9:41-52 (describing various types of actuators for generating force feedback); 3:3 (describing “force feedback ‘effects,’ such as jolts, vibrations, etc.”); 4:7-11 (same); 8:13-41 (same).

107. Theodore does not expressly disclose generating an actuator signal configured to activate the tactile buzzer and output a haptic effect. However, Shahoian discloses this. For example, Shahoian discloses that: “To provide the desired haptic sensations, a large piezo buzzer should provide large sustainable displacements (accelerations) of the mass and the carrier frequency (the frequency at which it oscillates) should be modulated with the haptic signal.” Ex. 1105, ¶

106. Shahoian further discloses circuitry for driving the actuator, such as a self-exciting oscillation circuit for driving the actuator and a gating feature “to start and stop the oscillation as well as a proportional control to allow modulation of the amplitude of the output.” *Id.* A POSITA would readily appreciate that this circuitry generates and transmits signals to drive the tactile buzzer (actuator).

Accordingly, it would have been obvious to a POSITA at the time of the alleged

invention to incorporate circuitry such as the oscillation circuit described in Shaoian to generate actuator signals to activate the buzzer in Theodore's input device 14 to provide tactile feedback to the user.

108. Motivation to combine the teachings of Shahoian and Theodore arises from at least the fact that both references disclose the use of tactile buzzers to provide tactile feedback. A POSITA would have been further motivated to combine the teachings of Shahoian and Theodore, because applying a known technique (*i.e.*, Shahoian's haptic feedback circuitry) to a known device (*i.e.*, the one disclosed by Theodore) would yield predictable results (*i.e.*, to implement a tactile buzzer). In addition, combining Shahoian with Theodore in this manner would have been obvious to try because it amounts to merely choosing from a finite number of identified, predictable solutions for implementing a tactile buzzer, with a reasonable expectation of success. This combination would have been well within the skill of a POSITA, could have been accomplished with minimal effort, and would have led to predictable results.

5. **Limitation 13.e: "if the user input is recognized and the command is determined: ... transmitting the first actuator signal to the actuator."**

109. Theodore does not expressly disclose transmitting the actuator signal to activate the tactile buzzer. However, Shahoian discloses this. As discussed above in connection with the preceding limitation, Shahoian discloses a circuitry

for driving a tactile buzzer, including a self-exciting oscillation circuit and a gating feature “to start and stop the oscillation as well as a proportional control to allow modulation of the amplitude of the output.” Ex. 1105, ¶ 106. A POSITA would readily appreciate that this circuitry generates and transmits signals to drive the tactile buzzer (actuator). And, it would have been obvious to combine the teachings of Shahoian with Theodore for the reasons discussed above.

6. **Limitation 13.f: “otherwise: generating a second actuator signal configured to cause the actuator to output a second haptic effect;”**

110. As discussed above in Section III.C, the PTAB previously determined in IPR2016-01603 that a prior art reference does not need to teach the steps recited in the similar “otherwise” limitations of claim 1 in order to render the claim obvious. IPR2016-01603, Paper 7 at 19. And, I understand from Apple counsel that applying the same rationale, a prior art reference need not teach the “otherwise” limitations of claim 13 to render the claim obvious.

111. Regardless, this limitation is obvious in view of Theodore and Shahoian. For example, Theodore discloses that “[i]f the voice instruction received from the user does not correspond with any of the expected instructions in the set of valid instructions, program flow continues to step 122 whereat a ‘Not Recognized Signal’ is transmitted to the user indicating that the voice instruction received was not recognized.” Ex. 1104, 6:64-7:2. As discussed for claim element

13.d, Theodore contemplates that the Not Recognized Signal can initiate a “tactile indicator such as buzzers.” *Id.*, 7:30-36.

112. Theodore does not expressly disclose generating an actuator signal to configured to activate the tactile buzzer and output a haptic effect. However, as discussed above in connection with element 13.d, Shahoian discloses this. See Ex. 1105, ¶ 106. And it would have been obvious to combine Shahoian’s teachings of circuitry for generating and transmitting an actuator signal to drive the tactile buzzer for the reasons discussed above in connection with element 13.d

7. Limitation 13.g: “otherwise: ... transmitting the second actuator signal to the actuator.”

113. Theodore does not expressly disclose transmitting the actuator signal to activate the tactile buzzer. However, Shahoian discloses this. As discussed above in connection with the claim element 13.d, Shahoian discloses a circuitry for driving a tactile buzzer, including a self-exciting oscillation circuit and a gating feature “to start and stop the oscillation as well as a proportional control to allow modulation of the amplitude of the output.” Ex. 1105, ¶ 106. A POSITA would readily appreciate that this circuitry generates and transmits signals to drive the tactile buzzer (actuator). And, it would have been obvious to combine the teachings of Shahoian with Theodore for the reasons discussed above.

8. **Claim 18**: “The computer-implemented method of claim 13, further comprising: generating an audio signal configured to cause a speaker to output a sound; and transmitting the audio signal to the speaker.”

114. Theodore discloses the additional limitation of claim 18. For example, Theodore discloses that “[i]f the voice instruction received from the user does not correspond with any of the expected instructions in the set of valid instructions, program flow continues to step 122 whereat a ‘Not Recognized Signal’ is transmitted to the user indicating that the voice instruction received was not recognized. In the embodiment illustrated, the Not Recognized Signal is generated as a tone and transmitted through the speaker 66 of the handset 18 to the user.” Ex. 1104, 6:64-7:4 (emphasis added). Similarly, if the signal is recognized, then “the Recognition Signal is used to initiate an audible tone provided to the user.” *Id.*, 7:15-18 (emphasis added).

115. To the extent this limitation is found not to be disclosed in Theodore, a POSITA would have found it obvious. A POSITA would understand, or at least would have found obvious, that to generate an audio tone as taught by Theodore, requires generating an audio signal corresponding to audible tone and transmitting the audio signal to the speaker for the user to hear.

9. **Claim 19**: “The computer-implemented method of claim 13, further comprising: generating a display signal configured to cause a display to display an image; and transmitting the display signal to the display.”

116. Theodore discloses the additional limitation of claim 19. For example, Theodore discloses that the signals generated via the “Recognized Signal,” “Not Recognized Signal,” etc., are not limited to audible tones, rather “other types of indications can be used in addition or in place of the audible tones described above for the Activation Signal, the Speech Recognition Ready Signal, the Computer Error Signal, the Recognized Signal and the Not Recognized Signal. For example, each of these signals can initiate visual indicators such as lights, or tactile indicators such as buzzers. ***Likewise, a display, such as a liquid crystal display (LCD) can be provided on the input device 14 to display icons or text corresponding to each of the signals.***” Ex. 1104, 7:30-39 (emphasis added).

117. To the extent this limitation is found not to be disclosed in Theodore, a POSITA would have found it obvious. A POSITA would understand, or at least would have found obvious, that to display icons or text corresponding to each of the signals as disclosed by Theodore, requires generating a display signal corresponding to the icon or text and then transmitting the display signal to the display for the user to see.

V. CONCLUSION

118. For the foregoing reasons, it is my opinion that claims 13, 18, 19 and 20 of the '710 patent are invalid as disclosed and/or obvious in light of Martin, Makela, Theodore, and Shahoian.

119. I declare that all statements made herein of my own knowledge are true and that all statements 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 Section 1101 of Title 18 of the United States Code.

Executed on May 3, 2017 in Washington, DC



Dr. Tony Givargis

APPENDIX A

Tony Givargis
Professor of Computer Science
University of California, Irvine
Irvine, CA 92697-3435
givargis@uci.edu
(949) 824-9357

Objective

Research and teaching in the areas of computer science with emphasis on embedded systems.

Education

- Ph.D., Computer Science, UCR, 2001, Thesis: *System-Level Exploration for Pareto-Optimal Configurations in Parameterized System-on-a-Chip*, Received Best Thesis Award.
- B.S., Computer Science, UCR, 1997, Graduated Cum Laude.

Position

- Professor, Department of Computer Science, University of California, Irvine, 2011-present.
- Associate Dean for Student Affairs, School of Information & Computer Sciences, University of California, Irvine, 2011-2016.
- Associate Professor, Department of Computer Science, University of California, Irvine, 2007-2011.
- Assistant Professor, Department of Computer Science, University of California, Irvine, 2001-2007.

Consulting

- Provided expert reports and testimony in the U.S. International Trade Commission Institutes Investigation Regarding Certain Communications Or Computing Devices, 2014-2015.
- Provided expert reports and testimony in the Apple Inc. vs. Samsung Electronics Co. Ltd. judicial proceedings, 2011-2012.

Member

- Institute of Electrical and Electronics Engineers (IEEE), Senior Member.
- Association for Computing Machinery (ACM).

Service

Editorial Board

- Associate Editor, ACM Transactions on Embedded Computing Systems (TECS), 2008-2014.
- Online Editor, Odysci, 2010-2011.

- Associate Editor, ACM SIGDA Bimonthly Newsletter, 2005-2007.
- Guest Editor, International Journal of Parallel Programming (IJPP), 2006, 2007.
- Associate Editor, Journal of Embedded Computing (JEC), 2004-2006.

Distinguished Service

- Executive Committee Member, ACM Special Interest Group on Design Automation (SIGDA), 2009-2011.
- Technical Program Committee Co-Chair, International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), 2010.
- Technical Program Committee Co-Chair, IFIP Workshop on Software Technologies for Future Embedded & Ubiquitous Systems (SEUS), 2008.
- Technical Program Committee Chair, Special Interest Group on Design Automation (SIGDA) Ph.D. Forum at Design Automation Conference, 2007.
- Technical Program Committee Co-Chair, Special Interest Group on Design Automation (SIGDA) Technical Committee on System Design, 2006.
- Technical Program Committee Co-Chair, Special Interest Group on Design Automation (SIGDA) Ph.D. Forum at Design Automation Conference, 2006.
- Special Sessions Chair, International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), 2005.

Technical Program Committee Member

- Non-Volatile Memory Systems and Applications Symposium (NVMSA), 2017-present.
- Design Automation Conference (DAC), 2017-present.
- Design, Automation and Test in Europe Conference (DATE), 2016-present.
- IEEE Symposium on Embedded Systems for Real-Time Multimedia (ESTIMedia), 2012-present.
- International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), 2003-present.
- IEEE Real-Time and Embedded Technology and Applications Symposium (RTAS), 2013.
- Design Automation Conference (DAC), 2012-2014.
- ACM Student Research Competition at DAC, 2010.
- International Conference on Embedded Software and Systems (ICESS), 2008.
- International Symposium on Low Power Electronics and Design (ISLPED), 2007-2011.
- International Workshop on Embedded Single and Multicore Systems on Chips (MCSoc), 2007.
- International Workshop on Embedded Software Optimization (ESO), 2006.
- International Workshop on SoC and MCSoc Design (SoC), 2006.
- International Workshop on Embedded Computing (EC), 2006.

- International Conference on Compilers, Architecture, and Synthesis for Embedded Systems (CASES), 2005, 2009-2011.
- Special Interest Group on Design Automation (SIGDA) Ph.D. Forum at Design Automation Conference (DAC), 2005-2008.
- International Conference on Embedded And Ubiquitous Computing (EUC), 2005.
- International Workshop on Logic and Synthesis (IWLS), 2004-2006.
- International Conference on Computer Aided Design (ICCAD), 2003-2005, 2010-2011.
- Asia and South Pacific Design Automation Conference (ASP-DAC), 2003.
- International Workshop on Embedded System Codesign (ESCODES), 2002.

Topic Chair

- Embedded Software: International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), 2006, 2013, 2014.
- Micro-Architecture and Memory Optimizations: International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), 2004, 2005.

Session Chair

- International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), 2002, 2005, 2009.
- International Conference on Compilers, Architecture, and Synthesis for Embedded Systems (CASES), 2005, 2009.
- Design Automation Conference (DAC), 2007-2009.
- Design Automation and Test in Europe (DATE), 2008.
- International Symposium on Low Power Electronics and Design (ISLPED), 2005.
- International Conference on Computer Aided Design (ICCAD), 2001, 2003-2005.
- International Workshop on Embedded System Codesign (ESCODES), 2002.

Conference Organizer

- Finance Chair, Embedded Systems Week (ESWEEK), 2008.
- Finance Chair, International Symposium on Low Power Electronics and Design (ISLPED), 2007.
- Student Travel Grants Chair, International Conference on Supercomputing (ICS), 2006.
- Web Chair, International Symposium on Low Power Electronics and Design (ISLPED), 2006.
- Audio Visual Chair, International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), 2006.
- Finance Chair, Special Interest Group on Design Automation (SIGDA) Ph.D. Forum at Design Automation Conference (DAC), 2005.

- Publicity Chair, International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), 2004.
- Poster Committee Chair, Southern California Embedded Systems Symposium (SCESS), 2003.
- Local Chair and Treasurer, International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), 2003.
- Local Chair, International Workshop on Languages, Compilers, and Tools for Embedded Systems (LCTES), 2003.
- Finance and Registration Co-Chair, International Symposium on High Performance Computer Architecture (HPCA), 2003.

Reviewer & Panelist

- National Science Foundation (NSF).
- Kentucky Science & Engineering Foundation (KSEF).
- University of California Microelectronics Innovation and Computer Research Opportunities (UC-MICRO).
- Council of Physical Sciences of the Netherlands Organization for Scientific Research (NWO).
- IEEE Computer.
- IEEE Transactions on Computers (TC).
- IEEE Transactions on Computer Aided Design (TCAD).
- IEEE Transactions on Very Large Scale Integration Systems (TVLSI).
- IEEE Transactions on Design & Test of Computers (TD&T).
- IEEE Transactions on Circuits and Systems II (TCAS-II).
- ACM Transactions on Embedded Computing Systems (TECS).
- ACM Transactions on Design Automation of Electronic Systems (TODAES).
- IEE Proceedings - Computers and Digital Techniques (IEE-C&DT).
- Springer Design Automation for Embedded Systems (SDAES).
- Cluwer Design Automation for Embedded Systems (CDAES).
- Elsevier Journal of Microprocessors and Microsystems (MICPRO).
- Elsevier Journal of System Architecture (JSA).
- Asia and South Pacific Design Automation Conference (ASP-DAC).
- Design Automation Conference (DAC).
- International Conference on Computer Aided Design (ICCAD).
- International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS).
- International Symposium on Micro-architecture (MICRO).
- International Workshop on Compilers, Architecture, and Synthesis for Embedded Systems (CASES).
- International Workshop on Logic and Synthesis (IWLS).

University

- Member, University Committee on Computing and Communications (UCCC), 2007-2010.

Campus

- Member, Council on Enrollment and Student Success, 2015-2016.
- Member, Graduate Professional Development and Career Outcomes Task Force, 2013-2014.
- Member, Council on Research, Computing and Library Resources (CORCLR), 2007-2010.
- Chair, Faculty Board for Undecided/Undeclared Students: A Board of the Council on Educational Policy, 2003-2007.

School

- Associate Dean, ICS Student Affairs, 2011-2016.
- Ex Officio Member, Graduate Policy Committee, Undergraduate Policy Committee, CSE Steering Committee, CGS Steering Committee, 2011-2016.
- Chair, ICS Enrollment Growth Task Force, 2014.
- Chair, ICS Strategic Planning: Graduate Education Group, 2011-2012.
- Member, Task Force on ICS First Year Curriculum, 2010-2011.
- Chair, Task Force on the CS Major, 2010-2011.
- Member, Computer Science Chair Recommendation Committee, 2009-2010.
- Chair, Computing & Network Policy, 2009-2010.
- Member, Computing & Network Policy, 2008-2009.
- Member, CS&E Steering Committee, 2003-2006.
- Member, DARPA Grand Challenge Team eXtreme Anteater Racers (XAR) Group, 2004-2005.
- Member, Entrepreneurship Committee, 2004-2005.
- Member, Executive Committee, 2003-2004.
- Member, Transition Committee, 2003-2004.
- Member, Faculty Recruit Committee (Ubiquitous Computing), 2003-2004.
- Member, Faculty Recruit Committee (Embedded Systems), 2002-2003.
- Member, CS Degree Program Committee, 2002-2003.
- Member, Graduate Recruit & Admissions Committee, 2002-2003.
- Member, CS&E Degree Program Committee, 2001-2002.

Awards

- NSF Grant (#1563652), National Science Foundation, \$1.0M, 2016.
- A. Richard Newton Young Student Advisor Award, The Design Automation Conference, San Francisco, 2015.
- NSF Grant (#1136146), National Science Foundation, \$1.5M, 2011.
- ASEE ECE Division Hewlett-Packard Frederick Emmons Terman Award, 2011.
- NSF Grant (#1016789), National Science Foundation, \$200K, 2010.
- ICS Dean's Award for Excellence in Undergraduate Teaching, University of California, Irvine, 2010.
- NSF Grant (#0837124), National Science Foundation, \$70K, 2009.
- Best Paper, International Conference on Compilers, Architecture, and Synthesis for Embedded Systems (CASES), 2008.
- Research & Travel Award, Council on Research, Computing, and Library Resources (CORCLR), University of California, Irvine, 2007.
- NSF Grant (#0749508), National Science Foundation, \$200K, 2007.
- Faculty Desktop Computing Initiative Award, University of California, Irvine, 2007.
- SIGDA Technical Leadership Award, American Computing Machinery (ACM), 2007.
- Best Paper, American Control Conference (ACC), 2006.
- Best Paper, ACM Transactions on Design Automation of Electronic Systems (TODAES), 2006.
- Research & Travel Award, Council on Research, Computing, and Library Resources (CORCLR), University of California, Irvine, 2005.
- Collaborative Research Initiation Award (CRIA), School of Information and Computer Sciences, University of California, Irvine, 2005.
- Chancellor's Award for Excellence in Fostering Undergraduate Research, University of California, Irvine, 2005.
- Research & Travel Grant, School of Information and Computer Sciences, University of California, Irvine, 2004.
- Ted & Janice Smith Faculty Seed Funding Award, 2004.
- Discovery Grant, University of California, 2003.
- Research Grant, Microsoft Corporation & University of California MICRO Matching Funds, 2003.
- Excellence in Teaching Award, Instructional Resource Center/Division of Undergraduate Education, University of California, Irvine, 2003.
- Research & Travel Grant, School of Information and Computer Science, University of California, Irvine, 2003.
- Equipment Donation, Xilinx University Program, 2002.
- NSF ITR Grant, National Science Foundation, 2002.

- Research & Travel Grant, School of Information and Computer Sciences, University of California, Irvine, 2002.
- Equipment Donation, Xilinx University Program, 2001.
- Outstanding Ph.D. Thesis, Department of Computer Science & Engineering, University of California, Riverside, 2001.
- Best Paper, Design Automation and Test in Europe (DATE), 2000.
- GAANN Fellowship, Department of Computer Science & Engineering, University of California, Riverside, 1998.
- Graduate Scholarship, Design Automation Conference, 1998.
- Scholarship, International Council on Systems Engineering Inland Empire, 1997.
- MICRO Fellowship, Department of Computer Science & Engineering, University of California, Riverside, 1997.
- Outstanding Student Award, College of Engineering, University of California, Riverside, 1997.
- Outstanding Academic Program Excellence, Honors Convocations, University of California, Riverside, 1997.

Presentations

Tutorials

- ESL Design: Why the Time is Right and What are the Key Enabling Technologies. IEEE International Conference on Computer Aided Design (ICCAD) 2005.
- New Developments in Embedded System Design: Software for Embedded System. IEEE International Conference on Computer Design (ICCD) 2005.

Patents

Issued

- P.11** T. Givargis, R. Sadri. Methods for Optimizing Data Movement in Solid State Devices. United States Patent, 8,612,719, December 2013.
- P.10** T. Givargis. Systems and Methods for Managing Key-Value Stores. United States Patent, 8,612,402, December 2013.
- P.9** A. Nacul, T. Givargis. Phantom Serializing Compiler and Method of Operation of Same. United States Patent, 7,886,283, February 2011.
- P.8.** J. Addink, S. Addink, T. Givargis. Methods and apparatus for using water use signatures and water pressure in improving water use efficiency. United States Patent 7,330,796, February 2008.
- P.7.** J. Addink, S. Addink, T. Givargis. Methods and Apparatus for Using Water use Signatures in Improving Water use Efficiency. United States Patent 6,963,808, November 2005.
- P.6.** J. Addink, T. Givargis. Interactive Irrigation System. United States Patent 6,950,728, September 2005.

- P5.** J. Addink, K. Buhler, T. Givargis. Modifying Irrigation Schedules of Existing Irrigation Controllers. United States Patent 6,892,114, May 2005.
- P4.** J. Henkel, T. Givargis, F. Vahid. Method for Core-Based System-Level Power Modeling using Object-Oriented Techniques. United States Patent 6,865,526, March 2005.
- P3.** K. Buhler, T. Givargis. Two Tire Irrigation Valve Controller. United States Patent 6,812,826, November 2004.
- P2.** J. Addink, T. Givargis. Detecting Weather Sensor Malfunctions. United States Patent 6,714,134, March 2004.
- P1.** J. Addink, K. Buhler, T. Givargis. Irrigation Accumulation Controller. United States Patent 6,298,285, October 2001.

Publications

Book

- B3.** F. Vahid, T. Givargis. Programming Embedded Systems - An Introduction to Time-Oriented Programming. UniWorld Publishing, July 2010. www.programmingembeddedsystems.com.
- B2.** A. Nacul, M. Lajolo, T. Givargis. Interface-Centric Abstraction level for Rapid Hardware/Software Integration, Book Chapter in Applications of Specification And Design Languages for SOCs. Springer, ISBN: 1-4020-4997-8, July 2006.
- B1.** F. Vahid, T. Givargis. Embedded System Design: A Unified Hardware/Software Introduction. John Wiley and Sons, ISBN: 0471386782, October 2001.

Journal

- J28.** S. Peter, B. Reddy, F. Momtaz and T. Givargis. Design of Secure ECG-Based Biometric Authentication in Body Area Sensor Networks. *Sensors*, vol. 16, no. 4, pp. 570-591, April 2016.
- J27.** T. Springer, S. Peter and T. Givargis. Fuzzy Logic Based Adaptive Hierarchical Scheduling for Periodic Real-Time Tasks. *ACM Special Interest Group on Embedded Systems (SIGBED) Review*, vol. 13, no. 1, pp. 8-14, January 2016.
- J26.** S. Peter, T. Givargis. Component-Based Synthesis of Embedded Systems using Satisfiability Modulo Theories, *ACM Transactions on Design Automation of Electronic Systems (TODAES)*, vol. 20, no. 4, pp. 49:1-49:27, September 2015.
- J25.** T. Springer, S. Peter and T. Givargis. Adaptive Resource Synchronization In Hierarchical Real-Time Systems. *ACM Special Interest Group on Embedded Systems (SIGBED) Review*, vol. 11, no. 4, pp. 37-42, December 2014.
- J24.** V. Gunes, S. Peter, T. Givargis, F. Vahid. A Survey on Concepts, Applications, and Challenges in Cyber-Physical Systems. *KSII Transactions on Internet and Information Systems (TIIS)*, vol. 8, no. 12, pp. 4242-4268, December 2014.
- J23.** B. Miller, F. Vahid, T. Givargis, P. Brisk. Graph-Based Approaches to Placement of Processing Element Networks on FPGAs for Physical Model Simulation. *ACM Transactions on Reconfigurable Technology and Systems (TRETs)*, vol. 7, no. 4, article 10, December 2014.

- J22.** C. Huang, F. Vahid, T. Givargis. Automatic synthesis of physical system differential equation models to a custom network of general processing elements on FPGAs. *ACM Transactions on Embedded Computing Systems (TECS)*, vol 13, no. 2, article 23, September 2013.
- J21.** C. Huang, B. Miller, F. Vahid, T. Givargis. Synthesis of Networks of Custom Processing Elements for Real-Time Physical System Emulation. *ACM Transactions on Design Automation of Electronic Systems (TODAES)*, vol. 18, no. 2, pp. 22-42, March 2013.
- J20.** C. Huang, F. Vahid, and T. Givargis. A Custom FPGA Processor for Physical Model Ordinary Differential Equation Solving. *IEEE Embedded Systems Letters*, vol. 3, no. 4, pp. 113-116, September 2011.
- J19.** S. Choudhuri, T. Givargis. Deterministic Service Guarantees for NAND Flash using Partial Block Cleaning. *Academy Publisher Journal of Software (JSW)*, vol. 4, no. 7, pp. 728-737, September 2009.
- J18.** M.A. Ghodrat, T. Givargis, A. Nicolau. Optimizing Control Flow in Loops using Interval and Dependence Analysis. *Springer Journal on Design Automation of Embedded Systems (DAES)*, vol. 13, no. 3, pp. 193-221, September 2009.
- J17.** S. Sirowy, D. Sheldon, T. Givargis, F. Vahid. Virtual Microcontrollers. *ACM SIGBED Review*, vol. 6, no. 1, January 2009.
- J16.** A. Nacul, T. Givargis. Synthesis of Time-Constrained Multitasking Embedded Software. *ACM Transactions on Design Automation of Electronic Systems (TODAES)*, vol. 11, no. 4, pp. 822-847, October 2006.
- J15.** M.A. Ghodrat, T. Givargis, A. Nicolau. Expression Equivalence Checking using Interval Analysis. *IEEE Transactions on Very Large Scale Integration Systems (TVLSI)*, vol. 14, no. 8, pp. 830-842, August 2006.
- J14.** C.V. Lopes, A. Haghighat, A. Mandal, T. Givargis, P. Baldi. Localization of Off-the-Shelf Mobile Devices Using Audible Sound: Architectures, Protocols and Performance Assessment. *ACM Mobile Computing and Communications Review (MC2R)*, vol. 10, no. 2, pp. 38-50, April 2006.
- J13.** T. Givargis. Zero Cost Indexing for Improved Processor Cache Performance. *ACM Transactions on Design Automation of Electronic Systems (TODAES)*, vol. 11, no. 1, pp. 3-25, January 2006. *Received the 2006 TODAES Best Paper Award.*
- J12.** T. Givargis, David Eppstein. Memory Reference Caching for Activity Reduction on Address Buses. *Elsevier Journal of Microprocessors and Microsystems (MICPRO)*, vol. 29, no. 4, pp. 145-153, May 2005.
- J11.** A. Ghosh, T. Givargis. Cache Optimization for Embedded Processor Cores: An Analytical Approach. *ACM Transactions on Design Automation of Electronic Systems (TODAES)*, vol. 9, no. 4, pp. 419-440, October 2004.
- J10.** A. Nacul, T. Givargis. Adaptive Cache Management for Low Power Embedded Systems. *Korea Multimedia Society, Key Technology of Next Generation IT*, ISSN 1229-778X, pp. 30-39, December 2003.
- J9.** T. Givargis, F. Vahid, J. Henkel. Instruction-Based System-Level Power Evaluation of System-on-a-Chip Peripheral Cores. *IEEE Transactions on Very Large Scale Integration Systems (TVLSI)*, vol. 10, no. 6, pp. 856-863, December 2002.
- J8.** T. Givargis, F. Vahid, J. Henkel. System-Level Exploration for Pareto-Optimal Configurations in Parameterized System-on-a-Chip. *IEEE Transactions on Very Large Scale Integration Systems (TVLSI)*, vol. 10, no. 4, pp. 416-422, December 2002.

- J7.** T. Givargis, F. Vahid. Platune: A Tuning Framework for System-on-a-Chip Platforms. *IEEE Transactions on Computer Aided Design (TCAD)*, vol. 21, no. 11, pp. 1317-1327, November 2002.
- J6.** F. Vahid, T. Givargis, S. Cotterell. Power Estimator Development for Embedded System Memory Tuning. *Journal of Circuits, Systems, and Computers (JCSC)*, vol. 11, no. 5, pp. 459-476, October 2002.
- J5.** T. Givargis, F. Vahid. Tuning of Cache Ways and Voltage for Low-Energy Embedded System Platforms. *Springer Journal on Design Automation of Embedded Systems*, vol. 7, issue 1-2, pp. 35-51, September 2002.
- J4.** T. Givargis, F. Vahid, J. Henkel. Evaluating Power Consumption of Parameterized Cache and Bus Architectures in System-on-a-Chip Designs. *IEEE Transactions on Very Large Scale Integration Systems (TVLSI)*, vol. 9, no. 4, pp. 500-508, August 2001.
- J3.** F. Vahid, T. Givargis. Platform Tuning for Embedded Systems Design. *IEEE Computer*, vol. 34, no. 3, pp. 112-114, March 2001.
- J2.** J. Farrell, T. Givargis, M. Barth. Real-Time Differential Carrier Phase GPS-Aided INS. *IEEE Transactions on Control Systems Technology (TCST)*, vol. 8, no. 4, pp. 709-721, July 2000.
- J1.** J. Farrell, T. Givargis. Differential GPS Reference Station Algorithm - Design and Analysis. *IEEE Transactions on Control Systems Technology (TCST)*, vol. 8, no. 3, pp. 519-531, May 2000.

Conference

- C63.** S. Peter and T. Givargis. Towards a Timing Attack Aware High-level Synthesis of Integrated Circuits. *IEEE International Conference on Computer Design (ICCD)*, pp. 452-455, Phoenix, October 2016.
- C62.** F. Vahid, A. Edgcomb, B. Miller, T. Givargis. Learning Materials for Introductory Embedded Systems Programming using a Model-Based Discipline. *American Society for Engineering Education (ASEE)*, 10.18260/p.27324, New Orleans, June 2016.
- C61.** S. Peter, F. Momtaz, T. Givargis. From the Browser to the Remote Physical Lab: Programming Cyber-Physical Systems. *IEEE Frontiers in Education (FIE)*, pp. 1-7, El Paso, October 2015.
- C60.** V. Gunes, S. Peter, T. Givargis. Improving Energy Efficiency and Thermal Comfort of Smart Buildings with HVAC Systems in the Presence of Sensor Faults. *IEEE International Conference on Embedded Software and Systems (ICCESS)*, pp. 945-950, New York, August 2015.
- C59.** V. Gunes and T. Givargis. XGRID: A Scalable Many-Core Embedded Processor. *IEEE International Conference on Embedded Software and Systems (ICCESS)*, pp. 1143-1146, New York, August 2015.
- C58.** H. Buini, S. Peter, T. Givargis. Including Variability of Physical Models into the Design Automation of Cyber-Physical Systems. *Design Automation Conference (DAC)*, pp. 153:1-153:6, San Francisco, June 2015.
- C57.** T. Springer, S. Peter, T. Givargis. Resource Synchronization in Hierarchically Scheduled Real-Time Systems using Preemptive Critical Sections. *IEEE International Symposium on Object/Component-Oriented Real-Time Distributed Computing (ISORC)*, pp. 293-300, Reno, June 2014.
- C56.** V. Gunes, S. Peter, T. Givargis. Modeling and Mitigation of Faults in Cyber-Physical Systems with Binary Sensors. *IEEE International Conference on Computational Science and Engineering (CSE)*, pp. 515-522, Sydney, December 2013.

- C55.** S. Peter, T. Givargis. Utilizing Intervals in Component-Based Design of Cyber Physical Systems. IEEE International Conference on Computational Science and Engineering (CSE), pp. 635-642, Sydney, December 2013.
- C54.** B. Miller, F. Vahid, T. Givargis. Exploration with Upgradeable Models Using Statistical Methods for Physical Model Emulation. Design Automatic Conference (DAC), pp. 1-6, Austin, June 2013.
- C53.** S. Peter, F. Vahid, T. Givargis. A Ball Goes to School Our Experiences from a CPS Design Experiment. Workshop on Cyber-Physical Systems Education (CPS-Ed) at Cyber Physical Systems Week (CPSWeek), pp. 1-4, Philadelphia, April 2013.
- C52.** B. Miller, F. Vahid, T. Givargis. Embedding-Based Placement of Processing Element Networks on FPGAs for Physical Model Simulation. International Symposium on Field-Programmable Gate Arrays (FPGA), pp. 181-190, Monterey, February 2013.
- C51.** T. Chou, C. Huang, B. Miller, F. Vahid, T. Givargis. An Efficient Compression Scheme for Checkpointing of FPGA-Based Digital Mockups. IEEE/ACM Asian and South Pacific Design Automation Conference (ASP-DAC), pp. 632-637, Yokohama, January 2013.
- C50.** B. Miller, F. Vahid, T. Givargis. RIOS: A Lightweight Task Scheduler for Embedded Systems. Workshop on Embedded Systems Education (WESE), Tampere, October 2012.
- C49.** C. Huang, B. Miller, F. Vahid, T. Givargis. Synthesis of Custom Networks of Heterogeneous Processing Elements for Complex Physical System Emulation. International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), pp. 215-224, Tampere, October 2012.
- C48.** B. Miller, F. Vahid, T. Givargis. MEDS: Mockup Electronic Data Sheets for Automated Testing of Cyber-Physical Systems Using Digital Mockups. Design Automation and Test in Europe (DATE), pp. 1417-1420, Grenoble, March 2012.
- C47.** B. Miller, F. Vahid, T. Givargis. Digital Mockups for the Testing of a Medical Ventilator. ACM SIGHIT International Health ACM SIGHIT International Health Informatics Symposium (IHI), pp. 859-862, Miami, January 2012.
- C46.** B. Miller, F. Vahid, T. Givargis. Application-Specific Codesign Platform Generation for Digital Mockups in Cyber-Physical Systems. Electronic System Level Synthesis Conference (ESLsyn), pp. 1-6, San Diego, June 2011.
- C45.** M.A. Ghodrat, T. Givargis. Efficient Dynamic Voltage/Frequency Scaling through Algorithmic Loop Transformation. International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), pp. 203-209, Grenoble, October 2009.
- C44.** S. Sirowy, F. Vahid, T. Givargis. Digitally-Bypassed Transducers: Interfacing Digital Mockups to Real-Time Medical Equipment. International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS), pp. 919-922, Minneapolis, September 2009.
- C43.** A. Ghosh, T. Givargis. Source Routing made Practical in Embedded Networks. International Conference on Computer Communications and Networks (ICCCN), pp. 1-6, San Francisco, August 2009.
- C42.** A. Ghosh, T. Givargis. QoS Routing in Wired Sensor Networks with Partial Updates. World Academy of Science, Engineering and Technology (WASED), pp. 389-393, Oslo, July 2009.
- C41.** S.K. Mylavarapu, S. Choudhuri, A. Shrivastava, J. Lee, T. Givargis. FSAF: File System Aware Flash Translation Layer for NAND Flash Memories. Design Automation and Test in Europe (DATE), pp. 339-344, Dresden, April 2009.

- C40.** S. Choudhuri, T. Givargis. FlashBox: A System for Logging Non-Deterministic Events in Deployed Embedded Systems. International ACM Symposium on Applied Computing (SAC), pp. 1676-1682, Honolulu, March 2009.
- C39.** M.A. Ghodrat, T. Givargis, A. Nicolau. Control Flow Optimization in Loops using Interval Analysis. International Conference on Compilers, Architecture, and Synthesis for Embedded Systems (CASES), pp. 157-166, Atlanta, October 2008. *Received the 2008 CASES Best Paper Award.*
- C38.** F. Vahid, T. Givargis. Timing is Everything - Embedded Systems Demand Early Teaching of Structured Time-Oriented Programming. Workshop on Embedded Systems Education (WESE), Atlanta, October 2008.
- C37.** S. Sirowy, D. Sheldon, T. Givargis, F. Vahid. Virtual Microcontrollers. Workshop on Embedded Systems Education (WESE), Atlanta, October 2008.
- C36.** F. Vahid, T. Givargis. Highly-Cited Ideas in System Codesign and Synthesis. International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), pp. 191-196, Atlanta, October 2008.
- C35.** S. Choudhuri, T. Givargis. Deterministic Service Guarantees for NAND Flash using Partial Block Cleaning. International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), pp. 19-24, Atlanta, October 2008.
- C34.** S. Choudhuri, T. Givargis. Real-Time Access Guarantees for NAND Flash using Partial Block Cleaning. Workshop on Software Technologies for Future Embedded & Ubiquitous Systems (SEUS), pp. 138-149, Italy, September 2008.
- C33.** A. Ghosh, T. Givargis. A Software Architecture for Accessing Data in Sensor Networks. International Conference on Networked Sensing Systems (INSS), pp. 67-70, Japan, June 2008.
- C32.** S. Choudhuri, T. Givargis. Performance Improvement of Block Based NAND Flash Translation Layer. International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), pp. 257-262, Salzburg, September 2007.
- C31.** M.A. Ghodrat, T. Givargis., A. Nicolau. Short-Circuit Compiler Transformation: Optimizing Conditional Blocks. Asia and South Pacific Design Automation Conference (ASP-DAC), pp. 504-510, Tokyo, January 2007.
- C30.** S. Choudhuri, T. Givargis. System Architecture for Software Peripherals. Asia and South Pacific Design Automation Conference (ASP-DAC), pp. 56-61, Tokyo, January 2007.
- C29.** A. Nacul, T. Givargis. Phantom: A Serializing Compiler for Multitasking Embedded Software. American Control Conference (ACC), pp. 1918-1923, Minneapolis, June 2006. *Received the 2006 ACC Best Paper Award.*
- C28.** M.A. Ghodrat, T. Givargis, A. Nicolau. Equivalence Checking of Arithmetic Expressions using Fast Evaluation. International Conference on Compilers, Architecture, and Synthesis for Embedded Systems (CASES), pp. 147-156, San Francisco, September 2005.
- C27.** A. Nacul, T. Givargis. Lightweight Multitasking Support for Embedded Systems using the Phantom Serializing Compiler. Design Automation and Test in Europe (DATE), pp. 742-747, Munich, March 2005.
- C26.** A. Ghosh, T. Givargis. LORD: A Localized, Reactive and Distributed Protocol for Node Scheduling in Wireless Sensor Networks. Design Automation and Test in Europe (DATE), pp. 190-195, Munich, March 2005.

- C25.** A. Mandal, C.V. Lopes, T. Givargis, A. Haghighat, R. Jurdak, P. Baldi. Beep: 3D Indoor Positioning Using Audible Sound. IEEE Consumer Communications and Networking Conference (CCNC), pp. 348-353, Las Vegas, January 2005.
- C24.** A. Nacul, T. Givargis. Code Partitioning for Synthesis of Embedded Applications with Phantom. International Conference on Computer-Aided Design (ICCAD), pp. 190-196, San Jose, November 2004.
- C23.** A. Nacul, T. Givargis. Dynamic Voltage and Cache Reconfiguration for Low Power. Design Automation and Test in Europe (DATE), pp. 1376-1377, Paris, February 2004.
- C22.** M. Buss, T. Givargis, N. Dutt. Exploring Efficient Operating Points for Voltage Scaled Embedded Processor Cores. Real-Time Systems Symposium (RTSS), pp. 275-281, Cancun, December 2003.
- C21.** A. Ghosh, T. Givargis. Cache Optimization for Embedded Processor Cores: An Analytical Approach. International Conference on Computer-Aided Design (ICCAD), pp. 342-347, San Jose, November 2003.
- C20.** T. Givargis. Improved Indexing for Cache Miss Reduction in Embedded Systems. Design Automation Conference (DAC), pp. 872-880, Anaheim, June 2003.
- C19.** A. Ghosh, T. Givargis. Analytical Design Space Exploration of Caches for Embedded Systems. Design Automation and Test in Europe (DATE), pp. 650-655, Munich, March 2003.
- C18.** T. Givargis, D. Eppstein. Reference Caching Using Unit Distance Redundant Codes for Activity Reduction on Address Buses. International Workshop on Embedded System Hardware/Software Codesign (ESCODES), San Jose, September 2002.
- C17.** M. Palesi, T. Givargis. Multi-Objective Design Space Exploration Using Genetic Algorithms. International Workshop on Hardware/Software Codesign (CODES), Estes Park, May 2002.
- C16.** T. Givargis, F. Vahid, J. Henkel. System-Level Exploration for Pareto-Optimal Configurations in Parameterized Systems-on-a-Chip. International Conference on Computer-Aided Design (ICCAD), San Jose, November 2001.
- C15.** T. Givargis, F. Vahid, J. Henkel. Trace-Driven System-Level Power Evaluation of System-on-a-Chip Peripheral Cores. Asia and South Pacific Design Automation Conference (ASP-DAC), Yokohama, January 2001.
- C14.** G. Stitt, F. Vahid, T. Givargis, R. Lysecky. A First-Step Towards an Architecture Tuning Methodology. International Conference on Compilers, Architecture, and Synthesis for Embedded Systems (CASES), San Jose, November 2000.
- C13.** T. Givargis, F. Vahid, J. Henkel. Instruction-Based System-Level Power Evaluation of System-on-a-Chip Peripheral Cores. International Symposium on System Synthesis (ISSS), Madrid, September 2000.
- C12.** R. Lysecky, F. Vahid, T. Givargis. Experiments with the Peripheral Virtual Component Interface. International Symposium on System Synthesis (ISSS), Madrid, September 2000.
- C11.** T. Givargis, F. Vahid. Parameterized System Design. International Workshop on Hardware/Software Codesign (CODES), San Diego, May 2000.
- C10.** T. Givargis, F. Vahid, J. Henkel. Fast Cache and Bus Power Estimation for Parameterized System-on-a-Chip Design. Design Automation and Test in Europe (DATE), Paris, March 2000.
- C9.** R. Lysecky, F. Vahid, T. Givargis. Techniques for Reducing Read Latency of Core Bus Wrappers. Design Automation and Test in Europe (DATE), Paris, March 2000. *Received the 2000 DATE Best Paper Award.*

- C8.** T. Givargis, F. Vahid, J. Henkel. A Hybrid Approach for Core-Based System-Level Power Modeling. Asia and South Pacific Design Automation Conference (ASPDAC), Yokohama, January 2000.
- C7.** T. Givargis, J. Henkel, F. Vahid. Interface and Cache Power Exploration for Core-Based Embedded System Design. International Conference on Computer-Aided Design (ICCAD), San Jose, November 1999.
- C6.** R. Lysecky, F. Vahid, T. Givargis, R. Patel. Pre-Fetching for Improved Core Interfacing. International Symposium on System Synthesis (ISSS), San Jose, November 1999.
- C5.** J. Farrell, T. Givargis. Experimental Differential GPS Reference Station Evaluation. American Control Conference (ACC), San Diego, June 1999.
- C4.** J. Farrell, T. Givargis, M. Barth. Differential Carrier Phase GPS-Aided INS for Automotive Applications. American Control Conference (ACC), San Diego, June 1999.
- C3.** F. Vahid, T. Givargis. The Case for a Configure-and-Execute Paradigm. International Workshop on Hardware/Software Codesign (CODES), Rome, May 1999.
- C2.** F. Vahid, T. Givargis. Incorporating Cores into System-Level Specification. International Symposium on System Synthesis (ISSS), Hsinchu, December 1998.
- C1.** T. Givargis, F. Vahid. Interface Exploration for Reduced Power in Core-Based Systems. International Symposium on System Synthesis (ISSS), Hsinchu, December 1998.

Workshop

- W2.** A. Nacul, M. Lajolo, T. Givargis. Interface-Centric Abstraction Level for Rapid Hardware/Software Integration. Forum on Specification and Design Languages (FDL), Lausanne, September 2005.
- W1.** A. Haghighat, C. Lopes, T. Givargis, and A. Mandal. Location-Aware Web System. Workshop on Building Software for Pervasive Computing at the Object-Oriented Programming, Systems, Languages and Applications (OOPSLA) Conference, Vancouver, October 2004.

Miscellaneous

- M1.** U. Brinkschulte, M. Cinque, T. Givargis, S. Russo. Guest Editorial. Journal of Software, vol. 4, no. 7, pp. 631-633, September 2009.

Affiliated Students

Ph.D. Final Defense Committee Chair

- Tom Springer, Department of Computer Science, University of California, Irvine, 6/22/2015.
- Volkan Gunes, Department of Computer Science, University of California, Irvine, 5/27/2015.
- Mohammad Ali Ghodrat, Department of Computer Science, University of California, Irvine, 9/1/2009.
- Siddharth Choudhuri, Department of Computer Science, University of California, Irvine, 1/5/2009.
- Arijit Ghosh, Department of Computer Science, University of California, Irvine, 7/9/2008.
- Andre Nacul, Department of Computer Science, University of California, Irvine, 4/23/2007.

Ph.D. Final Defense Committee Member

- Hossein Tajikh, Department of Computer Science, University of California, Irvine, 9/15/2016.
- Zonglin Guo, Department of Computer Science, University of California, Irvine, 5/26/2016.
- SeungJae Lee, Department of Electrical Engineering & Computer Science, University of California, Irvine, 4/5/2016.
- Gulfem Savrun Yeniceri, Department of Computer Science, University of California, Irvine, 11/30/2015.
- Kyoungwon Kim, Department of Electrical Engineering & Computer Science, University of California, Irvine, 8/28/2014.
- Alex Edgcomb, Department of Computer Science & Engineering, University of California, Riverside, 6/9/2014.
- Bailey Miller, Department of Computer Science & Engineering, University of California, Riverside, 6/9/2014.
- Nam Duong, Department of Computer Science, University of California, Irvine, 2/25/2014.
- Mehryar Rahmatian, Department of Computer Science, University of California, Irvine, 1/30/2014.
- Hessam Kooti, Department of Computer Science, University of California, Irvine, 8/7/2012.
- Kazuyuki Tanimura, Department of Computer Science, University of California, Irvine, 8/6/2012.
- Chen Huang, Department of Computer Science & Engineering, University of California, Riverside, 5/16/2012.
- Mason Chang, Department of Computer Science, University of California, Irvine, 2/21/2012.
- Michael Bebenita, Department of Computer Science, University of California, Irvine, 10/11/2011.
- Jinsik Kim, Department of Electrical Engineering & Computer Science, University of California, Irvine, 5/18/2010.
- Yonghyun Hwang, Department of Computer Science, University of California, Irvine, 12/16/2009.
- Babak Salamat, Department of Computer Science, University of California, Irvine, 6/8/2009.
- Aseem Gupta, Department of Electrical Engineering & Computer Science, University of California, Irvine, 5/29/2009.
- Gabor Madl, Department of Computer Science, University of California, Irvine, 5/27/2009.
- Love Singhal, Department of Computer Science, University of California, Irvine, 1/13/2009.
- Lei Zhou, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/3/2008.
- Seung-Eun Lee, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/3/2008.
- Minyoung Kim, Department of Computer Science, University of California, Irvine, 7/8/2008.
- Jun Ho Bahn, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/20/2007.

- Daniel Jesus Valencia Sanchez, Department of Computer Science, University of California, Irvine, 9/10/2007.
- Chen Liu, Department of Electrical Engineering & Computer Science, University of California, Irvine, 8/3/2007.
- Vasanth Venkatachalam, Department of Computer Science, University of California, Irvine, 5/14/2007.
- Ning Wang, Department of Computer Science, University of California, Irvine, 5/14/2007.
- Kiran Ramineni, Department of Computer Science, University of California, Irvine, 3/13/2007.
- Shireesh Verma, Department of Computer Science, University of California, Irvine, 2/26/2007.
- Ilya Issenin, Department of Computer Science, University of California, Irvine, 12/6/2006.
- Hooman Parizi, Department of Electrical Engineering & Computer Science, University of California, Irvine, 11/14/2006.
- Partha Biswas, Department of Computer Science, University of California, Irvine, 3/2/2006.
- Samar Abdi, Department of Computer Science, University of California, Irvine, 11/28/2005.
- Chengzhi Pan, Department of Electrical Engineering & Computer Science, University of California, Irvine, 9/7/2005.
- Haobo Yu, Department of Computer Science, University of California, Irvine, 11/30/2004.
- Shean McMahon, Department of Computer Science, University of California, Irvine, 11/1/2004.
- Mahesh Naga Mamidipaka, Department of Computer Science, University of California, Irvine, 8/23/2004.
- Dongwan Shin, Department of Computer Science, University of California, Irvine, 4/16/2004.
- Junyu Peng, Department of Computer Science, University of California, Irvine, 4/2/2004.

Ph.D. Candidacy Exam Committee Chair

- Hamid Mirzaei Buini, Department of Computer Science, University of California, Irvine, 3/10/2017.
- Ting-Shuo Chou, Department of Computer Science, University of California, Irvine, 10/23/2012.
- Volkan Gunes, Department of Computer Science, University of California, Irvine, 6/20/2012.
- Tom Springer, Department of Computer Science, University of California, Irvine, 5/25/2012.
- Siddharth Choudhuri, Department of Computer Science, University of California, Irvine, 12/21/2006.
- Mohammad Ali Ghodrat, Department of Computer Science, University of California, Irvine, 3/25/2005.
- Arijit Ghosh, Department of Computer Science, University of California, Irvine, 9/14/2004.
- Andre Nacul, Department of Computer Science, University of California, Irvine, 5/26/2004.

Ph.D. Candidacy Exam Committee Member

- Congmiao Li, Department of Electrical Engineering & Computer Science, University of California, Irvine, 5/23/2016.
- SeungJae Lee, Department of Electrical Engineering & Computer Science, University of California, Irvine, 4/5/2016.
- Saman Jafarlou, Department of Electrical Engineering & Computer Science, University of California, Irvine, 3/16/2016.
- Hossein Mohammadnezhad, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/2/2015.
- Korosh Vatanparvar, Department of Electrical Engineering & Computer Science, University of California, Irvine, 9/14/2015.
- Zana Ghaderi, Department of Computer Science, University of California, Irvine, 7/28/2015.
- Chenying Hsieh, Department of Computer Science, University of California, Irvine, 7/9/2015.
- Bryan Donyanavard, Department of Computer Science, University of California, Irvine, 6/12/2015.
- Tim Schmidt, Department of Electrical Engineering & Computer Science, University of California, Irvine, 6/1/2015.
- Tiago Mck, Department of Computer Science, University of California, Irvine, 6/1/2015.
- Tongsheng Geng, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/10/2014.
- Jurngyu Park, Department of Computer Science, University of California, Irvine, 9/23/2014.
- Hossein Tajik, Department of Computer Science, University of California, Irvine, 9/16/2013.
- SeungJae Lee, Department of Computer Science, University of California, Irvine, 8/19/2013.
- Jun Luan, Department of Electrical Engineering & Computer Science, University of California, Irvine, 2/11/2013.
- Francis Caster, Department of Electrical Engineering & Computer Science, University of California, Irvine, 2/8/2013.
- Gulfem Savrun Yeniceri, Department of Computer Science, University of California, Irvine, 1/16/2013.
- Aras Pirbadian, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/13/2012.
- Abbas Banaiyanmofrad, Department of Computer Science, University of California, Irvine, 7/17/2012.
- Siavash Ahrar, Department of Biomedical Engineering, University of California, Irvine, 6/15/2012.
- Zheng Wang, Department of Electrical Engineering & Computer Science, University of California, Irvine, 3/14/2012.
- Pei-Yuan, Department of Electrical Engineering & Computer Science, University of California, Irvine, 3/12/2012.
- Christoph Kerschbaumer, Department of Computer Science, University of California, Riverside, 11/29/2011.

- Brett Chien, Department of Electrical Engineering & Computer Science, University of California, Irvine, 11/28/2011.
- Mehryar Rahmatian, Department of Computer Science, University of California, Irvine, 9/16/2010.
- Deepak Mishra, Department of Computer Science, University of California, Irvine, 9/15/2010.
- Dali Zhao, Department of Computer Science, University of California, Irvine, 9/2/2010.
- Tae Su Kim, Department of Computer Science, University of California, Irvine, 3/19/2010.
- Zhiming Chen, Department of Computer Science & Engineering, University of California, Irvine, 12/10/2009.
- Hessam Kooti, Department of Computer Science, University of California, Irvine, 12/7/2009.
- Vahid Salmani, Department of Computer Science & Engineering, University of California, Irvine, 12/2/2009.
- Marcelo Cintra, Department of Computer Science, University of California, Irvine, 11/17/2009.
- Patricia Lee, Department of Computer Science, University of California, Irvine, 9/18/2009.
- Rosario Cammarota, Department of Computer Science, University of California, Irvine, 9/17/2009.
- Kazuyuki Tanimura, Department of Computer Science, University of California, Irvine, 9/3/2009.
- Matthew Badin, Department of Computer Science, University of California, Irvine, 6/4/2009.
- Michael Bebenita, Department of Computer Science, University of California, Irvine, 5/29/2009.
- Mason Chang, Department of Computer Science, University of California, Irvine, 5/27/2009.
- Sangwon Chae, Department of Computer Science, University of California, Irvine, 12/9/2008.
- Wendy Zhang, Department of Computer Science, University of California, Irvine, 12/8/2008.
- Fred Tzeng, Department of Computer Science & Engineering, University of California, Irvine, 1/31/2008.
- Minyoung Kim, Department of Computer Science, University of California, Irvine, 1/15/2008.
- AmirHossein GholamiPour, Department of Computer Science, University of California, Irvine, 12/11/2007.
- Shahin Golshan, Department of Computer Science, University of California, Irvine, 12/10/2007.
- Scott Hendrickson, Department of Informatics, University of California, Irvine, 11/16/2007.
- David Sheldon, Department of Computer Science & Engineering, University of California, Riverside, 10/24/2007.
- Scott Sirowy, Department of Computer Science & Engineering, University of California, Riverside, 10/24/2007.
- Yonghyun Hwang, Department of Computer Science, University of California, Irvine, 9/19/2007.
- Zhen Zhang, Department of Computer Science, University of California, Irvine, 9/4/2007.
- Jing Qian, Department of Electrical Engineering & Computer Science, University of California, Irvine, 9/4/2007.
- Babak Salamat, Department of Computer Science, University of California, Irvine, 5/15/2007.

- Sudeep Pasricha, Department of Computer Science, University of California, Irvine, 2/7/2007.
- Deyi Pi, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/5/2006.
- Seung Eun Lee, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/1/2006.
- Jayram Nageswaran, Department of Computer Science, University of California, Irvine, 11/14/2006.
- Gabor Madl, Department of Computer Science, University of California, Irvine, 9/6/2006.
- Lei Zhou, Department of Electrical Engineering & Computer Science, University of California, Irvine, 6/16/2006.
- Love Singhal, Department of Computer Science, University of California, Irvine, 6/12/2006.
- Ilya Issenin, Department of Computer Science, University of California, Irvine, 5/23/2006.
- Sevin Fide, Department of Electrical Engineering & Computer Science, University of California, Irvine, 5/16/2006.
- Farzad Etemadi, Department of Electrical Engineering & Computer Science, University of California, Irvine, 4/13/2006.
- Vasanth Venkatachalam, Department of Computer Science, University of California, Irvine, 4/11/2006.
- Jiwon Hahn, Department of Electrical Engineering & Computer Science, University of California, Irvine, 3/28/2006.
- Ersin Sengul, Department of Electrical Engineering & Computer Science, University of California, Irvine, 3/8/2006.
- Daniel Jesus Valencia Sanchez, Department of Computer Science, University of California, Irvine, 2/24/2006.
- Hooman Torabi Parizi, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/15/2005.
- Afshin Niktash, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/13/2005.
- Jun Ho Bahn, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/7/2005.
- Chulsung Park, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/6/2005.
- Aseem Gupta, Department of Electrical Engineering & Computer Science, University of California, Irvine, 9/14/2005.
- Gunar Schirner, Department of Computer Science, University of California, Irvine, 9/6/2005.
- Pramod Chandraiah, Department of Electrical Engineering & Computer Science, University of California, Irvine, 9/6/2005.
- Yan Huang, Department of Computer Science, University of California, Irvine, 8/24/2005.
- Partha Biswas, Department of Computer Science, University of California, Irvine, 6/13/2005.

- Jiming Liu, Department of Computer Science, University of California, Irvine, 5/6/2005.
- Pablo Diaz Gutierrez, Department of Computer Science, University of California, Irvine, 3/24/2005.
- Srinivas Vadlamani, Department of Electrical Engineering & Computer Science, University of California, Irvine, 3/16/2005.
- Rafael Lopez, Department of Computer Science, University of California, Irvine, 2/2/2005.
- Kiran Ramineni, Department of Computer Science, University of California, Irvine, 12/9/2004.
- Seung-mok Yoo, Department of Electrical Engineering & Computer Science, University of California, Irvine, 12/7/2004.
- Chen Liu, Department of Electrical Engineering & Computer Science, University of California, Irvine, 11/30/2004.
- Ashish Bhargave, Department of Electrical Engineering & Computer Science, University of California, Irvine, 11/2005/2004.
- Cristian Petrescu-Prahova, Department of Computer Science, University of California, Irvine, 9/13/2004.
- Shireesh Verma, Department of Computer Science, University of California, Irvine, 9/9/2004.
- Chris Fensch, Department of Computer Science, University of California, Irvine, 9/8/2004.
- Ning Wang, Department of Computer Science, University of California, Irvine, 9/1/2004.
- Enis Akay, Department of Electrical Engineering & Computer Science, University of California, Irvine, 6/2004/2004.
- Amir Kamalizad, Department of Electrical Engineering & Computer Science, University of California, Irvine, 6/3/2004.
- Deepak Chandra, Department of Computer Science, University of California, Irvine, 3/30/2004.
- Chunhui Zhang, Department of Electrical Engineering & Computer Science, University of California, Irvine, 3/15/2004.
- David Lee, Department of Chemistry, University of California, Irvine, 5/7/2003.
- Jinfeng Liu, Department of Electrical Engineering & Computer Science, University of California, Irvine, 3/20/2003.
- Mehrdad Reshadi, Department of Computer Science, University of California, Irvine, 3/19/2003.
- Chengzhi Pan, Department of Electrical Engineering & Computer Science, University of California, Irvine, 3/12/2003.
- Samar Abdi, Department of Computer Science, University of California, Irvine, 9/12/2002.
- Marcio Dias, Department of Informatics, University of California, Irvine, 6/3/2002.
- Chris Lüer, Department of Informatics, University of California, Irvine, 5/14/2002.
- Dongwan Shin, Department of Computer Science, University of California, Irvine, 9/20/2001.
- John Xie, Department of Computer Science, University of California, Irvine, 9/20/2001.
- Haobo Yu, Department of Computer Science, University of California, Irvine, 9/20/2001.
- Junyu Peng, Department of Computer Science, University of California, Irvine, 9/14/2001.

Undergraduate Research (CS 199)

- Natalie Moshayedi, Department of Computer Science, University of California, Irvine, Summer 2015.
- Desiree Moshayedi, Department of Computer Science, University of California, Irvine, Summer 2015.
- Farshad Momtaz, Department of Computer Science, University of California, Irvine, Fall 2013, Winter 2014, Fall 2014.
- Jeanelle Castro, Department of Computer Science, University of California, Irvine, Winter 2013.
- Ina Li Liu, Department of Computer Science, University of California, Irvine, Fall 2012.
- Faraz Milani, Department of Electrical Engineering, University of California, Irvine, Spring 2012.
- Samir Majumdar, Department of Computer Science, University of California, Irvine, Summer 2011.
- Remington Brasga, Department of Computer Science, University of California, Irvine, Spring 2011.
- Jillian Gluck, Department of Computer Science, University of California, Irvine, Fall 2010.
- Sterling Pearson, Department of Computer Science, University of California, Irvine, Fall 2010.

Undergraduate Research Opportunities Program (UROP) Faculty Mentor

- Manish Sinha, Information & Computer Sciences, University of California, Irvine, 2007.
- Hussien Sleiman, Information & Computer Sciences, University of California, Irvine, 2005.
- Luis Angel, Information & Computer Sciences, University of California, Irvine, 2005.
- Martin Yasin, Information & Computer Sciences, University of California, Irvine, 2005.
- Anton Popov, Information & Computer Sciences, University of California, Irvine, 2005.
- Nick Mangano, Information & Computer Sciences, University of California, Irvine, 2005.
- Harvey Herela, Information & Computer Sciences, University of California, Irvine, 2005.
- Chad Christensen, Information & Computer Sciences, University of California, Irvine, 2005.
- Adam Wasserstrom, Information & Computer Sciences, University of California, Irvine, 2005.
- Lu Q Zheng, Information & Computer Sciences, University of California, Irvine, 2005.
- Ray Shen, Information & Computer Sciences, University of California, Irvine, 2005.
- Long Ting Kan, Information & Computer Sciences, University of California, Irvine, 2005.

Summer Undergraduate Research Program (SURP) Faculty Mentor

- John Liu, Computer Science & Engineering, University of California, Riverside, 2003.
- Kenny Vu, Information & Computer Sciences, University of California, Irvine, 2002.