

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LULULEMON ATHLETICA CANADA INC. and LULULEMON USA INC.
Petitioner,

v.

NIKE, INC.,
Patent Owner.

Patent: 9,278,256

DECLARATION OF DR. KEVIN LYNCH, PH.D.

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1. My name is Kevin Lynch. I have been retained regarding an *inter partes* review proceeding involving U.S. Patent No. 9,278,256 (Ex. 1001, “the ’256 patent”). I have been asked to analyze how a person of ordinary skill in the art (“POSITA”) would have understood certain references before March 3, 2008, and whether a POSITA would have modified or combined them. I identify the references that I considered and describe my opinions regarding them in this declaration. I understand that Petitioner will submit this declaration as an exhibit to a petition for *inter partes* review of U.S. Patent No. 9,278,256.

2. I have personal knowledge of the facts and opinions set forth in this declaration and believe them to be true. If called upon to do so, I would testify competently thereto. I have been warned that willful false statements and the like are punishable by fine or imprisonment, or both.

3. I am being compensated for my time at my standard consulting rate. I am also being reimbursed for expenses that I incur during my work. My compensation does not depend on the results of my study and analysis, the substance of my opinions, or the outcome of any proceeding involving the Challenged Claims. I have no financial interest in the outcome of this matter or in any litigation involving the ’256 patent.

I. Qualifications

4. I am a professor at Northwestern University's McCormick School of Engineering and the director of Northwestern University's Center for Robotics and Biosystems. I earned my Bachelor of Science in Engineering in Electrical Engineering with honors from Princeton in 1989 and my Ph.D. in Robotics from Carnegie Mellon University in 1996. I joined Northwestern University's faculty a year later, in 1997.

5. My research interests include (1) motion planning and control for dynamic robotic systems, robotic manipulation, and underactuated systems, (2) assembly and automation, (3) control of networked multi-robot systems ("swarm robotics"), (4) and physical human-robot interaction. In our work on networked robotics, we program swarm robots (small wheeled mobile robots) to sense their environment and communicate via wireless communication, using technologies such as Wi-Fi, Bluetooth, and Zigbee. In some configurations of our swarm robot systems, we program the swarm robots to communicate with a centralized coordinating computer, in a client-server configuration. In other configurations, the robots communicate directly with each other, forming a peer-to-peer communication network.

6. Both peer-to-peer and centralized client-server-type topologies are common in swarm robotics. Centralized topologies have the advantages of reduced

communication and the ability to concentrate computing and storage resources at the central server. If the centralized server is disconnected, damaged, or “goes down,” however, the robots can no longer coordinate their behaviors. Peer-to-peer topologies require more channels of communication and greater storage and computing resources at each robot, but have the advantage of robustness: coordinated behavior is not destroyed by damaging any single peer.

7. In our work on physical human-robot interaction, one or more robots physically interact with one or more humans in tasks such as assistive manipulation of large loads in warehouse-type settings, rehabilitation after injury, or assistance after injury. We use sensors such as force sensors, vision tracking, accelerometers, and electromyography (EMG) sensors to detect human activity. In one example of physical human-robot interaction, the activity of one human is measured (and possibly influenced) by a wearable robot and sent via a network to a remote robot worn by another human, establishing human-robot-robot-human interaction. Humans thus connected can remotely train each other, compete in games against each other, or participate in cooperative games together.

8. I have authored over 100 peer-reviewed journal articles, conference papers, and textbook chapters on a wide range of topics, including on computer networks. I have also coauthored three textbooks relating to robotics and computing:

- a. Kevin M. Lynch and Frank C. Park., *Modern Robotics: Mechanics, Planning, and Control*, Cambridge University Press, 2017;
- b. Kevin M. Lynch, Nicholas Marchuk, and Matthew L. Elwin. *Embedded Computing and Mechatronics with the PIC32 Microcontroller*, Elsevier/Newnes, 2015;
- c. Howie Choset, Kevin M. Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun. *Principles of Robot Motion*, MIT Press, 2005;

9. At Northwestern, I have taught courses in robotics and mechatronics, using material from the three textbooks above as well as other source material. In mechatronics courses, I have taught the programming of microcontrollers for integration of sensors and electromechanical systems. Among other topics, in these courses I have taught signal processing, programming the interaction of peripherals with a CPU over a bus, communication between microcontrollers, and communication between microcontrollers and networked computers running modern operating systems, using wired communication methods such as Ethernet, USB, universal asynchronous receiver/transmitter (UART), inter-integrated circuit (I²C), serial peripheral interface (SPI), controller area network (CAN), parallel ports, and others.

10. I have published YouTube videos on Northwestern Robotics' YouTube channel, youtube.com/c/NorthwesternRobotics. In those videos, I lecture about embedded computing and mechatronics; robot mechanics, planning, and control; and other topics. My online Coursera courses on robotics have been taken by tens of thousands of students around the world.

11. I am Editor-in-Chief of the *IEEE Transactions on Robotics*, one of the leading journals in robotics. I handle over 1000 research paper submissions per year and manage an international group of six senior editors, approximately 70 associate editors, and thousands of reviewers. I was previously Editor-in-Chief of the Conference Editorial Board for the IEEE International Conference on Robotics and Automation (ICRA), the largest and most influential annual research conference in robotics.

12. I have received significant recognition for my teaching, research, and leadership throughout my career. Below is a partial list of the awards and recognition that I have received over the years:

- a. In 2022, I won the George Saridis Leadership Award in Robotics and Automation;
- b. In 2017, I won the Harashima Award for Innovative Technologies;
- c. In 2010, I was named an IEEE fellow;

- d. In 2007, I won the Charles Deering McCormick Professor of Teaching Excellence Award, the highest teaching award given by Northwestern University;
- e. In 2007, I won the Society of Automotive Engineers Ralph R. Teetor Educational Award;
- f. In 2001, I won the Early Career Award in Robotics and Automation from the Institute of Electrical and Electronics Engineers;
- g. In 1998, I won the McCormick School of Engineering and Applied Science Teacher of the Year Award;
- h. In 1998, I won a National Science Foundation Career Award.

13. Additional information about my qualifications and experience is available in my *curriculum vitae*, attached as Exhibit A to this Declaration.

II. Materials Considered

14. In performing my analysis and forming the opinions below, I considered the '256 patent (Ex. 1001), its prosecution history, and materials listed as exhibits to the petition in this IPR (Exs. 1004-1012).

III. Understanding of Relevant Legal Principles

15. I am not a lawyer, and I will not provide any legal opinions. Rather, I have been asked to provide my technical opinions based on how a person of ordinary

skill in the art would have understood various references before the '256 patent's March 3, 2008, priority date. Although I am not a lawyer, I have been advised to apply certain legal standards in forming my opinions.

A. Claim Construction Standard

16. I understand that claim terms are given their ordinary and customary meaning, as would be understood by a person of ordinary skill in the relevant art in the context of the patent's entire disclosure and prosecution history. A claim term, however, will not receive its ordinary meaning if the patentee acted as their own lexicographer and clearly set forth a definition of the claim term in the specification. In that case, the claim term will receive the definition set forth in the patent.

B. Anticipation and Obviousness

17. I understand that a patent claim is invalid if it is anticipated or obvious in view of the prior art. I further understand that invalidity of a claim requires that the claim be anticipated or obvious from the perspective of a person of ordinary skill in the art at the time the invention was made.

18. I have been informed that a patent claim is invalid if it would have been obvious to a person of ordinary skill in the art. In analyzing the obviousness of a claim, I understand the following factors may be taken into account: (1) the scope and content of the prior art; (2) the differences between the prior art and the claims; (3) the level of ordinary skill in the art; and (4) any so called "secondary

considerations” of non-obviousness if they are present. I am not aware of any evidence of secondary considerations of non-obviousness relevant to the patent. I reserve the right to supplement this Declaration if Patent Owner introduces evidence of secondary considerations of non-obviousness.

19. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. I further understand that exemplary rationales that may support a conclusion of obviousness include:

- combining prior art elements according to known methods to yield predictable results;
- simple substitution of one known element for another to obtain predictable results;
- use of known technique(s) to improve similar devices (methods or products) in the same way;
- applying a known technique to a known device (method or product) ready for improvement to yield predictable results;
- “obvious to try” – choosing from a finite number of identified, predictable solutions with a reasonable expectation of success;
- known work in one field of endeavor may prompt variations of the work for use in either the same field or a different field based on design incentives or

other market forces if the variations are predictable to a person of ordinary skill in the art; and

- some teaching, suggestion, or motivation in the prior art that would have led a person of ordinary skill in the art to modify the prior art reference or to prior art reference teachings to arrive at the claimed invention.

20. I have been informed that, in considering obviousness, I may not use hindsight reasoning derived from the patent-at-issue.

IV. Background

A. Technical Background

21. The technical background pertains to computer networks consisting of at least (1) user devices (computers, wireless nodes, or other), possibly incorporating input devices (e.g., biometric sensors, keyboards, touch screens, mice, cameras, etc.) and possibly incorporating output devices (e.g., video displays, motors, audio, etc.); (2) remote devices not local to any particular user, such as servers; and (3) signal communication among these devices, perhaps enabled by other devices such as routers. The user devices could be of different types (e.g., a computer or a phone) or of the same type. Similarly, the remote devices (e.g., servers) could be of different types or the same type. Communication among devices could use a combination of wireless (e.g., Wi-Fi, Bluetooth, Zigbee, etc.) or wired (e.g., Ethernet, USB, serial ports, etc.) technologies. Networked systems such as these were well known in the

early 2000s, and many different network topologies (which describe the pattern of the communication links between devices) were in common use.

22. Two common network topologies are peer-to-peer and client-server. In a peer-to-peer topology, devices communicate directly with each other; each device is a “peer” of every other device. In a client-server topology, clients communicate with a remote server, which provides “centralized” services such as data storage, computing, or coordination and synchronization of the clients. In a typical configuration, clients communicate with a remote server via the Internet.

B. Overview of the '256 Patent

23. The '256 patent is a United States patent numbered 9,278,256. (Ex. 1001.) It is titled “INTERACTIVE ATHLETIC EQUIPMENT SYSTEM” and is dated March 8, 2016. (*Id.*) In general terms, the '256 patent relates to “[s]ystems and techniques for the collection and display of athletic information.” (*Id.*)

1. Hardware

24. Three categories of devices described in the '256 patent are (1) an athletic information monitoring device 201, (2) an athletic information collection and display device 501, and (3) an athletic data display configuration device 601.

25. Athletic information monitoring device 201. Device 201 collects athletic activity data from users. (*Id.*, 7:56-59.) It includes “a digital music player 203, an electronic interface device 205, and an athletic parameter measurement

device 207.” (*Id.*, 7:61-63.) “[T]he digital music player 203 is (releasably) connected to the electronic interface device 205, and the combination is worn or otherwise carried by the user while he or she is performing an athletic activity, such as running or walking.” (*Id.*, 7:63-67.) Device 207 sends collected data to device 205, which sends it to device 203. (*Id.*, 8:4-10.) Device 201 is shown below:

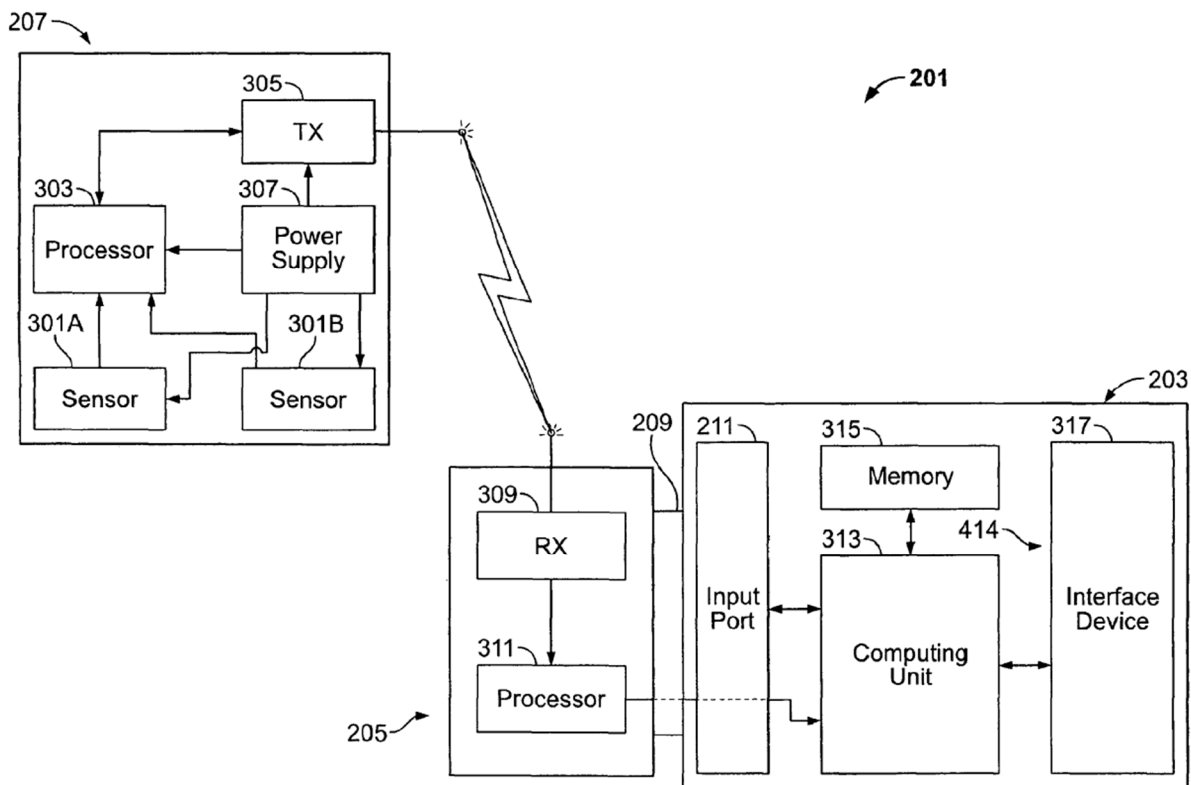


FIG. 3

(*Id.*, Fig. 3.)

26. The '256 patent's "athletic parameter measurement device 207 is worn or carried by the user ... and measures one or more athletic parameters relating to the athletic performance being performed by the user." (*Id.*, 7:67-8:4.) It includes "one or more sensors 301 for measuring an athletic parameter associated with a

person wearing” it, such as “piezoelectric accelerometers.” (*Id.*, 8:11-17.) The ’256 patent discloses a user wearing device 207 in “the sole of a user’s shoe 401.” (*Id.*, 8:19-24.)

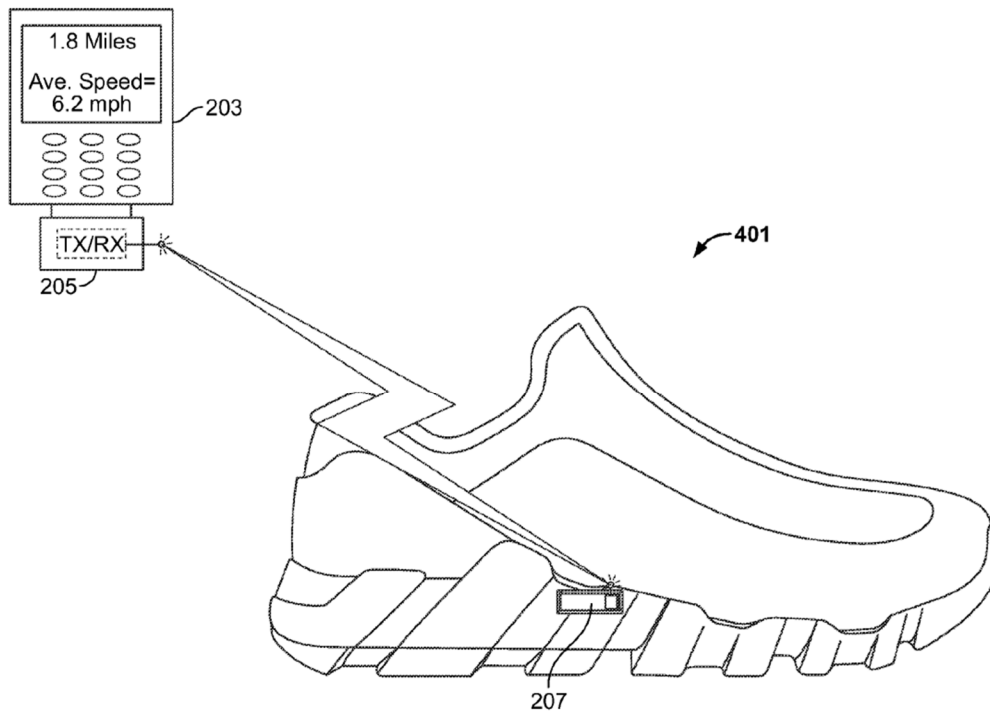


FIG. 4

(*Id.*, Fig. 4.) In another embodiment, “the invention may employ a ... watch or personal digital assistant that incorporates accelerometers ... for measuring athletic activity.” (*Id.*, 11:50-54.)

27. Athletic information collection and display device 501. Device 501 “collect[s] and/or display[s] athletic data” and “may be implemented using any suitable variation of the computing device 101” (*Id.*, 11:62-63, 12:2-3.) For example, it may be “commercially implemented using a desktop or laptop personal

computer using, e.g., a version of the Microsoft Windows operating system”

(*Id.*, 12:5-7.) Computing device 101 is shown below:

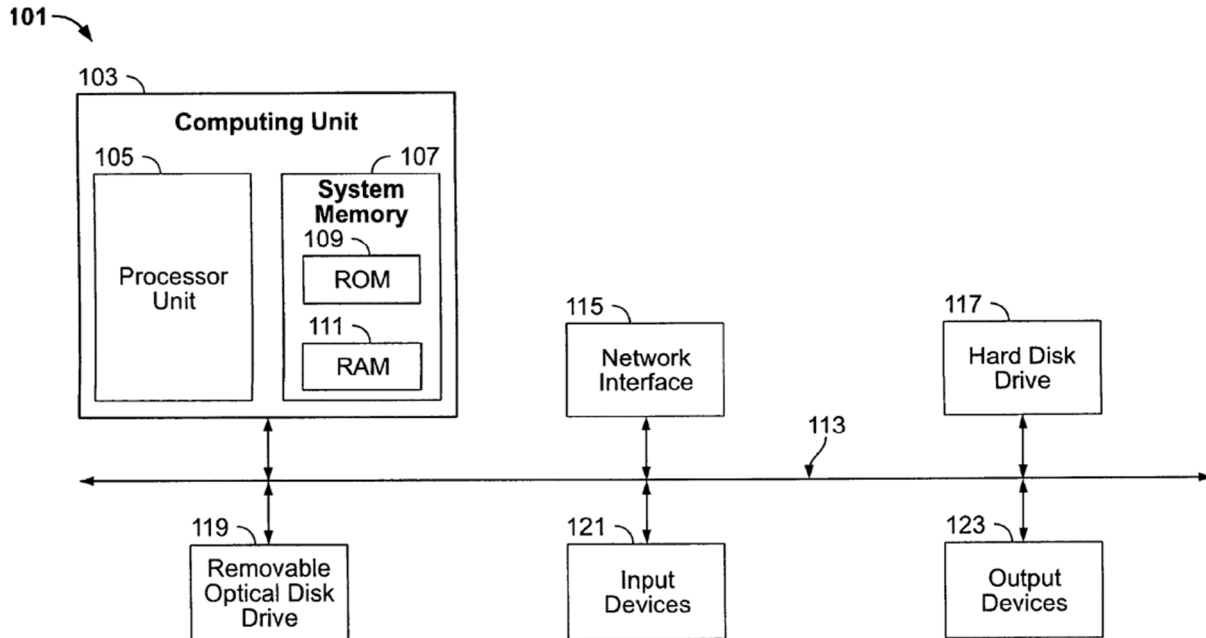


FIG. 1

(*Id.*, Fig. 1.)

28. Device 501 also includes an interface 503, an athletic data collection module 505, an interface module 507, an athletic data display module 509, and another interface 511:

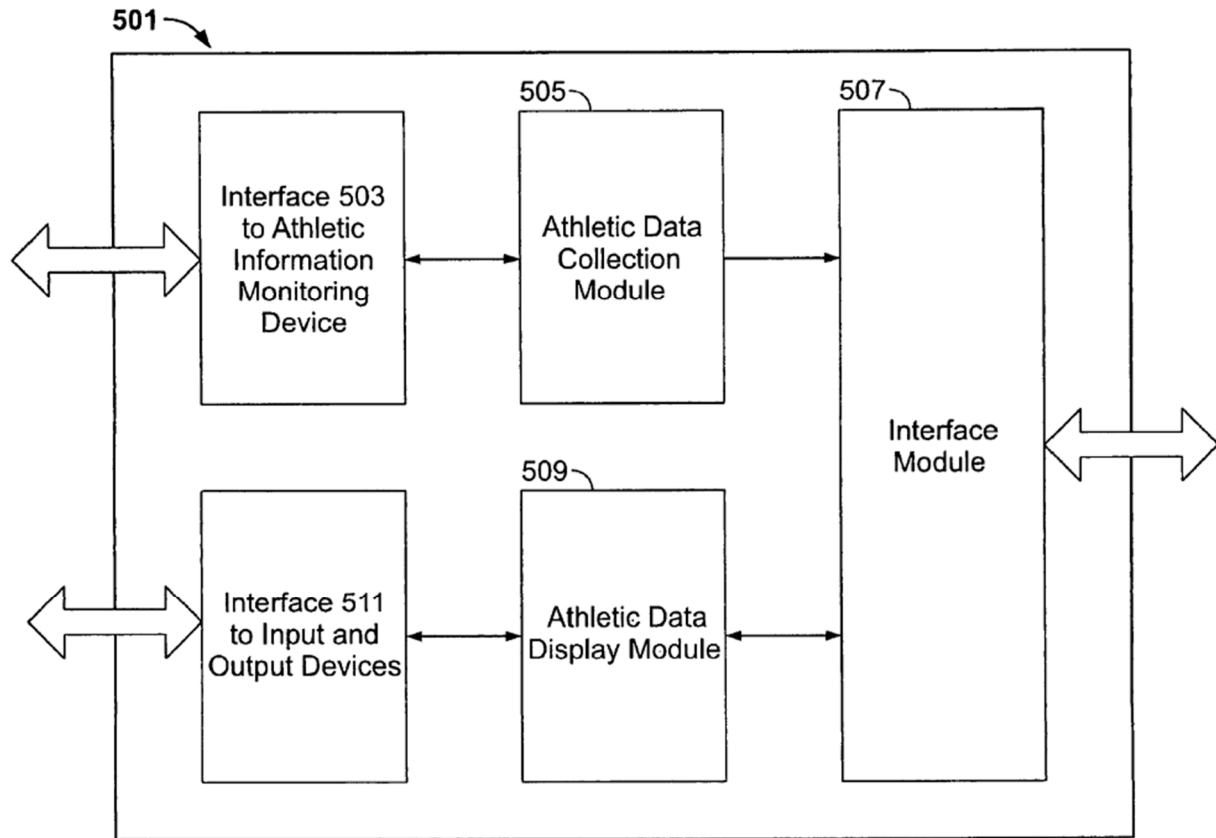


FIG. 5

(*Id.*, Fig. 5; *see also id.*, 11:62-65.)

29. Interface 503 can be hardware, software, or “some combination thereof.” (*Id.*, 12:15-17.) It receives “data from the athletic information monitoring device 201.” (*Id.*, 12:13-14.)

30. Athletic data collection module 505 “may be implemented by, for example, software instructions executed by a computing unit 113 of a computing device 101.” (*Id.*, 12:59-61.) It has a variety of functions, including detecting, establishing a communication session with, and retrieving data from device 203. (*Id.*, 12:19-27.) It can also process data received from device 203. (*Id.*, 12:31-41.)

31. “[T]he interface module 507 may be implemented using any conventional type of network interface, such as a network interface card.” (*Id.*, 13:15-17.) Interface module 507 allows device 501 to send athletic activity data to device 601: “[T]he athletic data collection module 505 transmits the athletic data set to an athletic data display configuration device 601 through an interface module 507.” (*Id.*, 13:9-11.)

32. Interface module 507 also allows device 501 to receive data from device 601. (*Id.*, Fig. 5.) The ’256 patent describes device 601 providing “configured athletic data to the athletic data display module 509 for display to the user.” (*Id.*, 14:51-52.)

33. Interface 511 “may be implemented using any desired combination of hardware and software components” (*Id.*, 14:6-9.) It receives a user’s request to view information about their athletic activity or the activities of others: “The display request is then provided to an athletic data display module 509 through a conventional interface input/output module 511.” (*Id.*, 14:3-6.)

34. Finally, “the athletic data display module 509 may be implemented using any conventional tool for receiving input to request and control the display of data, and then subsequently displaying the data in the manner requested.” (*Id.*, 14:13-17.) Such tools include “a conventional browser program, such as Microsoft Internet Explorer, Mozilla Firefox, or Opera executing on a computing unit 113.”

(*Id.*, 14:18-20.) Module 509 can also perform some or all of the data display configuration functions performed by the athletic data display configuration module 605. (*Id.*, 14:64-15:3.)

35. Athletic data display configuration device 601. As shown below, device 601 includes at least three parts: an interface 603, an athletic data display configuration module 605, and an athletic data storage 607:

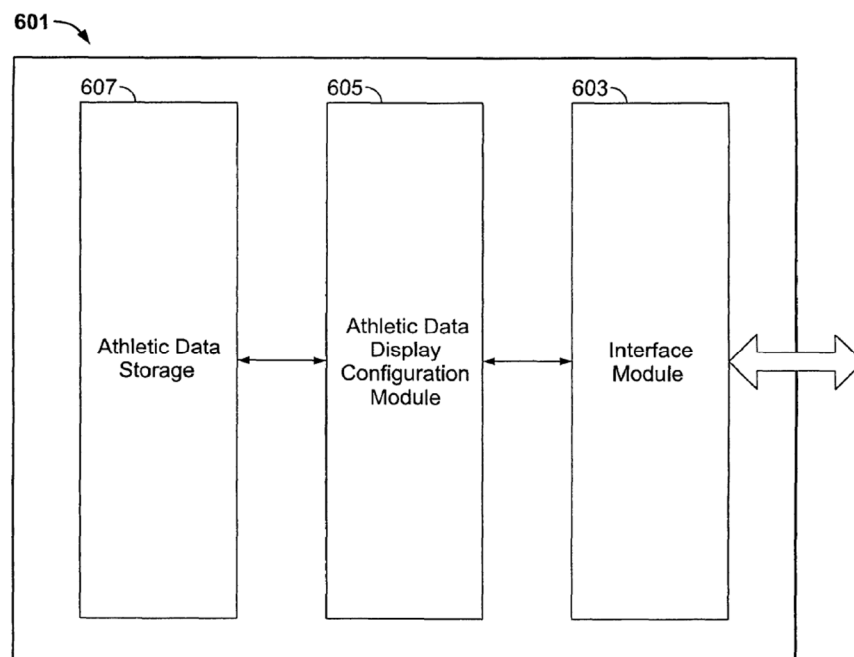


FIG. 6

(*Id.*, Fig. 6; *see also id.*, 13:34-36.) Interface module 603 “may be implemented using any conventional type of network interface, such as a network interface card[,]” (*id.*, 13:43-45), and “communicat[es] with the athletic information collection and display device 501[,]” (*id.*, 13:38-39.) Athletic data display

configuration module 605 moves user data to and from memory in athletic data storage 607 and configures the data for display to users. (*Id.*, 13:52-64.)

36. Device 601 is “[t]ypically ... implemented at a remote location from the athletic information collection and display device 501.” (*Id.*, 15:4-6.) It connects to device 501 through “an electronic communication network” such as “the Internet” (*Id.*, 15:6-12.) In one example, the ’256 patent describes device 601 connecting “a plurality of client devices 705 for collecting and/or displaying athletic data.” (*Id.*, 15:12-15.) It shows device 601 connecting to those devices via the Internet:

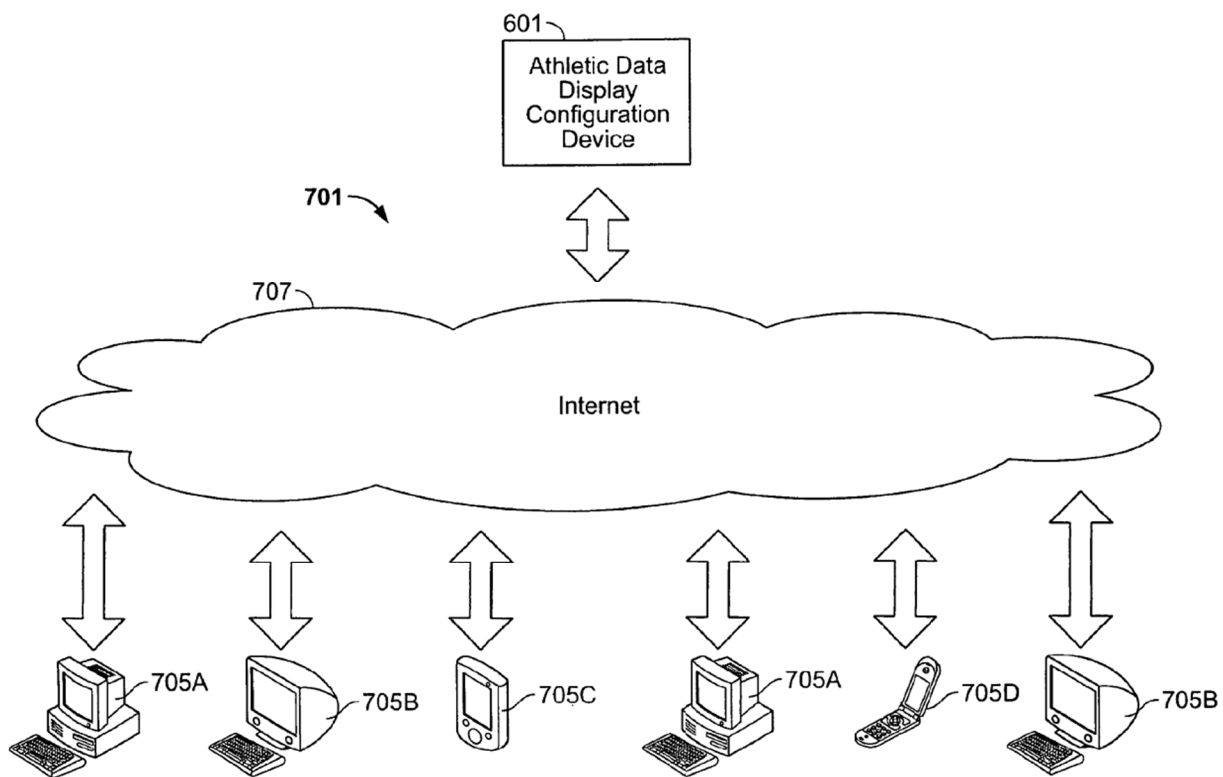


FIG. 7

(*Id.*, Fig. 7.) In other words, device 601 is a central computer that remotely connects to other computers over the Internet, e.g., a server. (*See also id.*, 7:42-46 (“Some

implementations of the invention, for example, may employ one or more computing devices that are intended to have a very specific functionality, such as a digital music player or server computer”).)

2. Challenges

37. The '256 patent discloses that the network formed from devices 201, 501, and 601, enables virtual competitions between athletes. For example, the '256 patent discloses challenges involving “who can run a specified distance first,” “who can run the most miles in a given period of time,” “who can make the fastest run in a given period of time,” and “who can run a specified distance in a given period of time.” (*Id.*, 22:9-10, 23:40-41, 24:14-15, 24:55.)

38. The '256 patent teaches that a user can propose a challenge by “requesting the user interface 1301 shown in FIG. 13A.” (*Id.*, 21:63-65.) A user can specify a challenge by selecting a button, such as “‘Distance Race’ button 1303” in the interface.

1301

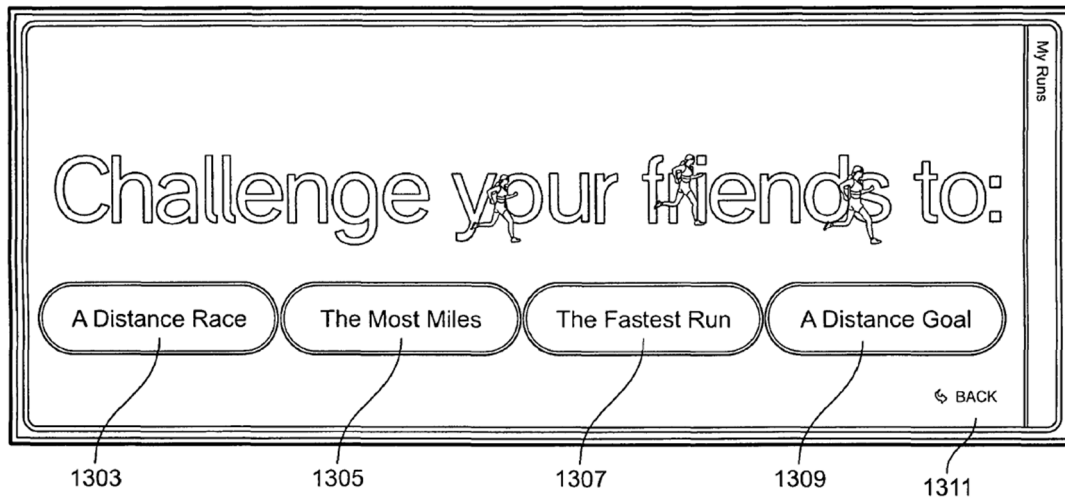


FIG. 13A

(*Id.*, Fig. 13A.) In response to a user selecting button 1303, “the athletic data display configuration module 605 configures the user interface 1301 to include a sub-interface 1313.” (*Id.*, 22:12-14.) That interface is shown below:

1301

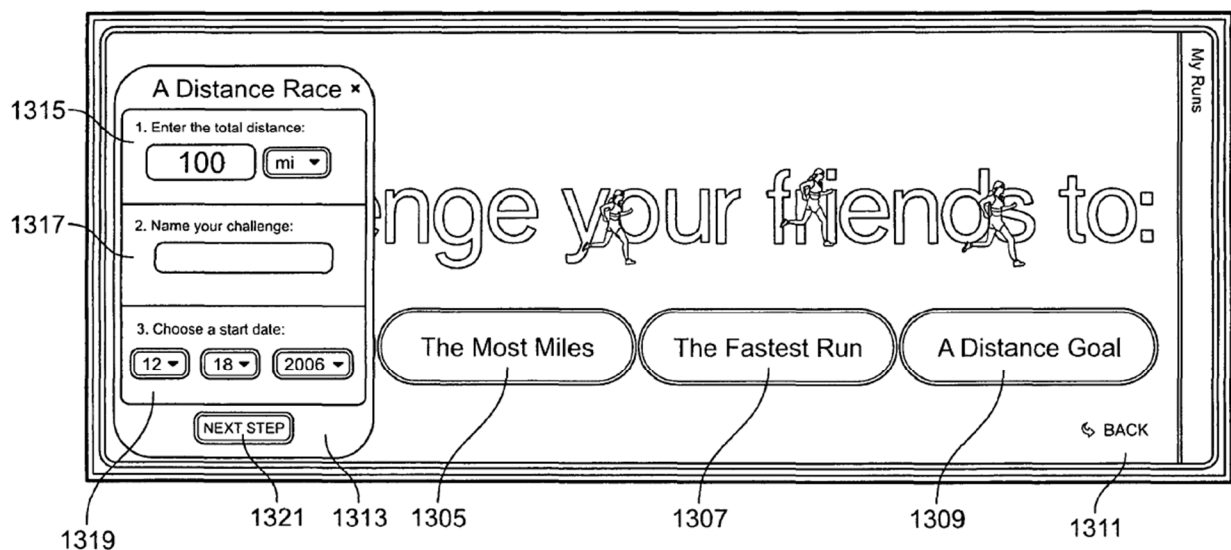


FIG. 13B

(*Id.*, Fig. 13B.) The user can then specify the challenge's distance, name, and date.

(*Id.*, 22:14-30.) After doing so, the user then “activates the ‘Next Step’ button 1321[,]” causing “module 605 [to] reconfigure[] the user interface 1301” again. (*Id.*, 22:37-41.)

39. After specifying a challenge, a user can then invite participants. As shown below, the user can “specify the email address for each person he or she wishes to invite to participate in the challenge.” (*Id.*, 22:46-49.)

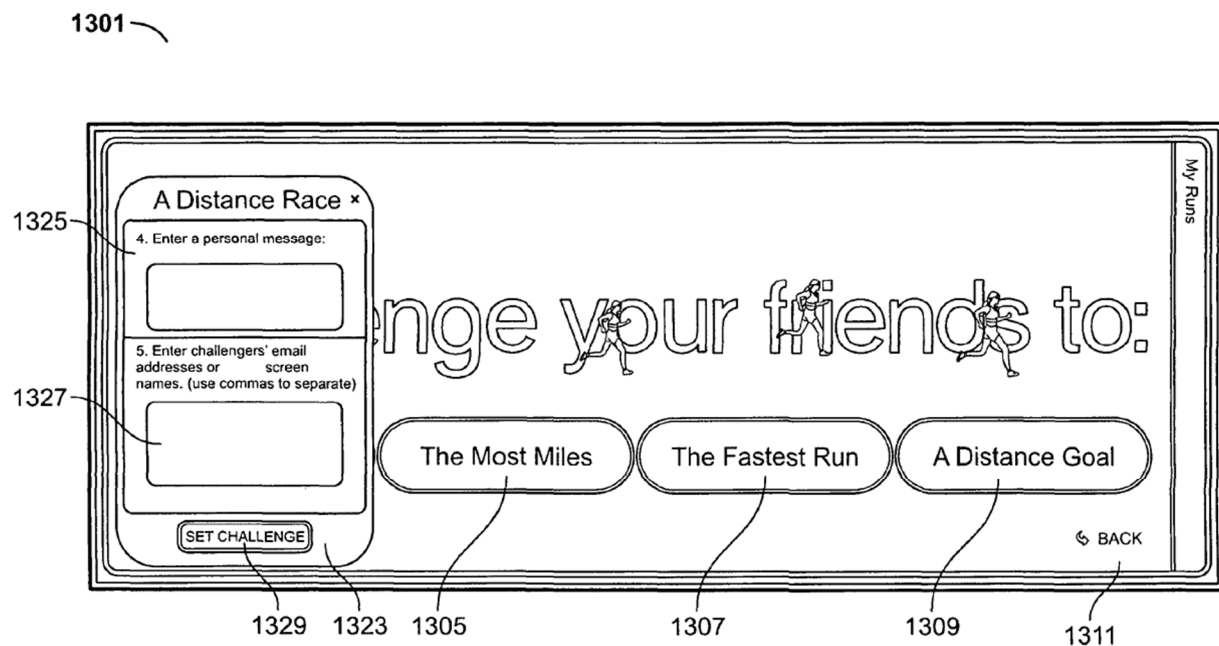


FIG. 13C

(*Id.*, Fig. 13C.) The user “initiate[s] the challenge by activating the ‘Set Challenge’ button 1329.” (*Id.*, 22:54-56.) In response, “the athletic data display configuration device 601 (or, with some implementations of the invention, the user’s athletic information collection and display device 501) sends an email to each of the

specified invitees.” (*Id.*, 22:56-61.) The email includes an “interactive prompt to join the challenge.” (*Id.*, 22:61-62.)

40. Once a challenge starts, “device 601 ... monitors the collected athletic data for each of the participants, and aggregates the relevant data values in the collected athletic data.” (*Id.*, 23:4-7.) Device 601 can, for example, “sum the total distance value in each data set collected for that participant after the start date.” (*Id.*, 23:10-12.) It determines the winner of the challenge by identifying the first “participant [with] a sum of his or her total distance values that matches or exceeds the specified challenge distance” (*Id.*, 23:12-16.) Device 601 notifies the participants of who won a competition by, for example, displaying a special-purpose interface. (*Id.*, 23:18-25.)

41. Device 601 also notifies participants of the status of a challenge in real-time. During a challenge, “device 601 may additionally provide updates regarding the status of a participant relative to the other participants.” (*Id.*, 23:26-29.) It can, for example, “configure and provide a user interface showing each participant’s progress toward the goal of the challenge using, e.g., bar graphs for each participant” (*Id.*, 23:33-38.)

C. '256 Patent Prosecution History

42. I reviewed the prosecution history of the '256 patent. (Ex. 1002.) I did not see anything in the prosecution history of the '256 patent that affected my opinions in this declaration.

V. Level of Skill in the Art

43. In my opinion, a POSITA for the technology of the '256 patent would have had (1) at least a bachelor's degree in engineering, computer science, industrial design, biomechanics, or a related field, and (2) at least two years of experience researching, developing, designing, and/or testing fitness or physiological sensors, wearable devices, physiological or biomechanical devices, remotely-controlled systems or interfaces, and/or network-based applications and/or equipment, or the equivalent experience or education.

44. The foregoing level of education and experience would have provided a POSITA with adequate background to understand the '256 patent's technology. As I explained above, the '256 patent describes a straightforward computer network that processes athletic activity data. Such a system would be familiar to a POSITA.

VI. Claim Construction

45. I have been instructed to perform my analysis with the understanding that the terms of the Challenged Claims should be afforded their plain and ordinary meaning. However, should Patent Owner and/or Patent Owner's expert choose to

construe additional claim terms or challenge the ones herein, I reserve the right to provide my opinion regarding Patent Owner's construction(s) as well as the meaning a POSITA would have ascribed to those claim terms.

VII. The Prior Art

46. I was asked to review each of Arrasvuori, Watterson, and Ellis, and provide a written description of my findings regarding each reference. I summarize my understanding of each reference below.

A. Arrasvuori

47. Arrasvuori is a United States Patent Application Publication numbered 2007/0239479. (Ex. 1005.) It is titled "SYSTEM AND METHOD FOR GAMING" and has a publication date of October 11, 2007. (*Id.*) In broad terms, Arrasvuori describes remote competitions involving "multi-player video game[s] ... wherein one or more players perform real-world fitness tasks" (*Id.*, ¶ 17.)

1. Network Architecture

48. Arrasvuori describes a computer network with multiple "wireless nodes." (*See, e.g.*, ¶ 18.) The wireless nodes can be computers: "[D]evices described herein may be and/or may incorporate computers." (*Id.*, ¶ 90; *see also, e.g.*, ¶ 19 ("wireless nodes and/or *other* computer" (emphasis added)).)

49. The wireless nodes can communicate with one another according to various protocols. (*See id.*, ¶¶ 37, 55, 91). For example, the wireless nodes can

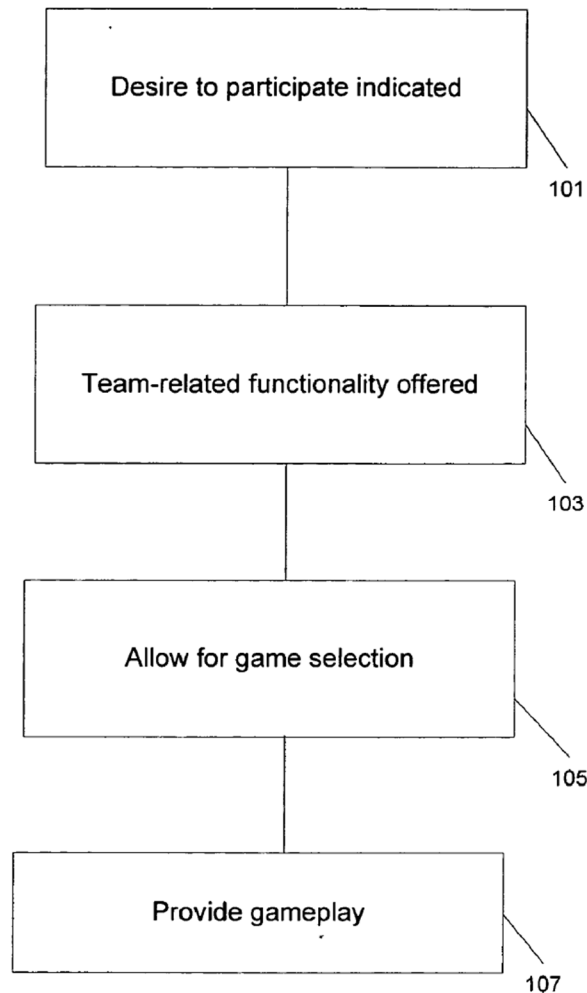
communicate over “WiFi ... and/or the Internet” where “[s]uch WiFi might, for instance, be IEEE 802.11b and/or IEEE 802.11g.” (*Id.*, ¶ 37.) IEEE 802.11 is a wireless local area networking standard that structures how a computer sends information over a local area network to, for example, an Internet router.

50. Arrasvuori’s wireless nodes can also communicate with servers. Arrasvuori discloses: “[V]arious of the above-discussed game initiation and game play operations might involve communication among one or more wireless nodes and/or other computers of users, and/or other wireless nodes and/or other computers (e.g., one or more servers).” (*Id.*, ¶ 37; *see also id.*, ¶¶ 55, 83, 89.)

51. In some cases, “servers might be operated by service providers” (*Id.*, ¶ 37.) A POSITA would have understood that “service providers” refers to companies that host servers remotely from user wireless nodes. In other cases, “one or more user wireless nodes and/or other computers might act as servers.” (*Id.*)

2. Game Initiation and Game Play Operations

52. Arrasvuori flowcharts its game initiation and game play operations in Figure 1:



(*Id.*, Fig. 1.)

a. Game Initiation Operations

53. Arrasvuori states: “[I]n various embodiments, a user’s wireless node and/or other computer might ... present her with a portal for viewing games available for play” (*Id.*, ¶ 34.) These games include multiplayer, virtual challenges in which users perform real-world fitness tasks, “include[ing] running, swimming, climbing, and/or use of exercise equipment.” (*Id.*, ¶ 13.) Users can form teams, (*id.*, ¶ 18), and can cooperate or compete against one another during challenges: “[U]sers

competing with and/or against one another might play at the same time and/or at different times[,]” (*id.*, ¶ 34.) As I explain further in section VII.A.3, below, Arrasvuori’s system monitors the status of the challenges and provides feedback to users, including by ranking users in leaderboards and by providing other interfaces. (*See id.*, ¶¶ 50-53; *see also id.*, ¶¶ 38-49, 54-55.)

54. At step 101 of game initiation and game play operations, “a user wishing to participate in a video game might indicate a desire to do so via her wireless node and/or other computer” (*Id.*, ¶ 17.) A user can select a “multiplayer video game and/or a video game wherein one or more players perform real-world fitness tasks in the context of the game.” (*Id.*)

55. At step 103, “the wireless node and/or other computer might offer team-related functionality to the user” (*Id.*, ¶ 18.) Arrasvuori describes exemplary team-related functionalities in its paragraph 18. (*See id.*)

56. At step 105, “the wireless node and/or other computer might allow for selection of one or more games to play” (*Id.*, ¶ 20.)

57. Arrasvuori teaches that “various of the above-discussed game initiation and game play operations might involve communication among one or more wireless nodes and/or other computers of users, and/or other wireless nodes and/or other computers (e.g., one or more servers).” (*Id.*, ¶ 37.) A POSITA would have understood from this disclosure that, at least in some embodiments, a user’s wireless

node sends the user's step 101 indication of desire to participate and the user's step 105 selection of one or more games to a server.

b. Game Play Operations

58. At step 107, "the wireless node and/or other computer might provide game play functionality to the user ... [s]uch functionality might be implemented in a number of ways." (*Id.*, ¶ 23.) Arrasvuori describes one example of game play functionality in paragraph 36 of its specification: "[U]sers might be presented with real-world fitness tasks in the context of a game-world athletic competition." (*Id.*, ¶ 36.) It continues: "Users might ... be able to select ... the order in which they performed the fitness tasks" during a triathlon. (*Id.*) It states: "[S]uch information regarding such an indication might be communicated from a user's wireless node and/or other computer to a server." (*Id.*; *see also id.*, ¶ 37.)

c. Obvious Modifications to Game Initiation and Game Play Operations

59. Obvious Modification #1. I was asked to consider, alternatively, if Arrasvuori does not disclose a server receiving a user's selection of a challenge in any of steps 101, 105, and 107, whether it would have been obvious to configure Arrasvuori's server to receive those selections. In my opinion, this would have been obvious for the reasons I set forth below.

60. Arrasvuori's disclosure of multiplayer video games would have motivated a POSITA to configure Arrasvuori's server to receive the user selections.

(See *id.*, ¶¶ 2, 13, 17, 24, 36.) A POSITA would have understood that, at least in some embodiments, a server hosts Arrasvuori's multiplayer video games. Arrasvuori implies that its system uses this common architecture in paragraph 36 of its specification: "such information regarding an indication might be communicated from a user's wireless node and/or other computer to a server." (*Id.*, ¶ 36.) It does so again in paragraph 37 of its specification: "[V]arious of the above-discussed game initiation and game play operations might involve communication among one or more wireless nodes and/or other computers of users, and/or other wireless nodes and/or other computers (e.g., one or more servers)." (*Id.*, ¶ 37.) But even if Arrasvuori did not disclose this architecture, it would have been obvious for a POSITA to configure a server to host the multiplayer video games for the reasons I identify in paragraphs 73-77 of my report. (*Infra* ¶¶ 73-77.)

61. A POSITA would have recognized that a server hosting a multiplayer video game needed to know which game or task a user wanted to play or perform before it could provide the user with access to that game or task. A POSITA therefore would have been motivated to provide the user's selection(s) of a video game and/or tasks from steps 101, 105, and 107 to the server. Doing so would have been trivial because, as Arrasvuori explains in paragraph 37 of its specification, user wireless nodes already communicate with "one or more servers." (*Id.*, ¶ 37.)

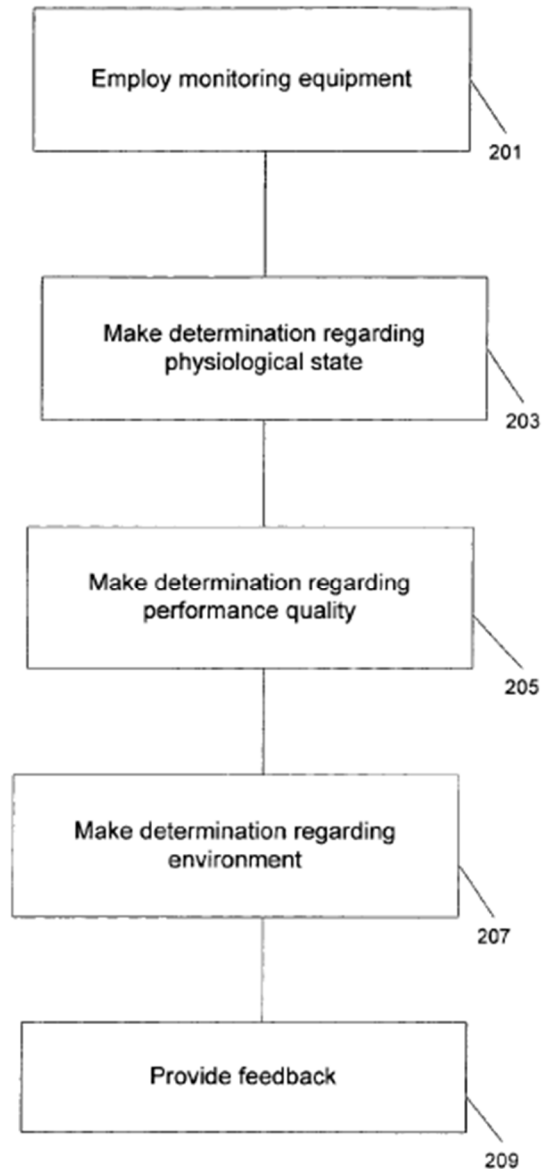
62. Obvious Modification #2. I was also asked to consider whether, if Arrasvuori does not disclose prompting its users to participate in challenges, it would have been obvious to configure Arrasvuori's system to do so. As I have already explained, Arrasvuori discloses that "a user's wireless node and/or other computer might ... present her with a portal for viewing games available for play ...[,]" (*id.*, ¶ 34), and that users "might be presented with real-world fitness tasks in the context of a game-world athletic competition," (*id.*, ¶ 36; *see also id.*, ¶¶ 25-29.) Arrasvuori further discloses: "[T]he user might ... via a GUI and/or other interface[] be informed that she has been made a member of, been offered membership in, and/or is able to request membership in one or more teams made up of ... other users wishing to play one or more of those games." (*Id.*, ¶ 22; *see also id.*, ¶ 18.) A POSITA would have understood that presenting a user with games available for play, indicating specific fitness tasks, and informing a user of membership in, offering a user membership in, and/or informing a user of their ability to request membership in a team preparing to play a game all constitute prompting a user to participate in a challenge. (*See id.*, ¶¶ 18, 22, 34, 36.) Nevertheless, assuming for the sake of argument that Arrasvuori does not disclose prompts, it would have been obvious to configure Arrasvuori's system to issue prompts for the reasons I set forth below.

63. A POSITA would have been motivated to configure Arrasvuori's wireless nodes to prompt users to participate in challenges to shorten the waiting time between a user's selection of a challenge and the start of a challenge. Imagine, for example, that a user indicates their desire to participate in a challenge that requires 10 users. Prompting users to select that challenge rather than waiting for users to independently select it would likely shorten how long it would take to accrue 10 users for the challenge.

64. Configuring the wireless nodes to prompt users to participate in challenges would have been trivial. Arrasvuori already discloses sending invitations to its users: "The wireless node and/or other computer might, for instance, allow the users ... to invite one or more users to join one or more new and/or existing teams" (*Id.*, ¶ 18.) A POSITA would have reasonably expected that they could configure Arrasvuori's wireless nodes to issue similar invitations to join challenges.

3. Monitoring and Feedback Operations

65. Arrasvuori summarizes its monitoring and feedback operations in Figure 2, shown below.



(*Id.*, Fig. 2.)

a. Monitoring Operations

66. Step 201 of monitoring and feedback operations is “[e]mploy monitoring equipment.” (*Id.*, Fig. 2.) Arrasvuori describes using “monitoring equipment,” i.e., sensors, to collect athletic activity data from users while they perform “real-world fitness tasks.” (*Id.*, ¶¶ 38, 39.) That equipment includes

“Global Positioning System (GPS) hardware ... Radio Frequency Identification (RFID) tag interface hardware ... heart rate meter hardware . . . electrocardiogram hardware ... pedometer hardware ... [or] skin conductance measuring hardware” (*Id.*, ¶ 40.) The monitoring equipment can be “integrated into” user wireless nodes or it can be separate from them. (*Id.*, ¶ 39; *see also id.*, ¶ 38 (“Monitoring might, for example, be performed by one or more wireless nodes and/or other computers (e.g. servers, and/or wireless nodes and/or other computers of users)”).)

67. Arrasvuori describes how its monitoring equipment measures user athletic activity. It discloses “monitoring and/or ascertaining geographical locations” with “GPS[] hardware” (*Id.* ¶ 40.) A POSITA would have known how to use GPS hardware to detect how far a user ran in miles. Arrasvuori also discloses “monitoring and/or ascertaining ... number of steps taken and/or distance traveled” with “pedometer hardware.” (*Id.*) A POSITA would have known how to use a pedometer to determine how far a user ran in miles. (*See, e.g.*, Ex. 1009, 39:59-63 (describing calibration process for pedometer in which pedometer “calculates a measured distance (e.g., ‘3.1 miles’) based on measured foot contact times and the initial value of [a variable]”).)

68. Arrasvuori discloses that monitoring “might involve communication among multiple wireless nodes and/or other computers (e.g., between a user wireless node and/or other computer and a server).” (*Id.*, ¶ 38; *see also id.*, ¶ 55.) This makes

sense: where the monitoring equipment is integrated into the wireless node, for example, the wireless node would need to send that data to the server for the server to receive it. (*See id.*, ¶ 40 (“data so monitored and/or ascertained might, for instance, be stored (e.g., at a server) and/or mapped to video game parameters”).) The wireless nodes can communicate across “WiFi ... and/or the Internet,” among other options. (*Id.*, ¶ 37; *see also id.*, ¶¶ 90-91.) Arrasvuori states: “Such WiFi might, for instance, be IEEE 802.11b and/or IEEE 802.11g.” (*Id.*, ¶ 37.)

69. Arrasvuori also discloses that its system can monitor user performance in real time. Arrasvuori discloses that “in various embodiments, real-time feedback might be provided.” (*Id.*, ¶ 49.) That feedback “might, for example, be performed by one or more wireless nodes and/or other computers (e.g., servers, and/or wireless nodes and/or other computers of users), and/or might take into account various monitoring.” (*Id.*) A POSITA would have understood that providing real-time feedback based on monitoring requires real-time monitoring.

b. Feedback Operations

70. In Steps 203 and 205 of monitoring and feedback operations, Arrasvuori’s server interprets user data to determine whether a challenge was met. Steps 203 and 205 are “[m]ak[ing] [a] determination regarding physiological state” and “[m]ak[ing] [a] determination regarding performance quality,” respectively. (*Id.*, Fig. 2.) Arrasvuori states: “Such determinations might, for instance, be

performed by user wireless nodes and/or other computers, and/or by other wireless nodes and/or other computers (e.g., by one or more servers).” (*Id.*, ¶ 41.) A POSITA would have understood from these disclosures that a server can determine a user’s physiological state and performance quality.

71. Step 207 of monitoring and feedback operations is “[m]ake determination regarding environment.” (*Id.*, Fig. 2.) Arrasvuori describes this step in paragraph 47 of its specification. (*Id.*, ¶ 47.)

72. Step 209 of monitoring and feedback operations is “[p]rovide feedback.” (*Id.*, Fig. 2.) Feedback includes “leaderboards” that “show the performance of users with respect to other users” (*Id.*, ¶ 50.) It also includes depictions of “users that are performing and/or that have performed the real-world fitness task ... positioned relative to one another [and/or] a goal corresponding to the task” (*Id.*, ¶ 52.) Arrasvuori states that the server can provide this feedback: “Feedback operations might, for example, be performed by one or more wireless nodes and/or other computers (e.g., servers, and/or wireless nodes and/or other computers of users), and/or might take into account various monitoring.” (*Id.*, ¶ 49; *see also id.*, ¶ 50.) It further describes presenting the feedback to users via “one or more GUIs and/or other interfaces provided by wireless nodes and/or other computers of users.” (*Id.*, ¶ 52.) Feedback can be “real-time.” (*Id.*, ¶ 49.) A POSITA would have understood from these disclosures that Arrasvuori’s server can

generate and communicate leaderboards and graphics to users depicting user progress towards goals in real time, i.e., as the server generates them.

c. Obvious Modifications to Monitoring and Feedback Operations

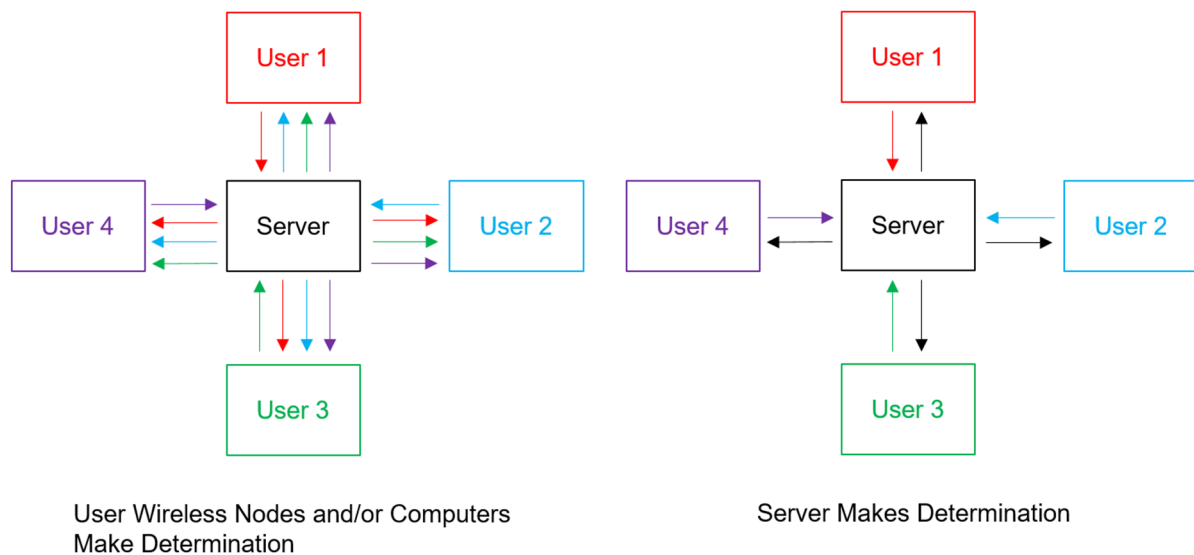
73. I was asked to consider whether, if Arrasvuori did not disclose centralizing the functions of determining the status of a competition and generating feedback at a server, it would have been obvious to do so. In my opinion, this configuration would have been obvious for the reasons I set forth below.

74. Arrasvuori discloses a network including two classes of devices: (1) “user” wireless nodes and/or other computers and (2) “other” (not “user”) wireless nodes and/or other computers (e.g., one or more servers). (*See, e.g., id.*, ¶ 37.) Thus, there are two candidates for what performs each of the determining and generating steps: (1) user wireless nodes and/or computers or (2) wireless nodes and/or computers not associated with individual users. In this latter category are “servers [that] might be operated by service providers.” (*Id.*, ¶ 37.)

75. Centralizing data processing at a server has obvious advantages over duplicating data processing throughout a network. One major advantage is that doing so can conserve communication and computing resources. Imagine that Arrasvuori’s network includes four wireless nodes (Users 1-4) and a server through which the nodes communicate, as illustrated in the figure below. If each of the four wireless nodes determined whether a challenge was met and generated feedback

showing the challenge status, then each node would have to receive raw performance data from every other node and separately perform the computation. Alternatively, if the server determined whether a challenge was met and generated the feedback showing the challenge status, then this computation would only have to be performed once, at the server. This would reduce the processing required of each wireless node and/or computer. Also, performing the computation at the server would eliminate sending raw performance data from every node to every other node. In view of these advantages, in my opinion, a POSITA would have been motivated to centralize data processing at a server.

76.



77. In my opinion, a POSITA would have reasonably expected this configuration to succeed. Based on my own experience designing computer networks, centralizing data processing at a server was well understood by 2008. In

addition, Arrasvuori already discloses that a server can perform monitoring and feedback operations. (*See, e.g., id.*, ¶¶ 38, 41, 49, 50.)

4. Compensatory Operations

78. Arrasvuori describes normalizing how its system determines and displays user performance in “Compensatory Operations.” (*See id.*, ¶ 56.) “Such compensatory operations might, for example, be performed by one or more wireless nodes and/or other computers (e.g., servers, and/or wireless nodes and/or other computers of users).” (*Id.*) According to Arrasvuori, one benefit of compensatory operations is “allowing for easier comparison between real-world fitness task performance by different users” (*Id.*, ¶ 57.)

79. Arrasvuori discloses: “[C]ompensatory operations might, for example, take into account one or more fitness levels of users performing real-world fitness tasks” (*Id.*) Those fitness levels could include “cardiovascular fitness, strength fitness, aerobic fitness, and/or sport-specific fitness” (*Id.*)

80. For example, Arrasvuori explains that its compensatory operations can normalize a competitor’s score according to the competitor’s physical fitness level:

[T]ak[ing] into account one or more fitness levels of the user such that performance of the task in a certain manner would yield a higher score in the case where one or more lower fitness levels were associated with the user and/or would yield a lower score in the case where one or more

higher fitness levels were associated with the user. As an illustrative example, in the case where overall fitness was to be taken into account in scoring and the real-world fitness task was to run a certain distance, in the case where two users ran the distance in the same amount of time the user associated with the lower overall fitness level might receive the higher score.

(*Id.*, ¶ 59.)

81. Alternatively, Arrasvuori explains, the compensatory operations can normalize a simulation of a competitor's progress during a virtual competition according to the competitor's physical fitness level:

[P]rovision of display wherein graphical indicators corresponding to users are positioned relative to one another, a goal, and/or a route might take into account one or more fitness levels of a user such that performance of the task in a certain manner would result in greater progress being depicted by the display in the case where one or more lower fitness levels were associated with the user and/or would result in lesser progress being depicted by the display in the case where one or more higher fitness levels were associated with the user. As an illustrative example, in the case where overall fitness level was to be taken into account in display and the real-world fitness task involved

running, in the case where two users performing the real-world fitness task each traveled the same real-world distance within a certain elapsed time, the user associated with the lower overall fitness level might be depicted as having gone further.

(*Id.*, ¶ 60.)

82. Arrasvuori discloses determining user “fitness levels” via “fitness tests” (*Id.*, ¶ 80.) Specifically, it discloses “Cooper Tests, step tests, cardiac stress tests, maximal oxygen uptake tests” and others. (*Id.*, ¶ 81.) “Administration of a fitness test might, for instance, involve the use of monitoring (e.g., of the sort discussed above)” (*Id.*, ¶ 82.) Arrasvuori states: “[I]n various embodiments, various data to be employed in fitness test administration might be ... recorded from users. Such data might, for instance, include ... target heart rate range” (*Id.*, ¶ 84.)

B. Watterson

83. Watterson is a United States patent numbered 6,458,060. (Ex. 1006.) It is titled “SYSTEMS AND METHODS FOR INTERACTION WITH EXERCISE DEVICE” and issued on October 1, 2002. (*Id.*)

1. Network Architecture

84. Watterson discloses a system 250 in which user modules 252a-252n communicate with a central communication module 254 through a network 16. (*Id.*, 29:28-29; *see also id.*, 6:28-30.)

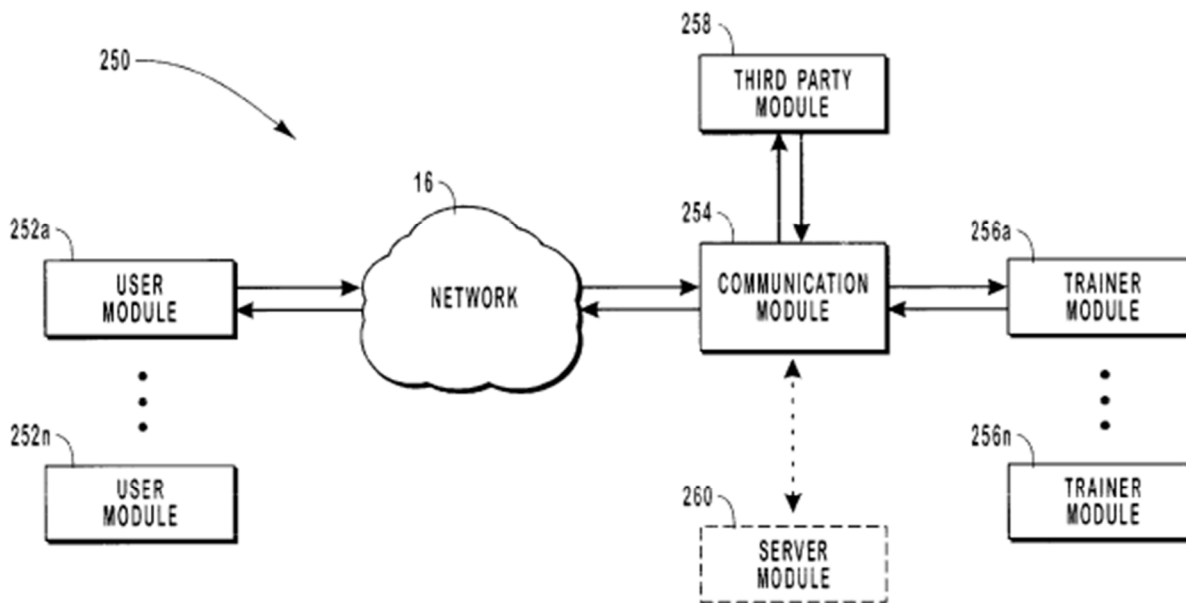


FIG. 10

(*Id.*, Fig. 10; *see also id.*, 27:58-60.)

85. “User modules 252a-252n may take the form of various other devices ... includ[ing] treadmill 12.” (*Id.*, 28:67-29:3.) Watterson teaches that “[t]readmill 12 ... includes one or more sensors, such as a belt speed sensor 230 and incline sensor 343.” (*Id.*, 25:10-12.) The sensors can also “gather various other operating parameters, such as but not limited to, maximum pulse and heart rate, average pulse

and heart rate, target heart rate, length of workout session, and the like.” (*Id.*, 25:17-20; *see also id.*, 31:5-6, 31:30-35.)

86. “[C]ommunication module 254 may act as and take the form of a server, with associated hardware and/or software modules to enable communication between the various modules of the illustrated system 250.” (*Id.*, 30:50-53.) Watterson states: “As a user exercises, control module 274 tracks the active status of the movable element of exercise module 264 to determine whether the user is continually exercising.” (*Id.*, 34:3-6.) As shown below in Watterson’s Figure 11, exercise module 264 is part of user module 252 and control module 274 is part of communication module 254:

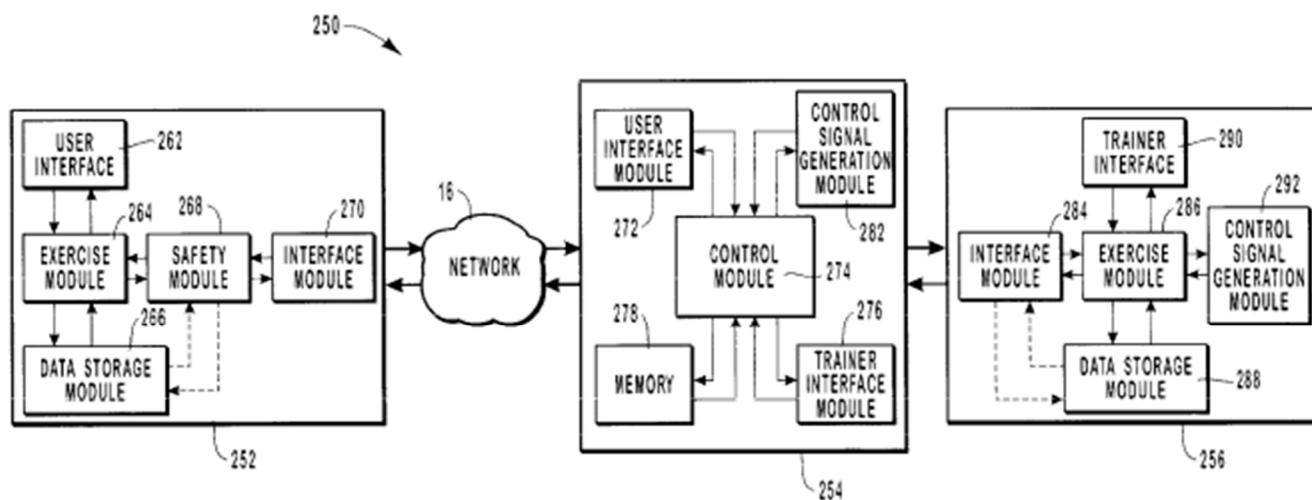


FIG. 11

(*Id.*, Fig. 11.)

87. One of communication module 254's functions is intermediating between user modules 252a-252n during competitions. Watterson discloses: "[A]ctivation of the connection with network 16 and/or communication system 18 **enables** one or more users to interact with one another, and optionally compete one against another as shall be described in detail hereinafter." (*Id.*, 10:48:51 (emphasis added); *see also* 29:30-33 ("communication module 254 has a similar configuration to that of communication system 18").) In a live competition embodiment, for example, Watterson teaches that "each competitor enters a private room to begin the race and to synchronize ***each competitor's exercise device with communication module 254*** and each other" (*Id.*, 41:57-60 (emphasis added).) A POSITA would have understood from these disclosures that Watterson's communication module 254 connects user modules 272a-272n during a competition.

88. Later disclosure in Watterson confirms that communication module 254 intermediates between user modules 272a-272n. After describing various competition embodiments, Watterson states:

It may be appreciated by one skilled in the art that competition module 314 may have various other configurations. For example, the functionality of competition module 314 may be incorporated within user modules 252a-252n. As such, two or more user modules 252a-252n may be in direct communication one with another, without the aid

of communication module 254, and the internal modules of user modules 252a-252n enable competition data to be transceived between the user modules 252a-252n.

(*Id.*, 42:56-64.) By disclosing that communication module 254 does not intermediate between user modules 252a-252n in an alternative configuration, Watterson confirms that communication module 254 does intermediate between user modules 252a-252n in its default configuration.

2. Competitions

89. Watterson's communication module 254 lets users compete against one another in athletic competitions. Watterson states: "[C]ommunication module 254 ... includes, in one embodiment, an iFit.com website 300" (*Id.*, 35:6-10.) The iFit.com website 300 includes a "personal training module 312" and a "competition module 314" (*Id.*, 35:26-32.) Competition module 314 enables one or more individuals to engage in competitive exercise programming with one another" (*Id.*, 40:18-21.)

90. Watterson's competition module 314 hosts three different race types: "race around the world 402, race against the computer 404, and personalized race 406[.]" (*Id.*, 40:32-36.)

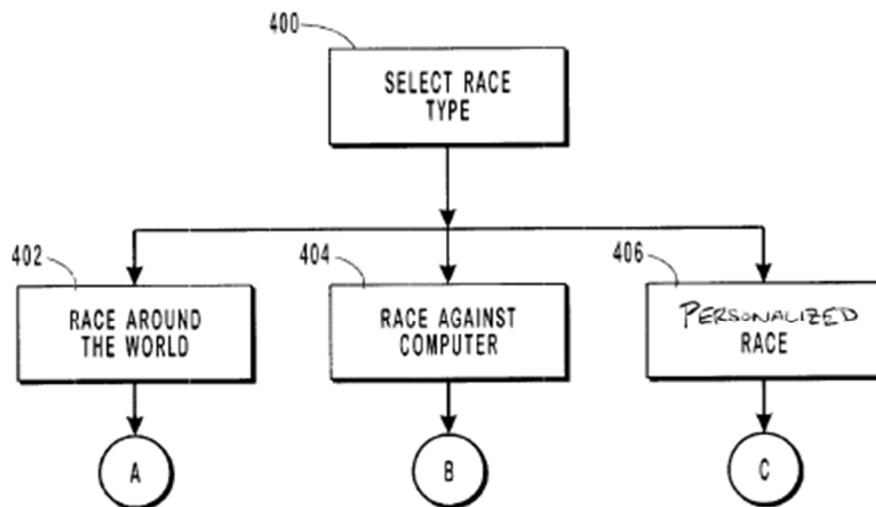


FIG. 17A

(*Id.*, Fig. 17A.)

91. Race around the world. In Watterson’s race around the world, “an individual races against various other individuals to determine who will run around the world in the shortest time.” (*Id.*, 40:39-40.) Watterson explains: “Communication module 254 tracks the exercising activities of competing users of user modules 252a-252[n] and computes the distance traveled per exercise session and per user.” (*Id.*, 40:40-43.)

92. Watterson discloses that competitors in a race around the world can view their progress against other competitors. “Once competition module 314 selects the stored statistical information [of a competitor], such information may be compared against other competitors in the race” (*Id.*, 40:53-56.) Then, “[c]ompetition module 314 may deliver comparison data to communication module

254.” (*Id.*, 40:56-57.) After that, “communication module 254 may deliver a graphical representation of the user’s exercise distan[ce], times, speed, and other information compared against other competitors to the user via user module 252a-252n.” (*Id.*, 40:58-61.) Watterson emphasizes: “Again, communication module 254 tracks the distance traveled of each competitor and may provide graphical representations of the position of one competitor against the other competitors.” (*Id.*, 41:15-18.) Thus, for Watterson’s race around the world, A POSITA would have understood that communication module 254—including competition module 314—determines a user’s position in a race, creates a graphical representation of that position, and provides that graphical representation to a competitor.

93. Personalized race. Watterson discloses: “In the personalized race, two or more individuals schedule a live on live session, such as in a private room of personal training module 312 where they may race against the other, while viewing graphical representations of the distan[ce], time, and speed of the other competitors.” (*Id.*, 41:43-48.) “For example, the display may include a racing track that shows a relative position of each competitor one with another, or a trail that each competitor races along.” (*Id.*, 42:3-6.)

94. A POSITA would have understood that Watterson’s communication module 254 and user interface module 272 receive competitor data from user modules 272a-272n during a personalized race in real time. As I explained above,

Watterson discloses that communication module 254 intermediates between user modules 252a-252n. (*Supra* ¶¶ 87-88.) Thus, for communication module 254 to provide users modules with “graphical representations of the distance, time, and speed of other competitors,” during a “live on live session,” communication module 254 necessarily receives user data in real time. Communication user interface module 272 also necessarily receives the same data in real time because it is the part of communication module 254 that receives data from user modules 252a-252n. (*See id.*, 33:33-44.)

3. Obvious Modifications to Watterson’s System

95. Watterson discloses that competitors in a personalized race can “race one against the other, while viewing graphical representations of the distance, time, and speed of the other competitors” during a “live on live session” (*Id.*, 41:44-48.) Unlike for the race around the world, however, Watterson does not specify which of user modules 252a-252n and communication module 254 (1) calculates performance metrics from user athletic activity data, (2) determines the status of the race, and (3) generates the graphical representation showing the status of the race. (*Compare id.*, 40:37-25 (race around the world) *with id.*, 41:42-42:55 (personalized race).) In my opinion, it would have been obvious to configure communication module 254 to perform each of those functions.

96. Obvious Modification #1. As I explained above in paragraphs 87-88, during competitions, communication module 254 intermediates between user modules 252a-252n. A POSITA therefore would have understood that either user modules 252a-252n or communication module 254 calculates any user performance metrics during a personalized race. For instance, a POSITA could have configured communication module 254 to calculate total distance run during a personalized race by (1) summing distance values determined by multiplying instantaneous speed values by corresponding time intervals and/or (2) multiplying average user speed by time.

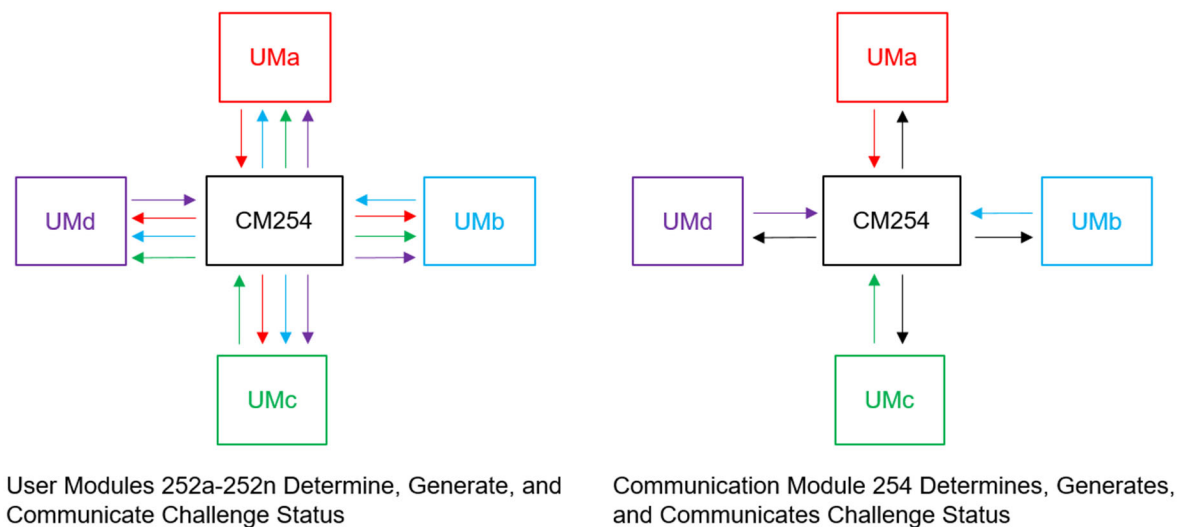
97. This configuration would have been obvious. Watterson discloses that communication module 254 already calculates distance values during a race around the world: “Communication module 254 tracks the exercising activities of competing users of user modules 252a-252b [*sic*, 252n] and computes the distance traveled per exercise session and per user[.] A running total of the distance traveled is maintained and updated.” (*Id.*, 40:40-44.) It also discloses that communication module 254 records average speed during a race around the world. (*See id.*, 40:51-53 (“The statistical information may include, but is not limited to ... average speed of the user ...”), 41:5-8 (“As the user exercises, communication module 254 records new statistical information for the user ...”).) Because communication module 254 already computes distance during a race around the world, and because there was no

reason to configure the system differently for the personalized race, a POSITA would have been motivated to reuse communication module 254 to compute distance in the personalized race. Further, because communication module 254 already computes distance during a race around the world, configuring Watterson's software to compute distance during a personalized race would have been trivial.

98. Obvious Modification #2. It would have been obvious to centralize determining the status of the race and generating the user interface showing the status of the race at communication module 254 for at least two reasons. First, centralizing these functions at communication module 254 would avoid duplicating functionality into user modules 272a-272n that already exists in communication module 254. Watterson already discloses that communication module 254 (and its sub-modules) performs both of the determining and generating functions in the race around the world embodiment. (*See id.*, 40:53-57 (determining race status), 40:58-61 (providing graphical representation of race status to users).) By configuring communication module 254 to perform these functions in the personalized race embodiment, a POSITA could reduce the processing power required by each user module and thereby conserve resources.

99. Second, centralizing the determining and generating functions at communication module 254 would have made Watterson's system more efficient than distributing them throughout user modules 252a-252n. If user modules 252a-

252n performed the determining or generating steps, every user module 252a-252n would have had to receive every other user's athletic activity data, determine the status of the competition, process the data into graphical representations of the same, and then display those graphical representations to the user. Alternatively, if communication module 254 performed each step, each user module 252a-252n would only have had to receive communication module 254's graphical representation of the competition's status and display the same to the user. These scenarios are shown below:



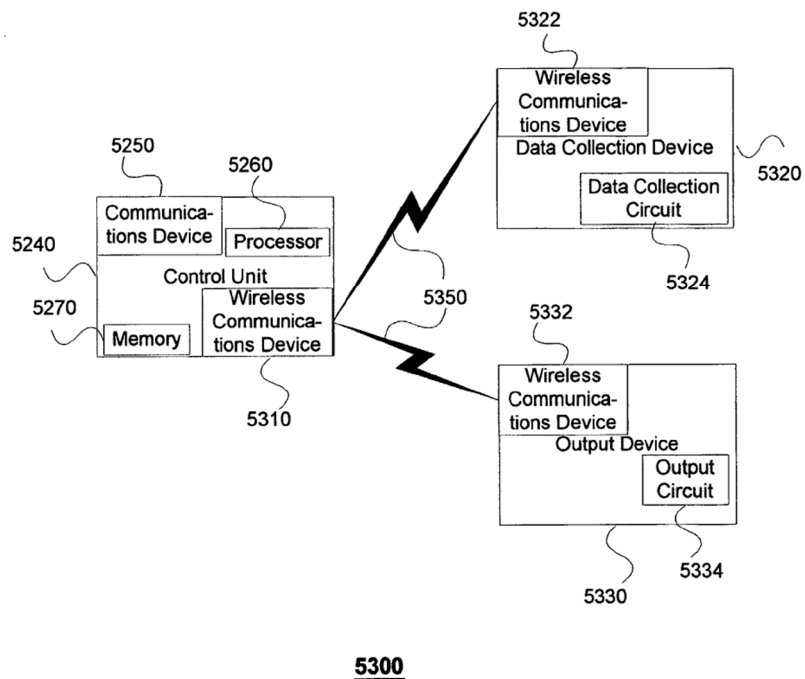
100. In my opinion, a POSITA would have reasonably expected this configuration to succeed. Based on my own experience designing computer networks, centralizing data processing at a server was well-understood by 2008. In addition, as I explained above, Watterson already discloses that communication module 254 can perform these functions. (*See id.*, 40:53-57, 40:58-61.)

C. Ellis

101. Ellis is an international patent publication numbered WO 02/067449. (Ex. 1007.) It is titled, “MODULAR PERSONAL NETWORK SYSTEMS AND METHODS” and was published on August 29, 2002. (*Id.*)

102. Ellis discloses, among other embodiments, “a system that can work with another system to provide a competition between multiple athletes.” (*Id.*, 3:31-32.) It teaches “a “modular personal network (MPN)” consisting of “multiple individual network components (INC)s, each of which may have one or more primary functions.” (*Id.*, 25:2-5.) Some of the INCs are sensors that monitor athletic data: “Data collection INC 5320 may have wireless communication device 5322 for sending collected data to control unit 5240 ... It may also have data collection circuit 5324.” (*Id.*, 69:31-70:2.)

FIG 53

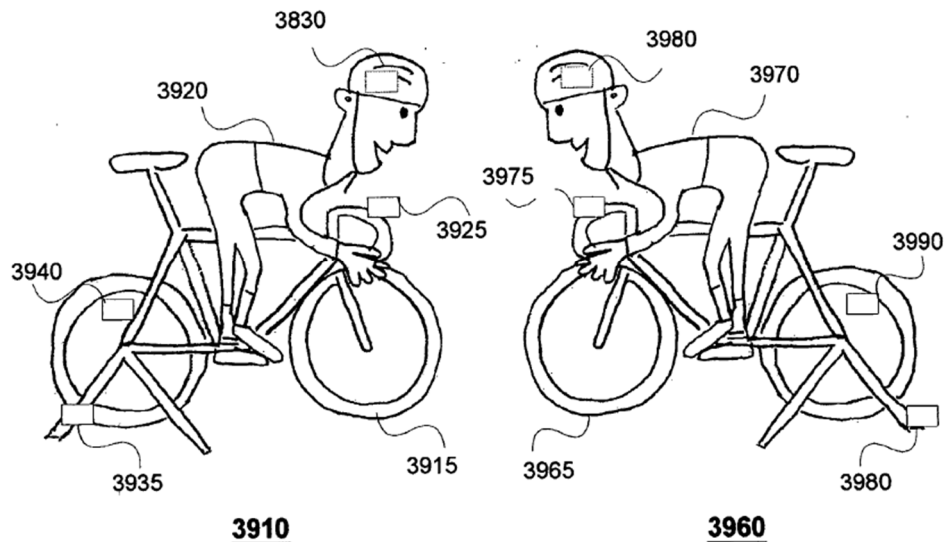


(*Id.*, Fig. 53.)

103. Some of Ellis’ INCs include accelerometers. Ellis explains: “[A] control unit may collect the data from the accelerometer, and measure the frequency at which the data reaches its relative maximums and minimums. This may correspond to the rate at which the user is swinging his or her arms ... which translates directly to cadence.” (*Id.*, 84:19-22.) Users can wear INCs including accelerometers on their wrists. (*Id.*, 64:12-13, 84:12-18, Figs. 44, 70.)

104. Ellis discloses that its MPNs allow users to compete in virtual athletic competitions. For example, Ellis’ Figure 39 depicts a bicycle competition in which “[t]he two control units may ... compare the speeds of the two riders ... [t]he display

INCs may be used to provide feedback on the comparative progress on the simulated course of the two riders, for example notifying each rider of the comparative position of the other.” (*Id.*, 58:22-26.)



(*Id.*, Fig. 39.) “The two MPNs may determine who wins the competition based on data gathered from the two stationary bicycles or other sensors.” (*Id.*, 57:28-29.)

VIII. Obvious Combinations

A. Arrasvuori & Ellis

105. I was asked to consider whether it would have been obvious to combine Ellis’ accelerometer with Arrasvuori’s computerized watch with a reasonable expectation of success. I was asked to assume, for the purposes of this analysis, that Arrasvuori’s pedometer cannot include an accelerometer. In my opinion, and based on that assumption, it would have been obvious to combine Ellis’ accelerometer with Arrasvuori’s computerized watch.

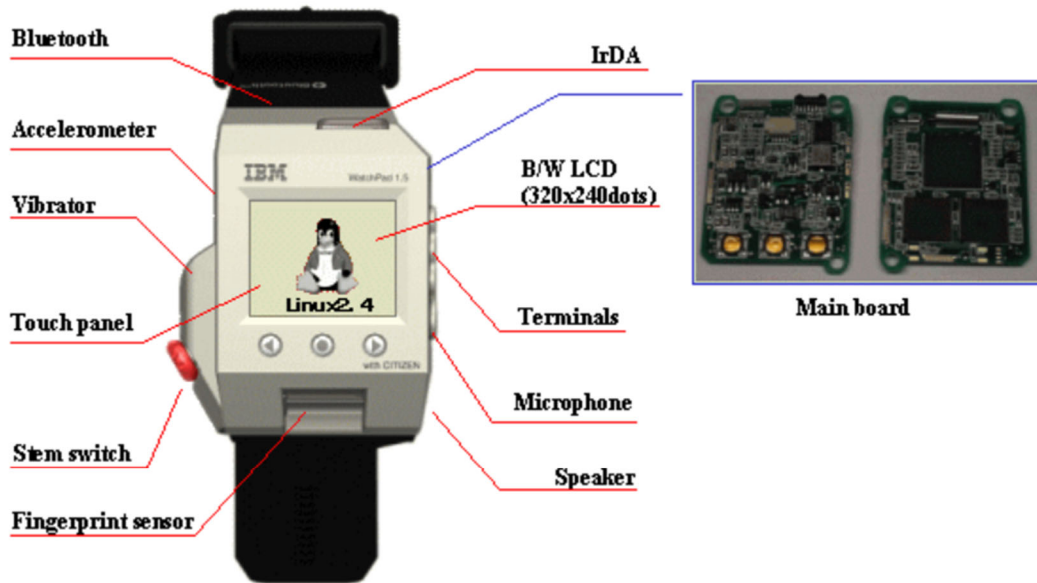
106. Disclosures from Arrasvuori and Ellis would have motivated a POSITA to combine these references. Arrasvuori discloses challenging a user with “[c]ertain exercise details,” (Ex. 1005, ¶ 29), and determining whether “a fitness task was performed in an acceptable manner and/or how well the fitness task was performed[,]” (*id.*, ¶ 43). Ellis discloses using data from an “accelerometer[] mounted on the arm” to calculate an athlete’s “cadence,” “form,” and “stride length.” (Ex. 1007, 64:16-17, 84:19-22, 84:29-30.) A POSITA would have recognized these data would have been useful for determining the acceptability of and how well an athlete performed a fitness task.

107. But while Arrasvuori discloses a wrist-worn computer, a “computerized watch,” (Ex. 1005, ¶ 90), it does not disclose that its monitoring equipment provides information about user “cadence,” “form,” or “stride length,” (*see id.*, ¶ 40 (listing monitoring equipment).) A POSITA therefore would have recognized that Ellis’ accelerometer could fill a hole in Arrasvuori’s quiver of monitoring equipment. Thus, a POSITA would have been motivated to add Ellis’ accelerometer to Arrasvuori computerized watch.

108. A POSITA would have reasonably expected this combination to succeed. Ellis’ accelerometer is already integrated into an “INC worn on a wristband,” i.e., a computerized watch. (Ex. 1007, 64:12-13, Fig. 44; *see also id.*, 84:12-18, Fig. 70.) Arrasvuori defines “computer” as including a “computerized

watch,” (Ex. 1005, ¶ 90), and discloses that its monitoring equipment “might, for instance, be integrated into and/or in communication with wireless nodes and/or other computers of users, and/or be attached to bodies of users[,]” (*id.*, ¶ 39.) Thus, a POSITA would have had no difficulty adding Ellis’ accelerometer, which is already configured to fit into Ellis’ wrist-worn INC, to Arrasvuori’s computerized watch, which can already include monitoring equipment.

109. A POSITA also would have expected this combination to succeed because others had already integrated accelerometers into computerized watches. As the CNN article shown in Exhibit 1010 and available at <http://www.cnn.com/2001/TECH/ptech/10/14/pc.wrist.idg/> explains, in 2001, IBM revealed a smartwatch including an accelerometer. (Ex. 1011.) Below, is a diagram of that smartwatch taken from IBM’s website at https://researcher.watson.ibm.com/researcher/view_group_subpage.php?id=5622:



WatchPad 1.5 hardware overview

(Ex. 1011 at 1.)

B. Watterson & Arrasvuori

110. I was asked to consider whether it would have been obvious to combine Watterson’s personalized race embodiment with Arrasvuori’s compensatory functions with a reasonable expectation of success. In my opinion, this combination would have been obvious to a POSITA in 2008.

111. Disclosures from Watterson and Arrasvuori would have motivated a POSITA to combine the references. Watterson states: “One common challenge with home exercise equipment is motivating the purchaser to use the device on a consistent and ongoing basis” (Ex. 1006, 1:26-28.) It identifies athletic competitions as a solution: “[C]ompetitive exercise programming motivates the

users to exercise on a more regular basis” (*Id.*, 40:23-24.) For example, Watterson’s personalized race involves competitors “rac[ing] against the other, while viewing graphical representations of the distan[ce], time, and speed of the other competitors.” (*Id.*, 41:43-48; *see also id.*, 42:3-6.)

112. Later disclosure in Watterson, however, hints that Watterson’s personalized race might not improve every user’s motivation to exercise. When describing a spin class, Watterson states: “The master may selectively choose groups of participants based on various criteria, such as participant’s heart rates, and change those participants exercise program, while maintaining other participants at the original or different exercise level.” (*Id.*, 49:7-11.) In other words, Watterson acknowledges that some athletes may not be able to participate in the same exercise programs—or the same personalized race—as others because of their relatively lower physical fitness levels, as reflected by their heart rates.

113. Arrasvuori identifies the same problem and provides a solution. Arrasvuori describes “compensatory operations” in which its software compensates for different user’s relative physical fitness levels. (*See Ex. 1005*, ¶ 56.) Those operations involve normalizing graphical representations of user performance according to each user’s physical fitness level. (*See, e.g., id.*, ¶ 60.) For example: “in the case where overall fitness level was to be taken into account in display and the real-world task involved running, in the case where two users performing the

real-world fitness task each traveled the same real-world distance within a certain elapsed time, the user associated with the lower overall fitness level might be depicted as having gone further.” (*Id.*) And, like Watterson, Arrasvuori identifies heart rate as a proxy for physical fitness. (*See id.*, ¶¶ 81, 82, 84.)

114. In my opinion, a POSITA would have recognized that Arrasvuori’s compensatory operations offered a solution to Watterson’s problem of how to allow users with different fitness levels to compete. Arrasvuori even highlights the benefit of its solution: “Compensatory operations might, in various embodiments, provide benefits including allowing for easier comparison between real-world fitness task performance by different users” (*Id.*, ¶ 57.) Thus, a POSITA would have been motivated to combine Watterson’s personalized race with Arrasvuori’s compensatory operations relying on heart rate as a proxy for physical fitness.

115. A POSITA would have had no difficulty implementing this combination with a simple tweak to Watterson’s software. To explain, I will first define two variables and a constant:

- Watterson’s software would likely include variables corresponding to each user’s current apparent velocity shown in the interface presented to each user during a personalized race. I will call v the velocity variable for an exemplary user.

- Watterson discloses measuring user heart rate with a “pulse watch,” (Ex. 1006, 19:6), and transmitting that data to communication module 254, (*id.*, 18:64-19:6 (interface 190 receives signals from a “pulse watch”), 33:38-40 (module 272 can take the form of interface 190).) I will refer to the measured heart rate of an exemplary user as h . I will also define a constant, h_c , which has same units as h .


116. Using v , h , and h_c , a POSITA could have normalized a user’s apparent velocity during Watterson’s personalized race by their heart rate. For example, a POSITA could have tweaked Watterson’s software to depict a user’s progress along a racing track at an “apparent” velocity v' rather than v , where $v' = v * h / h_c$. Because v' equals the multiple of a user’s actual velocity and a quotient proportional to a user’s heart rate, this modification would correlate a user’s apparent performance in a personalized race to their heart rate.

117. Modifying a virtual object’s apparent velocity by scaling a variable would have been trivial to a POSITA in 2008.

In signing this Declaration, I recognize that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case. If required, I will appear for cross-examination at the appropriate time.

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 that these statements were made with knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code.

Dated: November 8, 2022



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AFFILIATIONS

Northwestern Center for Robotics and Biosystems

Northwestern Institute on Complex Systems (NICO)

Northwestern Initiative for Manufacturing Science and Innovation (NIMSI)

POSITIONS

2019-	Director, Center for Robotics and Biosystems
2013-2020	Chair, Mechanical Engineering Department
2010-2013	Codirector, Northwestern Institute on Complex Systems (NICO)
2009-	Professor
2007-2010	Associate Chair, Mechanical Engineering Department
2003-2009	Associate Professor
1997-2003	Assistant Professor Mechanical Engineering Department, Northwestern University
2012-2015	Visiting Faculty, Northeastern University, Shenyang, China
2007	Visiting Faculty, Robotics Institute, Carnegie Mellon University
2007	Visiting Faculty, Control and Dynamical Systems, Caltech
1996-1997	NSF/STA Postdoctoral Fellow Mechanical Engineering Laboratory, AIST-MITI, Tsukuba, Japan
1996-1997	Visiting Lecturer Department of Engineering Systems, University of Tsukuba, Tsukuba, Japan

EDUCATION

1989-1996, Carnegie Mellon University

Ph.D. in Robotics, February 1996

Thesis: *Nonprehensile Robotic Manipulation: Controllability and Planning*

Advisor: Prof. Matthew T. Mason

1985-1989, Princeton University

B.S.E. with honors, Electrical Engineering, June 1989

HONORS

- 2022 George Saridis Leadership Award in Robotics and Automation
- 2021 IEEE Control Systems Magazine Outstanding Paper Award
- 2020 Distinguished Service Award, IEEE Robotics and Automation Society
- 2017 IROS Harashima Award for Innovative Technologies “for pioneering contributions to robotic manipulation”
- IEEE Fellow, 2010, “for contributions to robotic manipulation, motion planning, and control of

mechanical systems”

- DARPA Institute for Defense Analyses Defense Science Study Group, 2008-9
- Charles Deering McCormick Professorship of Teaching Excellence, 2007-10 (one of four awarded annually university-wide)
- Best Technical Paper Award, Int Conf on Climbing and Walking Robots (CLAWAR) 2011
- Best Automation Paper Award, 2007 IEEE Int Conference on Robotics and Automation
- Best Student Paper Award (student Tom Vose), 2008 Robotics: Science and Systems
- 2007 SAE Ralph R. Teetor Educational Award
- 2001 IEEE Early Academic Career Award in Robotics and Automation
“This award is intended to recognize a person in the early stage of his or her career (within seven years of being granted his or her highest academic degree) who has made contributions which have had a major impact on the robotics and/or automation fields.”
- McCormick School of Engineering and Applied Science Teacher of the Year, 1998-1999
- NSF CAREER Award, 1998
- Northwestern University June and Donald Brewer Junior Professorship, 1997-1999
- 1998 NSF New Century Scholars Engineering Education Workshop, Stanford CA
- Best Paper Award finalist, IEEE International Conference on Robotics and Automation, Nagoya, Japan, May 1995
- Anton Philips Best Student Paper Award finalist (three times), IEEE International Conference on Robotics and Automation, 1993, 1995, 1997
- NSF fellow, 1991 Summer Institute in Japan
- Princeton Charles Caldwell Scholarship for Advanced Education (given to Princeton's top four scholar / athletes continuing for advanced degrees), 1989
- Richard King Mellon National Merit Scholarship, 1985-89
- Westinghouse four year scholarship, 1985-89
- Western PA High School Scholar / Athlete of the Year, 1985 (scholarship 1985-89)

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- [C79] Matthew Elwin, Randy Freeman, and Kevin M. Lynch. Worst-case optimal average consensus estimators for robot swarms. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2014)*, Chicago, IL, September 2014.
- [C78] Yu-Wei Liao, Eric Scheerer, Eric J. Perreault, Matthew C. Tresch, and Kevin M. Lynch. Multi-muscle FES control of the human arm for interaction tasks---stabilizing with muscle cocontraction and postural adjustment: a simulation study. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2014)*, Chicago, IL, September 2014.
- [C77] Nelson Rosa Jr. and Kevin M. Lynch. Extending equilibria to periodic orbits for walkers using continuation methods. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2014)*, Chicago, IL, September 2014.
- [C76] Bryan Van Scoy, Randy A. Freeman, and Kevin M. Lynch. Asymptotic mean ergodicity of average consensus estimators. *American Control Conference*, Portland, OR, June 2014.
- [C75] Matthew L. Elwin, Randy Freeman, and Kevin M. Lynch. A systematic design process for internal model average consensus estimators. *IEEE Conference on Decision and Control*, Florence, Italy, December 2013.
- [C74] Nelson Rosa and Kevin M. Lynch. The passive dynamics of walking and brachiating robots: results on the topology and stability of passive gaits. *Int Conf on Climbing and Walking Robots (CLAWAR)*, Sydney, Australia, July 2013.

- [C73] Yu-Wei Liao, Eric Schearer, Xiao Hu, Eric Perreault, Matthew Tresch, and Kevin M. Lynch. Modeling open-loop stability of a human arm driven by a functional electrical stimulation neuroprosthesis. *IEEE Engineering in Medicine and Biology Conference*, Osaka, Japan, July 2013.
- [C72] Nelson Rosa and Kevin M. Lynch. Open-loop stability of time-based vs. event-based switching in locomotion. *Dynamic Walking 2013*, Pittsburgh, PA, June 2013.
- [C71] Eric Schearer, Yu-Wei Liao, Matt Tresch, Eric Perreault, and Kevin M. Lynch. Optimal sampling of recruitment curves for functional electrical stimulation control. *IEEE Engineering in Medicine and Biology Conference*, San Francisco, CA, August 2012.
- [C70] Thomas H. Vose, Paul Umbanhowar, and Kevin M. Lynch. Manipulation with vibratory velocity fields on a tilted plate. *IEEE Int Conf on Automation Science and Engineering (CASE)*, Seoul, Korea, 2012.
- [C69] Andrew W. Long, Amir Degani, and Kevin M. Lynch. Feedback control experiments with the ParkourBot. *Int Conf on Climbing and Walking Robots (CLAWAR)*, Baltimore, MD, 2012.
- [C68] Paul Umbanhowar, Thomas H. Vose, Atsushi Mitani, Shinichi Hirai, and Kevin M. Lynch. The effect of anisotropic friction on vibratory velocity fields. *IEEE International Conference on Robotics and Automation*, St. Paul, MN, May 2012.
- [C67] Eric M. Schearer, Yu-Wei Liao, Eric J. Perreault, Matthew C. Tresch, William D. Memberg, Robert F. Kirsch, and Kevin M. Lynch. System identification for 3D force control of a human arm prosthesis using functional electrical stimulation. *IEEE International Conference on Robotics and Automation*, St. Paul, MN, May 2012.
- [C66] Ji-Chul Ryu, Fabio Ruggiero, and Kevin M. Lynch. Control of nonprehensile rolling manipulation: balancing a disk on a disk. *IEEE International Conference on Robotics and Automation*, St. Paul, MN, May 2012.
- [C65] Nelson Rosa, Jr., Adam Barber, Robert D. Gregg, and Kevin M. Lynch. Stable open-loop brachiation on a vertical wall. *IEEE International Conference on Robotics and Automation*, St. Paul, MN, May 2012.
- [C64] Andrew W. Long, Robert Gregg, and Kevin M. Lynch. The simplest parkour model: experimental validation and stability analysis. *Int Conf on Climbing and Walking Robots (CLAWAR)*, Paris, France, September 2011. **(Best Technical Paper Award)**
- [C63] Maxim Kolesnikov, Davide Piovesan, Kevin M. Lynch, and Sandro Mussa-Ivaldi. On force regulation strategies in predictable environments. *Int Conf of the IEEE Engineering in Medicine and Biology Society (EMBC)*, Boston, MA, Aug-Sept, 2011.
- [C62] Robert Gregg, Yasin Dhaher, and Kevin M. Lynch. Functional asymmetry in a five-link 3D bipedal walker. *Int Conf of the IEEE Engineering in Medicine and Biology Society (EMBC)*, Boston, MA, Aug-Sept, 2011.
- [C61] Andrew W. Long, Todd D. Murphey, and Kevin M. Lynch. Optimal motion planning for a class of hybrid dynamical systems with impacts. *IEEE International Conference on Robotics and Automation*, Shanghai, China, May 2011.

[C60] Amir Degani, H. Benjamin Brown, Kevin M. Lynch, Howie Choset, and Matthew T. Mason. The ParkourBot -- A dynamic BowLeg climbing robot. *IEEE International Conference on Robotics and Automation*, Shanghai, China, May 2011.

[C59] Thomas H. Vose, Paul Umbanhowar, and Kevin M. Lynch. Sliding manipulation of rigid bodies on a controlled 6-dof plate. *Robotics: Science and Systems Conference*, June 2011.

[C58] Robert D. Gregg, Amir Degani, Yasin Dhaher, and Kevin M. Lynch. The basic mechanics of bipedal walking lead to asymmetric behavior. *International Conference on Rehabilitation Robotics*, Zurich, Switzerland, June-July 2011.

[C57] He Bai, Randy A. Freeman, and Kevin M. Lynch. Distributed Kalman filtering using the internal model average consensus estimator. *American Control Conference*, San Francisco, CA, June-July 2011.

[C56] Fabio Morbidi, Randy A. Freeman, and Kevin M. Lynch. Estimation and control of UAV swarms for distributed monitoring tasks. *American Control Conference*, San Francisco, CA, June-July 2011.

[C55] He Bai, Randy A. Freeman, and Kevin M. Lynch. Robust dynamic average consensus of time-varying inputs. *IEEE Conference on Decision and Control*, Atlanta, GA, December 2010.

[C54] Randy A. Freeman, Thomas R. Nelson, and Kevin M. Lynch. A complete characterization of a class of robust linear average consensus protocols. *American Control Conference*, Baltimore, MD, June-July 2010.

[C53] Thomas H. Vose, Paul Umbanhowar, and Kevin M. Lynch. Toward the set of frictional velocity fields generable by 6-degree-of-freedom oscillatory motion of a rigid plate. *IEEE International Conference on Robotics and Automation*, Anchorage, AK, May 2010.

[C52] Michael Epstein, Kevin M. Lynch, Karl Johansson, and Richard M. Murray. Using hierarchical decomposition to speed up average consensus. *International Federation of Automatic Control (IFAC) World Congress*, Seoul, Korea, July 2008.

[C51] Thomas H. Vose, Paul Umbanhowar, and Kevin M. Lynch. Friction-induced velocity fields for parts sliding on a rigid oscillated plate. *2008 Robotics: Science and Systems*, Zurich, Switzerland, June 2008. **(Best Student Paper Award, the only conference award)**

[C50] Peng Yang, Randy Freeman, Geoffrey J. Gordon, Kevin M. Lynch, Siddhartha Srinivasa, and Rahul Sukthankar. Decentralized estimation and control of graph connectivity in mobile sensor networks. *American Control Conference*, Seattle, WA, June 2008.

[C49] Thomas H. Vose, Paul Umbanhowar, and Kevin M. Lynch. Vibration-induced frictional force fields on a rigid plate. *IEEE International Conference on Robotics and Automation*, Rome, Italy, April 2007. **(Best Automation Paper Award)**

[C48] James Solberg, Kevin M. Lynch, and Malcolm A. MacIver. Robotic electrolocation: Active underwater target localization with electric fields. *IEEE International Conference on Robotics and Automation*, Rome, Italy, April 2007.

[C47] Peng Yang, Kevin M. Lynch, and Randy A. Freeman. Distributed cooperative active sensing using consensus filters. *IEEE International Conference on Robotics and Automation*, Rome, Italy, April 2007.

- [C46] Peng Yang, Randy A. Freeman, and Kevin M. Lynch. A general stability condition for multi-agent coordination by coupled estimation and control. *American Control Conference*, New York, NY, July 2007.
- [C45] Randy A. Freeman, Peng Yang, and Kevin M. Lynch. Stability and convergence properties of dynamic average consensus estimators. *IEEE Conference on Decision and Control*, San Diego, CA, December 2006.
- [C44] Heeseon Hwang, Kevin M. Lynch, and Youngil Youm. Locomotion via impact switching between decoupling vector fields. *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Beijing, China, October 2006.
- [C43] Randy A. Freeman, Peng Yang, and Kevin M. Lynch. Distributed estimation and control of swarm formation statistics. *American Control Conference*, Minneapolis, MN, June 2006.
- [C42] Peng Yang, Randy A. Freeman, and Kevin M. Lynch. Optimal information propagation in sensor networks. *IEEE International Conference on Robotics and Automation*, Orlando, FL, May 2006.
- [C41] Peng Pan, Kevin M. Lynch, Michael Peshkin, J. Edward Colgate. Human interaction with passive assistive robots. *International Conference on Rehabilitation Robotics*, June 2005.
- [C40] Jay D. Bernheisel and Kevin M. Lynch. Stable pushing of assemblies. *IEEE International Conference on Robotics and Automation*, Barcelona, Spain, April 2005.
- [C39] Eric Faulring, Kevin M. Lynch, J. Edward Colgate, and Michael A. Peshkin. Haptic interaction with constrained dynamic systems. *IEEE International Conference on Robotics and Automation*, Barcelona, Spain, April 2005.
- [C38] Vikram S. Chib, James L. Patton, Kevin M. Lynch, and Sandro Mussa-Ivaldi. The effect of stiffness and curvature on the haptic discrimination of surfaces. *First Joint EuroHaptics Conference on Haptic Interfaces for Virtual Environments and Teleoperator Systems*, Pisa, Italy, March 2005.
- [C37] Vikram S. Chib, James L. Patton, Kevin M. Lynch, and Sandro Mussa-Ivaldi. Haptic discrimination of perturbing fields and object boundaries. *International Symposium on Haptic Interfaces for Virtual Environments and Teleoperator Systems*, pp. 375-82, Chicago, IL, March 2004.
- [C36] Todd D. Murphey, David Choi, Jay Bernheisel, and Kevin M. Lynch. Experiments in the use of stable limit sets for parts handling. *International Conference on MEMS, NANO, and Smart Systems (ICMENS)*, Banff, Alberta, Canada, August 2004.
- [C35] Prasun Choudhury, Benjamin Stephens, and Kevin M. Lynch. Inverse kinematics-based motion planning for underactuated systems. *IEEE International Conference on Robotics and Automation*, New Orleans, LA, April 2004.
- [C34] Tom Worsnopp, J. Edward Colgate, Michael Peshkin, and Kevin M. Lynch. Controlling the apparent inertia of passive human-interactive robots. *IEEE International Conference on Robotics and Automation*, New Orleans, LA, April 2004.
- [C33] Peng Pan, J. Edward Colgate, Michael Peshkin, and Kevin M. Lynch. Static single-arm force generation with kinematic constraints. *IEEE International Conference on Robotics and Automation*, New Orleans, LA, April 2004.

- [C32] J. Edward Colgate and Kevin M. Lynch. Control problems solved by a fish's body and brain: A review. *13th Annual Symposium on Unmanned Untethered Submersible Technology*, Durham, NH, August 2003.
- [C31] Stefano Iannitti and Kevin M. Lynch. Exact minimum control switch motion planning for the snakeboard. *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Las Vegas, NV, October 2003.
- [C30] Jay D. Bernheisel and Kevin M. Lynch. Stable transport of assemblies — Pushing stacked parts. *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Las Vegas, NV, October 2003.
- [C29] Francesco Bullo, Andrew D. Lewis, and Kevin M. Lynch. Controllable kinematic reductions for mechanical systems: Concepts, computational tools, and examples. *2002 International Symposium on Mathematical Theory of Networks and Systems*, Notre Dame, IN, August 2002.
- [C28] Tanya Tickel, David Hannon, Kevin M. Lynch, Michael A. Peshkin, and J. Edward Colgate. Kinematic constraints for assisted single-arm manipulation. *IEEE International Conference on Robotics and Automation*, Washington, D.C., May 2002.
- [C27] Kevin M. Lynch, Michael Northrop, and Peng Pan. Stable limit set behavior in a dynamic parts feeder. *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Maui, HI, November 2001.
- [C26] Prasun Choudhury and Kevin M. Lynch. Rolling manipulation with a single control. *Conference on Control Applications*, Mexico City, Mexico, September 2001.
- [C25] Francesco Bullo and Kevin M. Lynch. Kinematic controllability and decoupled trajectory planning for underactuated mechanical systems. *IEEE International Conference on Robotics and Automation*, Seoul, Korea, May 2001.
- [C24] Allan Sorensen, Caizhen Liu, Songho M. Kim, Kevin M. Lynch, and Michael A. Peshkin. Experiments in ergonomic robot-guided manipulation. *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Takamatsu, Japan, November 2000.
- [C23] Kevin M. Lynch and Craig K. Black. Controllability and stabilizability of single input planar juggling. *38th Allerton Conference on Communication, Control, and Computing*, Monticello, IL, October 2000.
- [C22] Kevin M. Lynch and Caizhen Liu. Designing motion guides for ergonomic collaborative manipulation. *IEEE International Conference on Robotics and Automation*, San Francisco, CA, April 2000.
- [C21] Prasun Choudhury and Kevin M. Lynch. Controllability of single input rolling manipulation. *IEEE International Conference on Robotics and Automation*, San Francisco, CA, April 2000.
- [C20] Kevin M. Lynch and Craig K. Black. Control of underactuated manipulation by real-time nonlinear optimization. *1999 International Symposium on Robotics Research*, Snowbird, UT, October 1999.

- [C19] Kevin M. Lynch. Toppling manipulation. *1999 IEEE International Conference on Robotics and Automation*, Detroit, MI, May 1999.
- [C18] Craig K. Black and Kevin M. Lynch. Planning and control for planar batting and hopping. *36th Annual Allerton Conference on Communication, Control, and Computing*, Monticello, IL, September 1998.
- [C17] Kevin. M. Lynch, Naoji Shiroma, Hirohiko Arai, and Kazuo Tanie. Motion planning for a 3-DOF robot with a passive joint. *1998 IEEE International Conference on Robotics and Automation*, pp. 1958-1963, Leuven, Belgium, May 1998.
- [C16] Kevin. M. Lynch, Naoji Shiroma, Hirohiko Arai, and Kazuo Tanie. The roles of shape and motion in dynamic manipulation: The butterfly example. *1998 IEEE International Conference on Robotics and Automation*, pp. 927-932, Leuven, Belgium, May 1998.
- [C15] Kevin M. Lynch. Locally controllable polygons by stable pushing. *1997 IEEE International Conference on Robotics and Automation*, Albuquerque, NM, April 1997.
- [C14] Kevin M. Lynch and Matthew T. Mason. Dynamic manipulation with a one joint robot. *1997 IEEE International Conference on Robotics and Automation*, Albuquerque, NM, April 1997. **(Best Student Paper Award finalist)**
- [C13] Srinivas Akella, Wesley H. Huang, Kevin M. Lynch, and Matthew T. Mason. Sensorless parts orienting with a one joint manipulator. *1997 IEEE International Conference on Robotics and Automation*, Albuquerque, NM, April 1997.
- [C12] Kevin M. Lynch and Matthew T. Mason. Dynamic underactuated nonprehensile manipulation. *1996 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 889-896, Osaka, Japan, November 1996.
- [C11] Srinivas Akella, Wesley H. Huang, Kevin M. Lynch, and Matthew T. Mason. From robotic juggling to robotic parts feeding. *Yale Workshop on Adaptive and Learning Systems*, New Haven, CT, June 1996.
- [C10] Srinivas Akella, Wesley H. Huang, Kevin M. Lynch, and Matthew T. Mason. Planar manipulation on a conveyor with a one joint robot. *Seventh International Symposium on Robotics Research*, pp. 265-276, Munich, Germany, October 1995.
- [C9] Kevin M. Lynch and Matthew T. Mason. Controllability of pushing. *IEEE/RSJ International Conference on Robotics and Automation*, pp. 112-119, Nagoya, Japan, May 1995. **(Best Paper and Best Student Paper Award finalist)**
- [C8] Matthew T. Mason and Kevin M. Lynch. Dynamic robotic manipulation: Progress and plans. *Eighth Yale Workshop on Adaptive and Learning Systems*, New Haven, CT, June 1994.
- [C7] Matthew T. Mason and Kevin M. Lynch. Throwing a club: Early results. *Sixth International Symposium on Robotics Research*, Hidden Valley, PA, October 1993.
- [C6] Kevin M. Lynch. Planning pushing paths. *International Conference on Advanced Mechatronics*, pp. 451-456, Tokyo, Japan, August 1993.
- [C5] Matthew T. Mason and Kevin M. Lynch. Dynamic manipulation. *IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 152-159, Yokohama, Japan, July 1993.

[C4] Kevin M. Lynch. Estimating the friction parameters of pushed objects. *IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 186-193, Yokohama, Japan, July 1993.

[C3] Kevin M. Lynch and Matthew T. Mason. Pulling by pushing, slip with infinite friction, and perfectly rough surfaces. *IEEE International Conference on Robotics and Automation*, v. 1, pp. 745-751, Atlanta, GA, May 1993. **(Best Student Paper Award finalist)**

[C2] Kevin M. Lynch, Hitoshi Maekawa, and Kazuo Tanie. Manipulation and active sensing by pushing using tactile feedback. *IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 416-421, Raleigh, NC, July 1992.

[C1] Kevin M. Lynch. The mechanics of fine manipulation by pushing. *IEEE International Conference on Robotics and Automation*, pp. 2269-2276, Nice, France, May 1992.

ABSTRACTS, POSTERS, AND OTHER PUBLICATIONS

[A8] Max Kolesnikov, Maura Casadio, Kevin M. Lynch, and Sandro Mussa-Ivaldi. Investigating control strategies in force regulation tasks. *Neuroscience*, November 2010.

[A7] Vikram S. Chib, Matthew A. Krutky, Kevin M. Lynch, and Sandro Mussa-Ivaldi. The nervous system independently controls motions and forces. *Advances in Computational Motor Control Workshop*, Atlanta, GA, October 2006.

[A6] Peng Pan, Kevin Lynch, Michael Peshkin, J. Edward Colgate, and Mitra Hartmann. Static single-arm force generation with kinematic constraints. *Neuroscience*, San Diego, CA, October 2004.

[A5] Vikram Chib, James Patton, Kevin Lynch, and F. Mussa-Ivaldi. Interaction with surfaces of varying stiffness and curvature. *Neural Control of Movement*, Sitges, Spain, March 2004.

[A4] Vikram Chib, James Patton, Kevin Lynch, and F. Mussa-Ivaldi. The effect of stiffness and curvature on surface interaction. *Neuroscience*, New Orleans, LA, November 2003.

[A3] Vikram Chib, James Patton, Kevin Lynch, and F. Mussa-Ivaldi. Surface stiffness threshold detection through haptic feedback. *Neuroscience*, New Orleans, LA, November 2003.

[A2] Peng Pan, Kevin Lynch, Michael Peshkin, and J. Edward Colgate. Static single-arm force generation with kinematic constraints. *Neural Control of Movement*, Santa Barbara, CA, April 2003.

[A1] Vikram Chib, James Patton, Kevin Lynch, and F. Mussa-Ivaldi. Haptic discrimination of fields and surfaces. *Neural Control of Movement*, Santa Barbara, CA, April 2003.

PATENTS

[P3] US 9,795,966. Non-contact droplet manipulation apparatus and method. P. Umbanhowar and K. Lynch, October 24, 2017.

[P2] US 8,348,047. Parts Manipulation Method and Apparatus. K. M. Lynch and P. Umbanhowar, January 8, 2013. Licensed to Asyril, manufacturer of equipment for industrial automation, January 2015.

[P1] US 8,230,990. Parts Manipulation Method and Apparatus, K. M. Lynch and P. Umbanhowar, July 31, 2012. Licensed to Asyril, manufacturer of equipment for industrial automation, January 2015.

CONFERENCE AND WORKSHOP ORGANIZATION

- Program co-chair, 2019 IEEE/RSJ International Conference on Intelligent Robots and Systems, Macau, China
- Program co-chair, 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems, Madrid, Spain
- Session organizer, ASME ME/MET Department Heads Forum, ASME IMECE 2016
- Session organizer, ASME ME/MET Department Heads Forum, ASME IMECE 2015
- General Chair, 2014 IEEE/RSJ International Conference on Intelligent Robots and Systems, Chicago
- Senior Program Committee, 2013 IEEE/RSJ International Conference on Intelligent Robots and Systems, Tokyo, Japan
- Program Committee, ANTS 2012 (International Conference on Swarm Intelligence)
- Awards Co-chair, 2012 IEEE Int Conf Robotics and Automation
- Senior Program Committee, 2011 IEEE/RSJ International Conference on Intelligent Robots and Systems, San Francisco
- Workshop Chair, 2010 Robotics: Science and Systems Conference
- Program Committee, 2010 IEEE Workshops on Advanced Robotics and its Social Implications (ARSO), South Korea
- Program Committee, 2009 IEEE Workshops on Advanced Robotics and its Social Implications (ARSO), Tokyo, Japan
- Program co-chair for the Americas, 2009 IEEE Int Conf Robotics and Automation
- Co-organizer, NSF US-Japan Workshop on Robotics for Safety, Security, and Society, San Francisco, CA, August 2008
- Program Committee, 2008 Workshop on the Algorithmic Foundations of Robotics
- Area Chair, 2008 Robotics: Science and Systems Conference
- Program co-chair, 2006 IEEE International Conference on Robotics and Automation
- Area Chair, 2005 Robotics: Science and Systems Conference
- Advisory Committee, 2005 International Conference on Rehabilitation Robotics (ICORR)
- Program committee, 2005 IEEE International Conference on Robotics and Automation, Barcelona, Spain
- Program committee, 2005 International Symposium on Assembly and Task Planning, Montreal, Canada
- Program committee, 2004 IEEE/RSJ International Conference on Intelligent Robots and Systems, Sendai, Japan
- Program committee, 2004 IEEE International Conference on Robotics and Automation, New Orleans, LA
- Program committee, 2002 IEEE International Conference on Robotics and Automation, Washington D.C.
- Program committee, 2001 IEEE/RSJ International Conference on Intelligent Robots and Systems, Hawaii
- Invited session organizer, 2001 Conference on Control Applications, Mexico City, Mexico
- Program co-chair, 2000 Workshop on the Algorithmic Foundations of Robotics
- Program committee, 2000 World Automation Conference, Maui, Hawaii
- Program committee, IEEE International Conference on Robotics and Automation 2000, San Francisco, CA
- Workshop and Tutorials Review Committee, 2000 IEEE International Conference on Robotics and Automation
- Founder, Midwest Mechanical Motion Meeting
- Program committee, 1999 International Conference on Advanced Robotics, Tokyo, Japan

- Program committee, 1999 International Joint Conference on Artificial Intelligence
- Program committee, 1997 International Joint Conference on Artificial Intelligence

JOURNAL AND CONFERENCE EDITING

- Editor-in-Chief, *IEEE Transactions on Robotics*, 2018-
- Editor-in-Chief, IEEE International Conference on Robotics and Automation Conference Editorial Board, 2018
- Senior Editor, *IEEE Robotics and Automation Letters*, 2015-17
- Editorial Board, *Annual Reviews in Control*, 2014-19
- Senior Editor, *IEEE Transactions on Automation Science and Engineering*, 2011-2015
- Senior Editor, 2009 Special Issue on Rehabilitation Robotics, *IEEE Transactions on Robotics*
- Senior Editor, *IEEE Transactions on Robotics*, 2005-11
- Associate Editor, *IEEE Transactions on Robotics*, 2004-5
- Associate Editor, *IEEE Transactions on Robotics and Automation*, 2002-2004
- Guest editor, *International Journal of Robotics Research* special issue, 2002

OTHER PROFESSIONAL ACTIVITIES

- Chair of ASME ME Department Head Executive Committee (MEDHEC), 2018-19 (Secretary 2016-17, Vice Chair 2017-18)
- Elected member of ASME Department Head Executive Committee (MEDHEC), 2014-2016
- Academic Leadership Program, Big Ten Academic Alliance (formerly CIC), 2013-14
- External advisor, Project 111, Northeastern University, Shenyang, China, 2012-2015
- Advisor, Chicago Museum of Science and Industry "Robot Revolution" exhibit, 2012-2015
- Parliamentarian (Executive Committee), IEEE Robotics and Automation Society, 2013-2017
- Chair, IEEE Robotics and Automation Society Steering Committee for Technical Programs, 2012-13
- Chair, IEEE Robotics and Automation Society Early Career Award Evaluation Panel, 2012-13
- Secretary (Executive Committee and Administrative Committee), IEEE Robotics and Automation Society, 2010-11
- Member of the DARPA Institute for Defense Analyses Defense Science Study Group, 2008-9
- Kellogg Business and Leadership for Scientists and Engineers Executive Course, 2007-8
- Elected member of IEEE Robotics and Automation Society Administrative Committee, 2006-8
- Secretary, IEEE Robotics and Automation Society, 2004-2005
- Secretary, IEEE Robotics and Automation Long Range Planning Committee, 2002-2003
- 2004 IEEE Robotics and Automation Society Early Career Award Committee
- Various technical and legal consulting
- Reviewer for several funding agencies: NSF, NASA, US Department of State Russian Nonproliferation Office, Research Grants Council of Hong Kong, Netherlands Organization for Scientific Research, State of Indiana 21st Century Fund, Austrian Competence Centre Programme, European Commission
- Reviewer for many journals (*IEEE Transactions on Robotics and Automation*; *IEEE Transactions on Automatic Control*; *IEEE Transactions on Systems, Man, and Cybernetics*; *International Journal of Robotics Research*; *Journal of Robotic Systems*; *International Journal of Robotics and Automation*; *Journal of the Franklin Institute*; *International Journal of Control*; *SIAM Journal on Control and Optimization*; *Systems and Control Letters*; *ASME Journal of Engineering Materials and Technology*; *ASME Journal of Dynamic Systems, Measurement, and Control*; *ASME Journal of Mechanical Design*; *IEEE Transactions on Control Systems Technology*; *Automatica*; *Robotica*; *Journal of Nonlinear Science*; others), MIT Press, Wiley and Sons, McGraw-Hill, Oxford Press, and conferences (IEEE ICRA, IROS, IJCAI, CDC, IMECE, ACC, ICORR, others)
- Carnegie Mellon Japanese Science, Technology, and Manufacturing Program
- Participant, 1992 University of Pittsburgh Workshop on US Human Resource Needs in

- Japanese Science, Technology, and Manufacturing
- Co-winner, 1994 Carnegie Mellon School of Computer Science programming contest

EDUCATIONAL INITIATIVES

- Initiated two-quarter design sequence ME/ECE 495 Robot Design Studio in 2018
- Created the YouTube site <https://www.youtube.com/NorthwesternRobotics> for educational and research robotics videos (over 26k subscribers and 2M views)
- Developed six online courses for the Coursera MOOC specialization “Modern Robotics,” at <https://www.coursera.org/specializations/modernrobotics>. The courses are being taken by thousands of learners around the world.
- Developed approximately 100 short videos and led the development of a freely-distributed software library to accompany the textbook *Modern Robotics: Mechanics, Planning, and Control*, Cambridge University Press, 2017. Information at <http://modernrobotics.org>.
- Developed approximately 80 short videos on microcontrollers and mechatronics to support ME 333 Introduction to Mechatronics and our book *Embedded Computing and Mechatronics with the PIC32 Microcontroller*. Information at <http://nu32.org>.
- Developed new course, ME 333 Introduction to Mechatronics (first taught Winter 2000)
Course description: Introduction to microprocessor-controlled electromechanical systems. Interfacing sensors and actuators to computers, electrical and mechanical prototyping, dissection of a commercial product. Final team project.
- Developed new course, ME 449 Robotic Manipulation (first taught as ME D95, Fall 1998)
Course description: Mechanics of robotic manipulation, computer representations and algorithms for manipulation planning, applications to industrial automation, parts feeding, grasping, fixturing, and assembly.
- Developed new course, ME 450 Geometry in Robotics (first taught as ME 495, Spring 2001)
Course description: Application of tools from differential geometry and Lie groups to problems in dynamics, controllability, and motion planning for mechanical systems, particularly with non-Euclidean configuration spaces.
- Developed new course, ME 495 Motion Planning and Control Under Uncertainty, Spring 2006
Course description: Classical techniques from stochastic optimal control theory including Kalman filtering and linear quadratic Gaussian problems; recent computational techniques in Bayesian inference and Markov decision processes; applications to control of robot systems under sensor and actuator uncertainty.
- Developed new course, ME 495 Nonlinear Control, Fall 2010
- Developed the Mechatronics Design Laboratory, open 24/7 for classes and student design projects, part of Northwestern's Ford Motor Company Engineering Design Center. Also led the development of the supporting mechatronics design wiki page, http://hades.mech.northwestern.edu/index.php/Main_Page (or google “mechatronics wiki”).

SELECTED INVITED TALKS

- University of Illinois, September 2022

- Plenary, IEEE International Conference on Advanced Robotics and Mechatronics, Giulini, China, July 2022
- University of Pennsylvania, April 2022
- New Advances in Tactile Sensation, Interactive Perception, Control, and Learning, workshop at IROS 2021, September 2021
- Carnegie Mellon University, October 2020
- Plenary, Ubiquitous Robotics Conference, June 2020
- University of Notre Dame, April 2019
- Massachusetts Institute of Technology, December 2018
- University of Texas Dallas, October 2018
- Illinois Institute of Technology, March 2018
- University of Utah, ME Distinguished Lecture, December 2017
- Case Western Reserve University, April 2017
- University of Pittsburgh, March 2017
- Plenary, IEEE International Conference on Mechatronics and Automation, Harbin, China, August 2016
- Colorado State University, April 2016
- University of California Irvine, March 2016
- Purdue University, February 2016
- Northwestern University Physics Colloquium, January 2016
- World Robot Conference keynote, Beijing, China, November 2015
- Foundations of Intelligent Sensing, Action and Learning (FISAL), Philadelphia, PA, Oct 2015
- Boston Dynamics (Google), June 2015
- University of California, San Diego, June 2015
- University of Michigan, March 2015
- University of Michigan, December 2014
- NSF Workshop on Motion Planning, October 2013
- Osaka University, June 2013
- Chicago Museum of Science and Industry, April 2013
- University of Illinois Urbana Champaign, February 2013
- University of Delaware, September 2012
- Plenary, IEEE International Conference on Automation Science and Engineering, Seoul, Korea, August 2012
- Plenary, IEEE International Conference on Information and Automation, Shenyang, China, June 2012
- Georgia Institute of Technology, April 2012
- Chicago Museum of Science and Industry, Education Staff, March 2012
- Workshop on Contact Modeling and Simulation, RSS 2011, June 2011
- Institute of Automation, Chinese Academy of Sciences, Beijing, May 2011
- Beijing Institute of Technology, May 2011
- Tianjin University, May 2011
- Hebei University of Technology, May 2011
- Georgia Institute of Technology, May 2011
- Northwestern Institute on Complex Systems, October 2010
- JAIST LRC Summer School on Robotics, Kanazawa, Japan, August 2010
- University of Illinois Urbana-Champaign, February 2010
- Nagoya University, Nagoya, Japan, May 2009
- Ritsumeikan University, Kyoto, Japan, May 2009
- Minta Martin Distinguished Lecturer, Aerospace Engineering, University of Maryland, April 2009
- Cornell University, April 2009
- University of Siena, Siena, Italy, March 2009
- University of Pisa, Pisa, Italy, March 2009
- University of Rome “La Sapienza,” Rome, Italy, March 2009

- Distinguished Lecturer, University of California San Diego, Winter School of the Institute of Nonlinear Science, San Diego, CA, January 2009
- Carnegie Mellon University Center for Foundations of Robotics, November 2008
- ICRA 2008 Workshop on Contact Models for Manipulation and Locomotion, Pasadena, CA, May 2008
- Mathematical Biosciences Institute, Ohio State University, January 2008
- California Institute of Technology, June 2007
- University of California, Berkeley, May 2007
- University of California, Los Angeles, May 2007
- University of California, Santa Barbara, May 2007
- University of Southern California, April 2007
- Jet Propulsion Lab, April 2007
- University of Maryland, September 2006
- Carnegie Mellon University, March 2006
- AMS Workshop on Mathematical Problems in Robotics, Northwestern U., October 2004
- University of Pennsylvania, December 2003
- Stanford University, November 2003
- Japan Advanced Institute of Science and Technology, September 2003
- Intelligent Systems Institute, AIST, Tsukuba, Japan, September 2003
- University of Iowa, April 2003
- University of Michigan Control Seminar, April 2003
- Johns Hopkins University, March 2003
- Conference on Decision and Control Workshop on Control Problems in Robotics and Automation, Las Vegas, NV, December 2002
- Future Directions in Nonlinear Control of Mechanical Systems, NSF-ONR Workshop at UIUC, October 2002
- Mathematical Theory of Networks and Systems Special Session on Dynamics and Control of Mechanical Systems, August 2002 (presented by Andrew Lewis)
- Belgian Royal Academy of Sciences, Brussels, Belgium, July 2002
- University of Liege, Liege, Belgium, July 2002
- National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan, July 2001
- Advanced Science Institute, New Frontiers in Intelligent Robotics, Tokyo, Japan, July 2001
- Carnegie Mellon University, Pittsburgh, PA, December 2000
- Allerton Conference on Communication, Control, and Computing, Special Session on Motion Planning, Monticello, IL, October 2000
- Special Session on Nonholonomy on Purpose, International Conference on Intelligent Robot Systems, Takamatsu, Japan, October 2000
- Tutorial on Sensing and Actuation Toward the 21st Century, International Conference on Intelligent Robot Systems, Takamatsu, Japan, October 2000
- US-EU Workshop on Key Research Issues and Opportunities in Motion Planning, Toulouse, France, June 2000
- University of Michigan Dept. of Electrical Engineering and Computer Science, Ann Arbor, MI, May 2000
- IEEE International Conference on Robotics and Automation, Special Session on Grasping and Contact, San Francisco, CA, May 2000
- Ninth International Symposium on Robotics Research, Snowbird, UT, October 1999
- Stanford Workshop on Motion Support for Virtual Prototyping, Stanford, CA, May 1999
- Allerton Conference on Communication, Control, and Computing, Special Session on Control Issues in Locomotion, Monticello, IL, September 1998
- University of Illinois at Urbana-Champaign, Beckman Institute, Artificial Intelligence Seminar, Urbana-Champaign, IL, September 1998
- University of Tokyo Department of Mechano-informatics, Tokyo, Japan, August 1997
- University of Minnesota Computer Science Department, Minneapolis, MN, May 1997
- University of California Irvine Mechanical Engineering Department, Irvine, CA, May 1997

- Stanford University Computer Science Department, Stanford, CA, April 1997
- Vanderbilt University Computer Science Department, Nashville, TN, April 1997
- Westinghouse Science and Technology Center, Pittsburgh, PA, January 1997
- University of Pennsylvania GRASP Lab, Philadelphia, PA, January 1997
- Boston University Department of Manufacturing Engineering, Boston, MA, January 1997
- IEEE Robotics and Automation Society, Tokyo chapter meeting, Tsukuba, Japan, September 1996
- SONY Production Systems Design Department, Tokyo, Japan, September 1996
- Workshop on the Algorithmic Foundations of Robotics (WAFR), San Francisco, CA, February 1994
- University of Tokyo Department of Mathematical Engineering and Information Physics, Tokyo, Japan, January 1994
- Kawasaki Heavy Industries, Japan, January 1994
- International Conference on Advanced Mechatronics, Tokyo, Japan, August 1993

SERVICE TO NORTHWESTERN

- Northwestern Faculty Committee on Athletics and Recreation (CAR), 2021-
- Department of Athletics and Recreation Program Review, 2020-21
- Provost's Advisory Council on Women Faculty, 2016-21
- Faculty Senate, 2010-13
- Technological Institute Engineering Life Science building committee, 2008-
- ME ABET reaccreditation coordinator, 2003-6
- ME undergraduate NCA accreditation coordinator, 2003-4
- Updated ME grad school catalog, 1998; undergrad catalog, 2000
- Faculty advisor, Pi Tau Sigma, 1998-2007
- Faculty advisor, Theta Tau, 2001-2
- Undergraduate curriculum committee, 1998-
- Mechanical Engineering information session for freshmen, Spring (annually)
- Departmental representative, New Student Week information panel, 1999
- Chairman of the undergraduate curriculum committee, 1999-2000
- MC for "Evening with McCormick," New Student Week, periodically 1999-
- Dean's Scholar Advisor, 2000, 2004
- McCormick Teacher of the Year committee, 1999- 2002
- ME space committee, 2000
- Ford Engineering Design Studio planning subcommittee, 2001
- Day at Northwestern/Preview NU (prospectives) design contest, periodically 1999-
- McCormick Identity (image) Committee, 2002-3