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Filed on behalf of Meta Platforms, Inc.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
Petitioner

v.

MULLEN INDUSTRIES, LLC,
Patent Owner

Case No. IPR2025-00702
U.S. Patent No. 10,967,270

DECLARATION OF GREGORY WELCH, PH.D. IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 10,967,270

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I. INTRODUCTION.

1. I, Gregory Welch, have been retained by Meta Platforms, Inc. ("Meta") to provide an analysis of the scope and content of U.S. Patent No. 10,967,270 ("the '270 patent") relative to the state of the art at the time of the earliest application to which the '270 patent claims priority. My analysis relates to claims 4, 5, 16, 17, and 19. I have also been retained to provide analysis regarding what a person of ordinary skill in the art ("POSITA") would have understood at the time of the earliest application underlying the '270 patent.

2. This declaration summarizes the opinions I have formed to date. I reserve the right to modify or amend my opinions, if necessary, based on further review and analysis of information that I receive subsequent to the filing of this declaration, including in response to positions taken by Mullen Industries, LLC ("Mullen") or its experts that I have not yet seen, including any secondary considerations evidence that Mullen or its expert may consider and present.

3. It is my opinion that claims 4, 5, 16, 17, and 19 of the '270 patent are invalid based on the following grounds.

Ground 1	Claims 4, 5, 16, 17, and 19 are obvious over Cheok (EX1006) in view of Nakamura (EX1007) and Foxlin077 (EX1008)
Ground 2	Claims 4, 5, and 17 are obvious over Nakamura in view of Benini (EX1009)

Ground 3	Claims 16 and 19 are obvious over Nakamura in view of Benini and Foxlin068 (EX1010)

II. EXPERIENCE, QUALIFICATIONS, AND STATUS AS AN INDEPENDENT EXPERT.

4. My curriculum vitae ("CV") is Exhibit 1004. I am a Pegasus Professor and the AdventHealth Endowed Chair in Simulation at the University of Central Florida ("UCF") with appointments in the College of Nursing, the Department of Computer Science, and the Institute for Simulation & Training. I am also the Co-Director of the IST Synthetic Reality Lab. Prior to my appointment at UCF, I was an adjunct professor at the University of North Carolina at Chapel Hill ("UNC"), where I worked on the Voyager Spacecraft Project at NASA's Jet Propulsion Laboratory on airborne electronic countermeasures at Northrop-Grumman's Defense Systems Division.

5. In 1986, I was awarded a Bachelor of Science degree in Electrical Engineering Technology with *Highest Distinction* from Purdue University.

6. I was awarded a master's degree, and then, a Ph.D. in Computer Science from UNC in 1995 and 1997, respectively.

7. My research career has focused on human-computer interaction, human motion tracking, and virtual and augmented reality, with applications such as healthcare and defense. Notably, my research includes my highly cited 1995

introductory article on the Kalman Filter, which is an algorithm that provides an efficient way to estimate the state of a dynamic system from noisy observations (that is, data or measurements that are influenced by errors and inaccuracies). I maintain an internationally recognized website dedicated to the Kalman Filter.

8. I have published over 170 articles in peer-reviewed journals, conferences, and symposia. A sampling of these papers include "Revisiting Trends in Augmented Reality Research: A Review of the 2nd Decade of ISMAR (2008–2017)," "The Office Of The Future: A Unified Approach to Image-Based Modeling and Spatially Immersive Displays," "High-Performance Wide-Area Optical Tracking: The HiBall Tracking System," and "Motion Tracking: No Silver Bullet, But a Respectable Arsenal." Notably, my introductory paper on the Kalman Filter authored alongside Gary Bishop has been cited over 12,000 times. My work in Augmented Reality and tracking were cited in my promotion to IEEE Fellow, and a pair of seminal papers of mine on Spatial Augmented Reality in 1998 earned me and my co-authors the Long-Lasting Impact Award at the IEEE Virtual Reality Conference in 2016.

9. I have served as a peer reviewer and / or associate editor for more than 15 journals and other peer-reviewed publications, and I have served as a federal grant reviewer for multiple funding agencies / organizations. I have also written a dozen

book chapters and sections, including those on, for instance, virtual, mixed, and augmented reality in computer science.

10. I am named as an inventor on 28 issued patents, and have several others in various stages of prosecution. Two relevant examples are US Patent. No. 11,467,399, "Augmentation of Relative Pose In Co-located Devices," which pertains to the concept of cooperative tracking of two or more individuals in proximity of each other, and US Patent. No. 9,808,549, "System for Detecting Sterile Field Events and Related Methods," which pertains to the concept of establishing and maintaining bounded volumes around sterile medical procedures, and the detection of unsafe interactions within.

11. My teaching experience includes undergraduate and graduate level classes. Example topics include Virtual Reality and Augmented Reality and computer modeling and animation.

12. I am a Fellow of the National Academy of Inventors (NAI) and a Fellow of the Institute and Electrical and Electronics Engineers (IEEE). I was inducted into the IEEE Virtual Reality Academy in 2022.

13. I have received a number of awards, including the Virtual Simulation Innovation Award in 2025 (UCF CON STIM Center), IEEE Virtual Reality Technical Achievement Award in 2018, and the Long Lasting Impact Paper Award from the IEEE VR Conference as mentioned above. I have also been designated a

Pioneer of the Association for Computing Machinery's Special Interest Group on Graphics and Interactive Techniques ("ACM SIGGRAPH"), which is a recognition of long-time contributions in the computer graphics space. I currently serve as a technical expert for the IEEE for its virtual, augmented, and mixed reality Public Visibility Initiative.

14. I have been a keynote speaker at 20 scientific conferences, workshops, and colloquiums throughout the world. I have similarly been invited to give talks at, participate in, or serve on dozens of scientific committees for conferences, workshops, and panels worldwide.

15. A detailed list of my professional activities, memberships, and speaking engagements is included in my CV (EX1004).

16. I am being compensated at the rate of $600 per hour for my work on this declaration. My fee is not contingent on the outcome of any matter or on any of the technical positions I explain in this declaration.

17. I have no financial interest in Meta. I have been informed that Mullen claims ownership of the '270 patent. I have no financial interest in Mullen.

III. MATERIALS REVIEWED AND CONSIDERED.

18. My opinions in this declaration are based on working in the field of computer science and engineering, particularly in virtual, augmented, and mixed reality, including my teaching, research, and consulting. I have an established

understanding of the relevant field at the relevant time frame and I have an understanding of the skill set, capabilities, and knowledge of a POSITA as of September 2, 2003.

19. My opinions are also based on investigation and study of the patent at issue, its file history, and the prior art. In the course of forming my opinions, I have reviewed the exhibits submitted with the Petition, which are specifically identified in Appendix A.

20. I may rely upon these materials and/or additional materials to rebut arguments raised by Mullen. Further, I may also consider additional documents and information in formatting any necessary opinions including documents that may not yet have been provided to me.

IV. UNDERSTANDING OF RELEVANT LEGAL PRINCIPLES.

21. I understand that statutory and judicially created standards must be considered to determine the validity of a patent claim. I am not an attorney and, consequently, will offer no opinion on the law itself. My understanding of the pertinent law is described in this section and is the result of explanations provided by counsel. I have applied this understanding in my analysis.

22. I understand that a patent claim is unpatentable if it is anticipated by, or obvious in view of, the prior art. I further understand that the time frame of reference

for determining whether a claim is unpatentable is from the perspective of a POSITA at the time of invention.

A. Anticipation.

23. I have been informed that for a patent claim to be anticipated by the prior art, each and every limitation of the claim must be found, expressly or inherently, in a single prior art reference as recited in the claim. I have been informed that a claim limitation not expressly found in a prior art reference is inherent if the prior art necessarily functions in accordance with, or includes, the claim limitation. Mere probability that a limitation is included is not sufficient to establish inherency.

B. Obviousness.

24. In analyzing obviousness in light of the prior art I have been informed that it is important to understand the scope of the claims, the level of skill in the relevant art, the scope and content of the prior art, the differences between the prior art and the claims, and any objective indicia of non-obviousness (also called secondary considerations).

25. I have been informed that a patent claim is unpatentable for obviousness if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a POSITA to which said subject matter pertains. I have been

informed that obviousness may be based on one reference or a combination of references. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.

26. I have been informed that when a patented invention is a combination of known elements, the Patent Trial and Appeal Board ("Board") must determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue by considering the teachings of prior art references, the effects of demands known to people working in a field or present in the marketplace, and the background knowledge possessed by a POSITA.

27. I have been informed that the Supreme Court has recognized several rationales for combining references or modifying a reference to show obviousness of the claimed subject matter. I understand that several of these rationales are: (1) combining prior art elements according to known methods to yield predictable results; (2) simple substitution of one known element for another to obtain predictable results; (3) use of a known technique to improve a similar device (method or product) in the same way; (4) applying a known technique to a known device (method or product) ready for improvement to yield predictable results; (5) choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; (6) and some teaching, suggestion, or motivation in the prior

art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

28. I have been informed that in order to prove that a claimed invention is not patentable for obviousness, a petitioner must (1) identify the differences between the claim and particular disclosures in the prior art references, singly or in combination, (2) specifically explain how the prior art references could have been combined in order to arrive at the subject matter of the claimed invention, and (3) specifically explain why a POSITA would have had reasons to so combine the prior art references.

C. Priority.

29. I have been informed that to claim priority to a prior application, each application in the chain that leads to an earlier application must comply with the written description requirement. I have been informed that in order to satisfy the written description requirement, the specification of the provisional application must contain a written description of the invention and the manner and process of making and using it, in such full, clear, concise, and exact terms, that it would enable a person of ordinary skill in the art to practice the invention claimed in the non-provisional application. I have been informed that the provisional application must describe the invention claimed in the non-provisional application such that a person of skill in

the art can clearly conclude that the inventor had invented the claimed invention by the provisional application filing date.

V. TECHNOLOGY OVERVIEW.

30. In this section I provide overviews of technologies and prior art pertinent to the '270 patent and to the state of the art as of 2003. *See* Sec. VI.B.1 (addressing priority of the '270 patent). In later sections I address in detail how the prior art discloses and renders obvious the recitations of the challenged claims.

31. The prior art references described below and discussions of what was known to a person of ordinary skill in the art provide a general description of the state of the art at the time of the invention, provide additional motivation to modify the primary references evaluated in the grounds of invalidity with the knowledge of a person of ordinary skill in the art or other references cited herein, and provide support for why a person of ordinary skill in the art would have had a reasonable expectation of success in combining the teachings of the references. The additional prior art references identified in this section are exemplary in nature and are included to provide factual support for my opinions.

A. Virtual and Augmented Reality Paradigms.

32. The development and use of interactive computer-generated simulations of virtual environments and entities have been around for many decades — long before September of 2003. Such simulations have long been used for

applications such as training, education, science, and entertainment. What began as targeted, virtual simulations have grown into more comprehensive virtual "experiences," with the common goal of cognitive and sometimes sensory immersion driving these developments through the early 2000s.

33. A seminal example of such work is that of Ivan Sutherland and his students at the University of Utah in the 1960s, including Sutherland's "head-mounted three-dimensional display" paper, which is among the most well-known in the field. I reproduce some of the figures from that paper here:

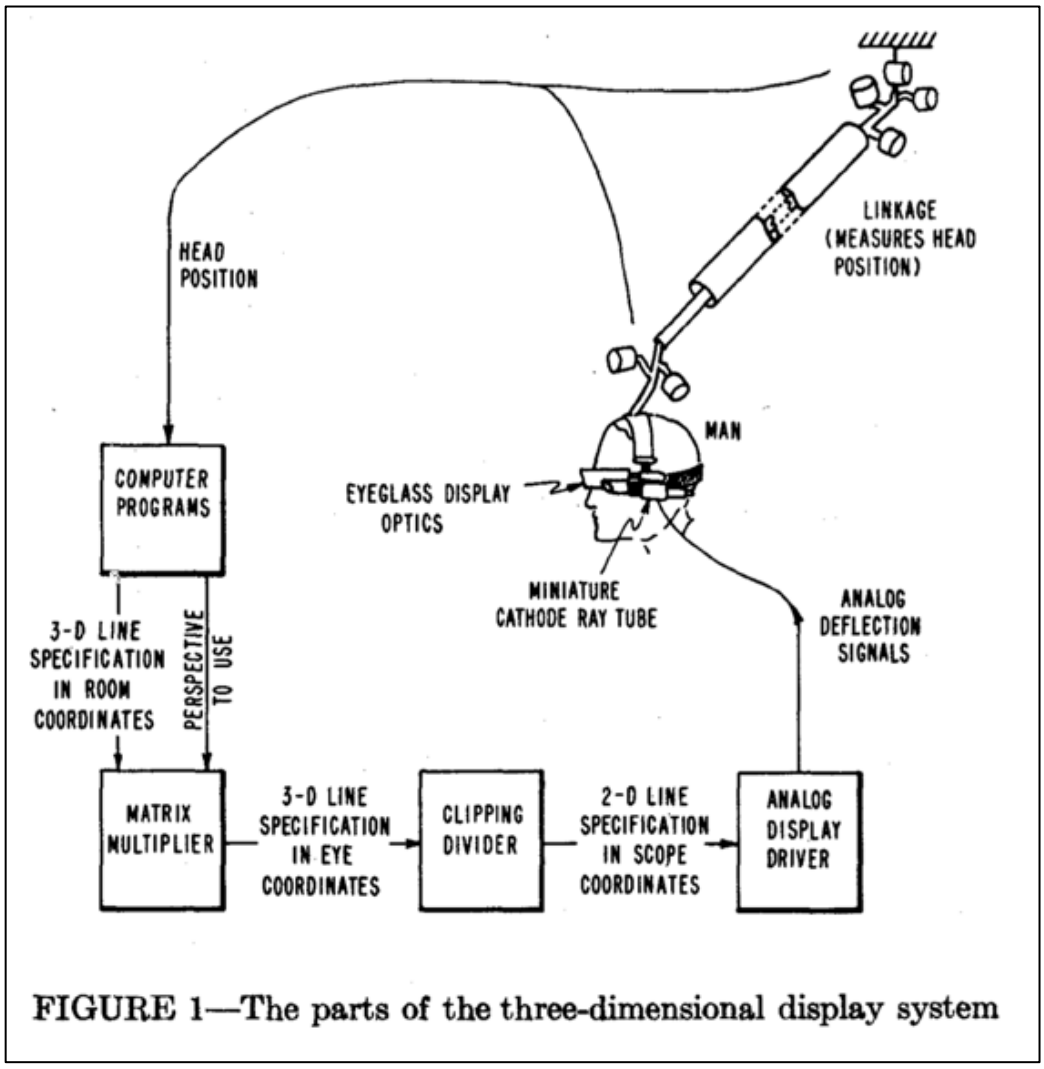


FIGURE 1—The parts of the three-dimensional display system

Sutherland, *A Head-Mounted Three Dimensional Display* (1968) ("Sutherland 1968") EX1015, Fig. 1 (Sutherland's three-dimensional display system); *see also id.* at Figs. 2-4 (photographs of Sutherland's prototype system, showing for example a custom graphics computer, a head tracking system, and a head-mounted display):

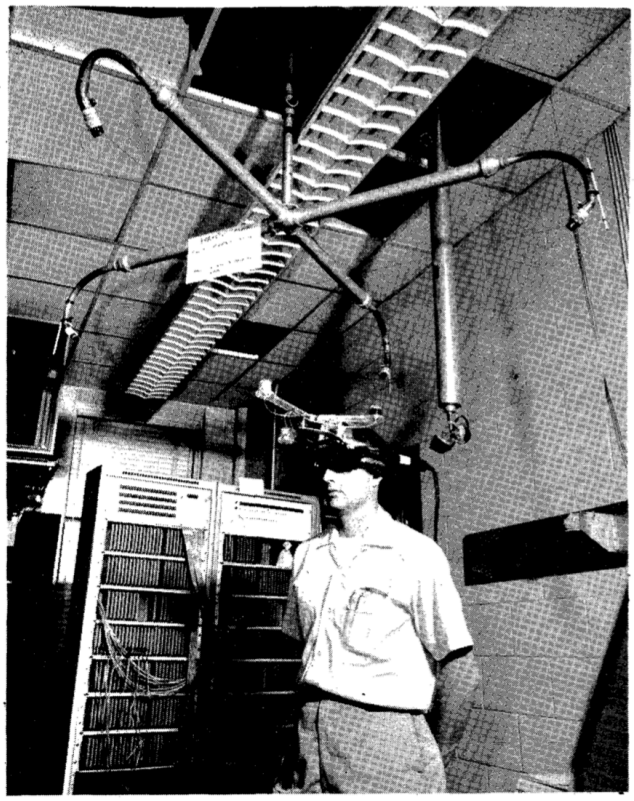


FIGURE 3—The mechanical head position sensor in use



FIGURE 4—The ultrasonic head position sensor in use

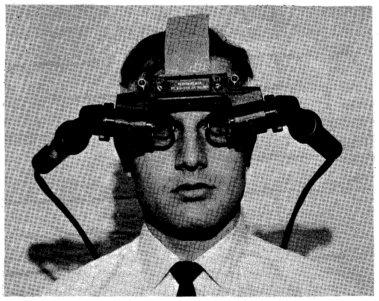


FIGURE 2—The head-mounted display optics with miniature CRT's

34. Sutherland's work above offers one of the earliest examples of wearable electronic devices for displaying computer-generated "virtual" content to users. Such systems continuously estimated or "tracked" the position and orientation ("pose") of a user's head in a coordinate system corresponding to real, physical space, mathematically transforming pose estimates into a coordinate system corresponding to virtual space, rendering the virtual environment, and displaying it in a head-worn device, e.g., with a head-mounted display ("HMD").

35. The notion of Virtual Reality on a handheld device originated at least as early as 1993. For example, in that year George Fitzmaurice et al. published two relevant articles: "Virtual Reality for Palmtop Computers" ("Fitzmaurice") EX1016, 197 and "Situated Information Spaces and Spatially Aware Palmtop Computers" ("FitzmauriceB") EX1017, 39.

36. The first article, "Virtual Reality for Palmtop Computers," appeared in the July edition of the ACM Transactions on Information Systems. In that article, Fitzmaurice et al. described how they were "exploring how virtual reality theories can be applied toward palmtop computers." EX1016, 197. They introduced a prototype, called the "Chameleon," which comprised a hand-held "palmtop" computer with a 4-inch monitor and six degree-of-freedom (6 DOF) tracking to "detect user gestures and input selections for issuing commands." *Id.*, 197. They also discussed how their "palmtop VR" fit in the general context of Virtual Reality, such as the work that originated with Ivan Sutherland et al. above. For example, they wrote that:

> "[T]here are a set of head-mounted display (HMD) systems [Sutherland 1968] which position a small monitor directly in front of one or both eyes, similar to a pair of goggles. As the user moves his or her head, the displays are updated to reflect the new viewpoint." *Id.*, 198.

They also wrote that:

> "Two seemingly disparate approaches have been pursued in the VR community: outside-in systems—simulating 3D environments within the 2D computer screen (e.g., rooms, information visualizer, and cone trees [Card et al. 1991]—and inside-out systems—virtual-reality environments in which users are completely immersed into an artificial 3D space by wearing a head-mounted display and, potentially, a DataGlove." *Id.*, 199.

I have included Figure 8c from (*Id.*, 211) below, which shows a user moving the palmtop virtual reality device until a cursor displayed in the window (the display) appeared to be positioned over the real box on the table in front of him.

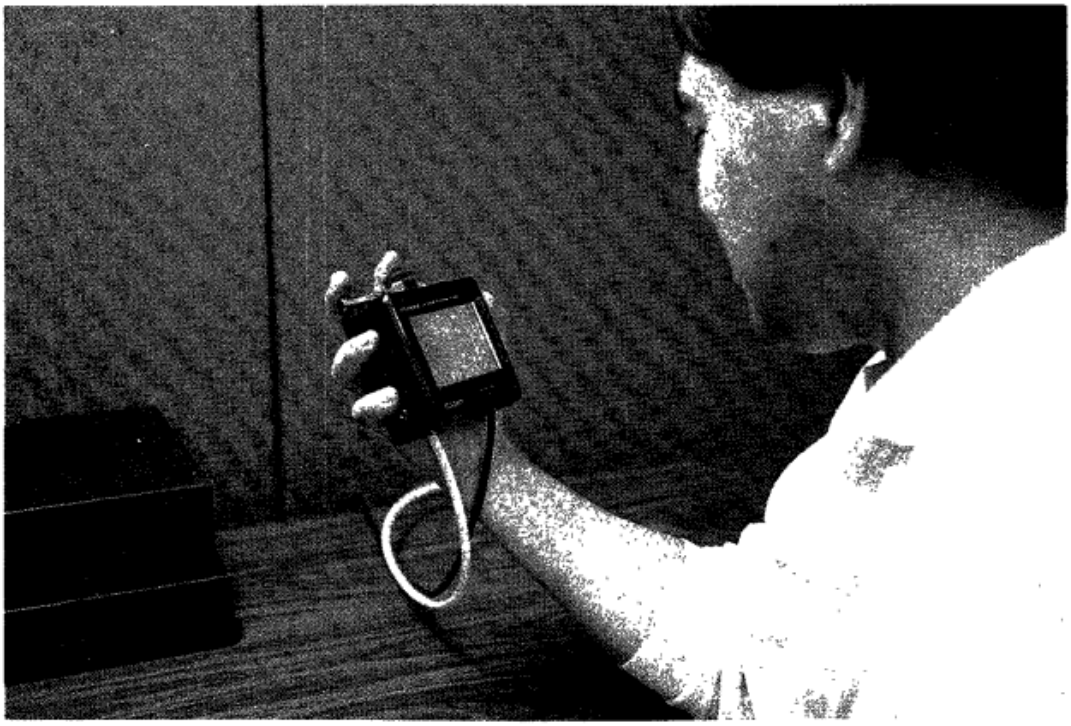


Fig. 8c. Third experiment condition consisting of a small 4-inch monitor, dynamic display using the palmtop virtual-reality system for input.

37. The second article, "Situated Information Spaces and Spatially Aware Palmtop Computers," appeared in *Communications of the ACM* (Association of Computing Machinery) in July of 1993. EX1017, 39. In that article, Fitzmaurice conveyed the idea that "[a] small, portable, high-fidelity display and spatially aware palmtop computer can act as a window onto the 3D-situated information space-providing a bridge between the computer-synthesized data and physical objects." *Id.*, 39. I have included Figure 3 from that article below, with the caption superimposed by me in the upper right.

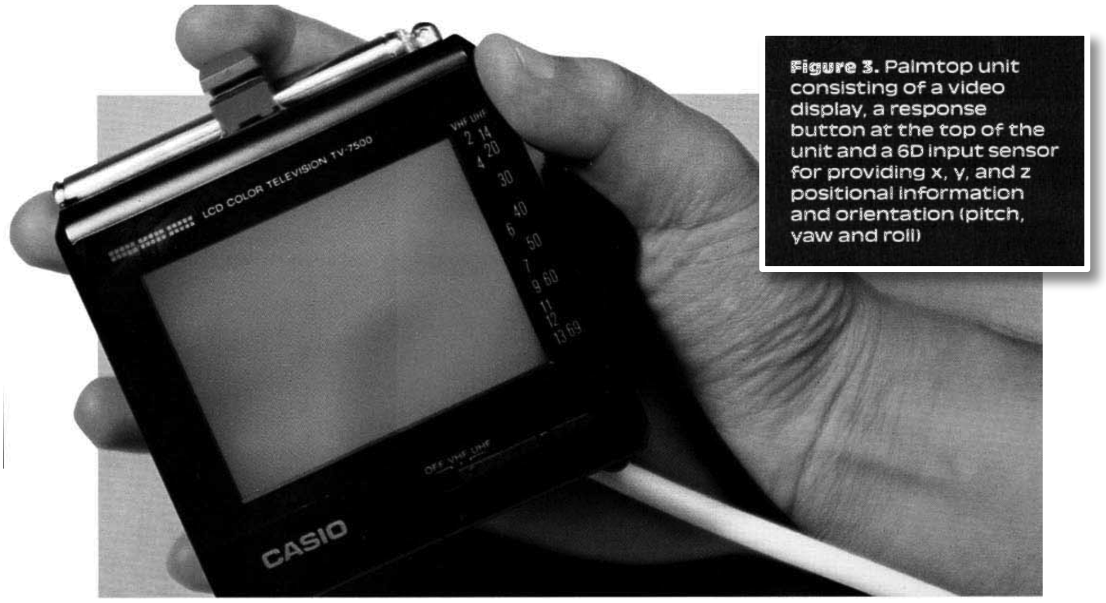


Figure 3. Palmtop unit consisting of a video display, a response button at the top of the unit and a 6D input sensor for providing x, y, and z positional information and orientation (pitch, yaw and roll)

38. FitzmauriceB discussed how "palmtop computers designed with a high-fidelity monitor can become spatially aware of their location and orientation and serve as bridges or portholes between computer-synthesized information spaces and physical objects." *Id.*, 42. In other words, the device could act as a dynamic window

into a virtual world, where movement of the handheld device in the *real* world causes corresponding movement in the *virtual* world, as seen through the "window" (the display). FitzmauriceB described how such a handheld device could be used to see and interact with things in the virtual world:

> "In order to allow users to select objects within the **virtual world**, a cross-hair cursor is fixed in the center of the screen. Users line up target objects over the cross-hair and click (or in some situations double-click) on the response button. This causes an imaginary ray centered at the cross-hair to emanate from the palmtop unit toward objects in the **virtual world**." *Id.*, 43 (emphasis added).

39. In his concluding thoughts, Fitzmaurice summarizes his idea for situated information spaces and spatially aware palmtop computers:

> "Electronic information will be available everywhere. In order to avoid being flooded and overwhelmed with the quantity of information, we need to adopt the notion of situated information spaces. The electronic information associated with physical objects should be collected, associated, and collocated with those objects. The physical objects anchor the information, provide a logical means of partitioning and organizing the associated information space into "hot spots," and serve as retrieval cues for users."

Id., 48. The concept of computation that is dependent on the location became known as *location-based computing*, and retrieval of spatially relevant information became known as *location-based services*.

B. Location-Based Virtual and Augmented Reality Gaming.

40. In 1994, following the work of Fitzmaurice et al. that I described above, Bill Schilit and Marvin Theimer published an article titled "Disseminating active map information to mobile hosts," where they discussed the idea of mobile distributed computing over wider physical areas:

> "In recent years an extended form of computing has emerged, called **mobile distributed computing**, in which users interact with many different mobile and stationary computers over the course of the day. Computation no longer occurs at a single location in a single environment, but rather spans a multitude of situations covering the office, meeting room, home, airport, hotel, plane, etc." EX1018, 1 (emphasis added).

They explained the necessity for knowing the *location* of the mobile device in such mobile distributed computing:

> "As users move about, the sets of mobile and stationary objects they interact with may change, producing a highly dynamic execution environment in which **location** is important. **Location information is necessary for users and applications that want to query and interact with nearby devices and**

> **services**. Such information also allows stationary clients to track moving objects. In general, **location information enables software to adapt according to its location of use, the collection of nearby people and objects, as well as the changes to those objects over time**. We use the term context-aware computing to describe software exhibiting these general capabilities." EX1018, 1-2 (emphasis added).

41. Over next decade, location-based applications, including location-based games, grew increasingly popular and sophisticated. By 2001, researchers in Sweden had developed a location-based game called "Pirates!" — which comprised "a fantasy archipelago setting, where each player takes on the role as the captain of a ship." EX1019, 1. The players each had a handheld device that could be located in the real world. "In Pirates!, a player's location in the game arena dictates the game events, such as the possibility to explore an island, or engage in combat with another player." EX1020, 2. As the player moved around the real world, they were simultaneously moved in the virtual world, such that "walking between different places in the game arena, becomes equivalent to sailing between islands on ocean. As a player enters the proximity of an island, or another ship in the game arena, he or she has the choice to make landfall and explore the island or engage in battle, respectively." EX1020, 1. Below I have reproduced Figure 2 and Figure 3 from EX1019, including the figure captions.



Figure 1: Screen shot when sailing the open sea in Pirates!



Figure 2: The initial view when exploring an island.



Figure 3: A two-player combat scene.

EX1019, 3.

42. At least by 1998, researchers were developing location-based games involving first-person Augmented Reality (AR) systems, where a user could move around outdoors and see the real physical world around them with spatially integrated virtual objects and beings all around them. At that time, AR systems typically used what are called "video see-through" head-mounted displays (HMDs). The HMDs would be worn on the head such that one or more displays on the inside were positioned in front of the user's eyes as shown in the two images below.



Left: Figure 3 from EX1021, 78. Right: Figure 12 from EX1006, 114.

43. Outward facing cameras mounted on the front of the HMDs would capture live video of the real world, which was sent to a computer (typically worn in a backpack at that time), and then displayed on the display inside the HMD, such that the user could see it. In some ways, the setup is not unlike viewing the screen on a digital camera if you held it in front of your face, however the computer could also add (overlay) virtual imagery onto the video feed from the real world, thus *augmenting* your view of the real world, as shown in the images below, which show HMD views from the same systems as shown above.



Left: Figure 7 from EX1021, 81. Right: Figure 7 from EX1006, 112.

44. The left-side images shown in above (Figure 3 and Figure 7 from EX1021) are from the 2002 paper "First person indoor/outdoor augmented reality application: ARQuake." EX1021, 75. The ARQuake system was a first-person indoor/outdoor AR application developed by Bruce Thomas et al. to replicate the popular game Quake (idSoftware) outdoors. The system used a body-worn AR system that used GPS, a digital compass, and fiducial vision-based tracking to track the person as they moved around a large outdoor space and even into certain indoor spaces, collaborated with other users to explore the real-virtual space, shot virtual monsters, and collected virtual objects.

45. The right-side images shown above (Figure 12 and Figure 7 from EX1006) are from a 2003 paper by Adrian Cheok et al. and titled "Human Pacman: a sensing-based mobile entertainment system with ubiquitous computing and tangible interaction." Adrian Cheok et al. developed multiple VR and AR

experiences and games, including Touch-Space, a "novel computer entertainment system which recaptur[ed] human touch and physical interaction with the real-world environment as essential elements of the game play, whilst also maintaining the exciting fantasy features of traditional computer entertainment," (EX1033, 430), and Human Pacman, which "strives to bring the computer gaming experience to a new level of emotional and sensory gratification by embedding the natural physical world ubiquitously and seamlessly with a fantasy virtual playground." EX1006, 106. The latter is a real working version of the virtual PACMAN game contemplated in the '270 patent, e.g., see the '270 patent at 3:30–4:4.

C. User Devices in VR and AR Location-Based Games.

46. While mobile personal computer devices ("mobile devices") are sometimes organized into categories corresponding to form factor or intended use, e.g., handheld, wearable, or head-mounted, they are all computers, and all have various forms of input and output. Forms of direct manual input can include keyboards, mice, joysticks, buttons, and dials. While one could certainly use a keyboard to enter their position and orientation, systems for estimating ("tracking") the position and/or orientation ("pose") can provide continuous automatic input to a personal system in the form of the estimated pose of the device. Real-time tracking information can be used by the system for location-based computing to, for example, look up, calculate, and/or display objects depending on the pose.

47. The most common form of output is that of a visual display. In some systems, a display might be integrated into a handheld component, e.g., with smart phones and handheld computers, as in the work of Fitzmaurice et al. that I described above (EX1016), whereas in other systems, the display might be integrated into a head-worn component, e.g., a HMD such as that used by Sutherland et al. described above.

48. HMDs are typically classified according to their capabilities and intended use. In particular, people often use the terms "Virtual Reality HMD" (VR HMD) or "immersive HMD" to refer to HMDs that only display computer-generated content to the user, i.e., the user cannot see the real world around them. Correspondingly, people often use the term "Augmented Reality HMD" (AR HMD) or perhaps "AR goggles" to refer to HMDs that are designed to show the user computer-generated imagery superimposed on a view of the real world. In other words, VR HMDs can be thought of as completely *replacing* the user's view of the real world, whereas AR HMDs can be thought of as *augmenting* the user's view of the real world.

49. Within the realm of AR HMDs, there are two common approaches to augmenting the user's view of the real world: the "video see-through" approach and the "optical see-through" approach. A popular article by Ron Azuma from 1997 ("A

Survey of Augmented Reality" (EX1022, 1) includes two often cited and replicated figures to illustrate the two approaches, which I have reproduced below.

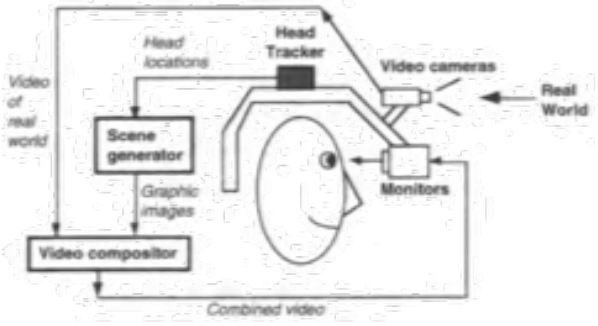


Figure 13. *Video see-through HMD conceptual diagram.*

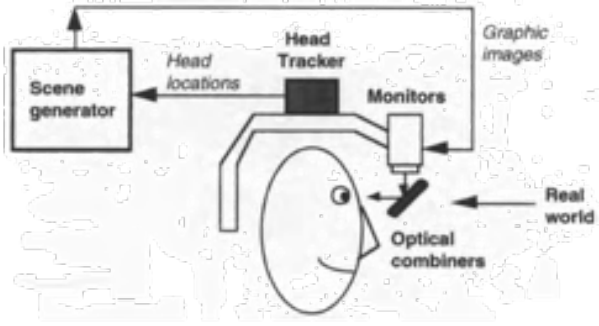


Figure 11. *Optical see-through HMD conceptual diagram.*

Figures 13 (left) and 11 (right) from EX1022, 11.

50. The *video* see-through approach, which I discussed some above in the context of location-based AR games, is depicted on the left above (Figure 13 from EX1022, 11). In video see-through systems, a forward view of the real world is continuously captured by one or more forward-facing cameras mounted on the HMD, the imagery is sent to a video compositor (a computer) where it is combined with computer-generated/virtual imagery, and the resulting combined video is sent to displays ("monitors" in the figure) that are not transparent. The result is that as a user moves around, they see the real world augmented by virtual imagery.

51. The *optical* see-through approach is depicted on the right (Figure 11 from EX1022, 11). In optical see-through systems, an optical combiner element, e.g., a half-silvered piece of glass, combines an actual view of the real world (i.e. the photons from the objects pass through the combiner) with computer-

generated/virtual imagery sent to the same optical element (e.g., reflected from a display mounted above the optical element — "monitors" in the figure), and the resulting optically combined imagery is seen by the user. As with the video see-through approach, the result is that as a user moves around, they see the real world augmented by virtual imagery.

52. While the video see-through and optical see-through approaches generally achieve the same result — the user sees the real world augmented by computer-generated (virtual) imagery — the end result is somewhat different due to the different approaches, and there are tradeoffs. For example, in the case of the video see-through approach, the system can directly replace or cover up anything from the real world, because it can completely replace pixels in the video. However the resolution of such systems is limited by the resolutions of the cameras and the displays, and such systems will always have some added delay in the imagery. In the case of the optical see-through approach, because the system is optically combining video from the display with photons from the real world, i.e. it is adding the light from the display and the real world, it cannot always replace or cover up things from the real world. For example, overlaying any virtual imagery over a bright object in the real world, e.g., a light, can result in the real imagery "swamping" the computer imagery. This is particularly common outdoors, where the system has to compete with light from the sun. Conversely, displaying dark virtual objects does

not typically work well, because darkness in computer graphics system typically corresponds to color values of 0, which in an AR display will appear transparent. So as AR virtual imagery becomes dark (e.g., when rendering dark colored virtual objects) it becomes transparent. However, with an optical see-through system the user's view of the real-world is generally as good as their natural eyesight in terms of resolution, and there is no added delay.

53. Communication between mobile devices, and between any mobile device and the nearby communication infrastructure is typically achieved using some form of electromagnetic radiation, e.g., infrared (IR) light or radio frequency waves. Two examples of devices that communicated via IR light are the Palm III device released in 1998 and the Nokia 8210 mobile phone released in 1999. They used the Infrared Data Association (IrDA) protocols to communicate serially with another device over a relatively short distance, e.g., a meter. IrDA was typically used to transfer data between devices including personal computers.

54. Communication via radio frequency (RF) waves is far more common. Voice communication over RF using cellular phones dates back to the late 1970s. EX1023. The 1980s saw the development of the Global System for Mobile Communications (GSM) standard for data communications. Some of the earliest mechanisms were the multimedia messaging capabilities afforded over the cellular communications networks. Those methods include short messaging service (SMS),

the enhanced messaging service (EMS), and the multimedia messaging service (MMS). These mechanisms were widely in use prior to 2003. EX1024, 431.

55. The concept of a general-purpose wireless local area network (LAN) has been around since the 1970s, but commercial wireless LAN devices only started becoming available in 1990. EX1025, 118. NCR introduced WaveLAN in 1991, and Lucent Technologies, who had played a leading role in driving the Institute of Electrical and Electronics Engineers (IEEE) 802.11 wireless standard, introduced WaveLAN-II in 1998. *Id*. Two examples of handheld mobile devices that used general-purpose RF network communications include the Palm VII device (1999–2000), which had an antenna for accessing wireless network services (EX1026, 119), and the HP Jornada (1998–2002) which included a PC Card Slot (EX1027, 12) that could accommodate a WaveLAN wireless card. For example, the mobile devices used in the location-based game Pirates! that I described above was an HP Jornada 690 with an IEEE 802.11 WaveLAN card. EX1019, 4. Body-worn Virtual Reality and Augmented Reality systems for location-based games also used wireless LAN cards. For example, the body-worn AR system developed by Thomas et al. for their ARQuake system used a WaveLAN card (EX1021, 84), and the mobile system developed by Cheok et al. for their Human Pacman game were Cisco Aironet Wireless LAN PC Cards. EX1006, FIG. 4. These wireless communication cards

allowed the mobile devices used by Thomas et al. and Cheok et al. to communicate over their standard campus 802.11 wireless networks.

56. Aside from user tracking, which I discuss in the next section, there are several common mechanisms for user input for mobile devices. For most mobile devices, a traditional QWERTY keyboard is not practical. Instead, for alphanumeric input, researchers and practitioners have turned to alphanumeric input devices that can be operated in one hand, out of sight, or remapped other user motion to input controls. An example of the former is the Twiddler2, a handheld "chorded" keyboard and mouse used by Cheok et al. with their Human Pacman game. EX1006, 110. Such chorded devices were designed to be operated with one hand, out of sight, by pressing combinations of buttons (chords) to indicate particular input. Thomas et al. determined that they generally did not need alphanumeric input, and so they programmed ARQuake to use a combination of head and body movement along with buttons (e.g., on the two-button haptic gun input device), to affect the necessary input/control.

57. The most common additional element of the user interface for mobile devices is the graphical interface realized with the display and other manual input devices. In some circumstances, this is not that different from the traditional "WIMP" metaphor (Windows, Icons, Mouse, and Pointer), but it is typically implemented with less complexity and larger icons or buttons, etc. because the user

is generally less precise in their control of input devices while moving. As can be seen in Figure 7 from EX1006 (above), the graphical user interface in the HMD for the Human Pacman game of Cheok et al. includes virtual buttons on the display, such as "Request Update." The user would use their thumb on the "mouse" on the Twiddler2 to control a cursor and select items on the display, e.g., a button or an item from a visual menu.

58. Below I include images from EX1021, 77 and EX1006, 110 that show the respective complete body-worn systems, including the manual input devices, tracking devices, and head-mounted displays.



Figure 2 from EX1021 (left) and Figure 4 from EX1006 (right).

D. User Tracking in Location-Based Games

59. For any human-made system that has any relationship to spatial location and/or orientation, the notion of a *coordinate system* comes into play. In the context of location-based computing, a coordinate system is a geometric reference framework used to define the position and orientation of entities in a space, e.g., a two-dimensional (2D) space in a planar grid, or the three-dimensional (3D) space where we live. The entities include points, objects, services, events, and even other (nested) coordinate systems.

60. A coordinate system consists of four primary components:

- A fixed reference point that establishes the position of the coordinate system in an enclosing "parent" coordinate system that is typically located at the spatial coordinates (0,0) in 2D, or the spatial coordinates (0,0,0) in 3D (e.g., root). The root of a coordinate system itself has a position and orientation in the parent coordinate frame, and that position and orientation can be changed.
- A set of mutually orthogonal lines in the space that establish the bases for independent directions (e.g., axes). For example, in 2D space the axes are typically labeled *x* and *y*, and in 3D space they are typically labeled *x*, *y*, and *z*. Points in the space can be defined *along* the axes, and rotations about a point can be defined *around* the axes.

- A representation of the measurement system being used along the axes, e.g., meters or inches, and around the axes, e.g., degrees or radians (e.g., units).
- A way of defining how the order of the axes corresponding to coordinates in the space (e.g., orientation). For example, a 3D coordinate system can be considered right-handed or left-handed, where the *x*, y, and z axes correspond to the fingers of the left or right hand, when held in a particular configuration.

61. Any 3D object in a 3D space has, or can be given, a 3D coordinate system. In general, when one refers to the "position" of the object in 3D, one is referring to the position of the root of the object's 3D coordinate system in the parent's 3D coordinate system. For example, a chair in a room would have a 3D coordinate system. If the chair had four legs, the root might be defined as being at the bottom of the back-left leg, with the *x* axis extending from the root toward the back-right leg, the y axis extending from the root toward the front-left leg, and the *z* axis extending from the root upwards. Similarly, the room itself would have a 3D coordinate system, with the *x*, *y*, and *z* axes defined appropriately in that space. The chair's root would have the x, y, z, coordinates (0,0,0) in its own coordinate system. Similarly, the room's root, which might be defined in one of the corners of the room, would have the x, y, z, coordinates (0,0,0) in its own coordinate system. However,

the chair's root is most likely *not* (0,0,0) in the *room's* coordinate system — it is most likely positioned somewhere in the interior of the room, not in the corner, for example, at room coordinates (1,1,0) to represent one meter into the room along the *x* and *y* axes, and on the floor ($z = 0$). Any object (defined by its own coordinate system) can be translated and rotated in its parent coordinate system by using linear algebra. For example, the chair could be moved an additional meter along the *x* axis of the room, resulting in the chair being at (2,1,0) in the room coordinate system. Similarly, the chair could be rotated around any of the axes of the room coordinate system using linear algebra, for instance, to rotate the chair to the "left," one would use linear algebra to rotate the chair's coordinate system 90° counterclockwise around the *z* axis (up).

62. Further, both real and virtual spaces have independent coordinate systems. While it is possible that the roots of the real and virtual spaces would coincide, it is unlikely. For example, if a VR game played on a tablet, a smart phone, or an HMD was launched while standing at near the southwest corner of Central Park in New York City, e.g., at the corner of Central Park W and W 59th Street, the root of the virtual world of the game, which is (0,0,0) in the coordinate system of the virtual world of the game, would be positioned at a corresponding latitude, longitude, and elevation such as (40.768°, -73.981°, 1601 feet) in the coordinate system of the earth — the earth's *x*, *y*, and *z*. However, if the same game was

launched while standing in the Bronx Zoo, the root of the virtual world of the game would be positioned at something like (40.850°, -73.880°, 280 feet) in the coordinate system of the earth. In either situation, the root of the virtual world in the coordinate system of the *virtual world* would *remain* at (0,0,0), while the root of the virtual world in the coordinate system of the *earth* would *change*.

63. One result of nested coordinate frames such as that I described above, is that any point in either the real or virtual world corresponds exactly to a point in the other world. In addition, translating an object one meter in some direction in one world, e.g., along one of the earth's axes, would typically result in corresponding translation along the aligned axes of the virtual world's coordinate system, in whatever translational units and scale are appropriate. Similarly, rotating an object 90° around some axis in one world, e.g., around the vertical axis, would typically result in corresponding rotation around the aligned axes of the virtual world's coordinate system, in whatever rotational units and scale are appropriate.

64. For a typical location-based game, or a typical VR/AR application, the position and orientation of the display and/or the user's head must be estimated, so that the appropriate imagery can be shown. This is very much like the navigation systems in our smart phones — as we drive around, the unit is continuously determining our position and direction of travel on earth, and rendering the map appropriately, so that we can see where we are on the map. There are many ways to

estimate the position and orientation of a device or a person's head, hands, etc. I have published several articles on this topic, including for example my article "Motion Tracking: No Silver Bullet, but a Respectable Arsenal" with Eric Foxlin EX1028, 24 and the course notes from the ACM SIGGRAPH 2001 course "Tracking: Beyond 15 Minutes of Thought" with Danette Allen and Gary Bishop. In the following I provide a relatively brief overview of some relevant mechanisms.

65. Using latitude, longitude, and elevation (lat-lon-el) coordinates in the earth (real world) coordinate system as I did above, corresponds to the most commonly used outdoor positioning system in the U.S.: the Global Positioning System (GPS). The GPS system comprises a collection of satellites that orbit the earth in precise patterns while transmitting a radio signal toward earth, a receiver that receives the signals on earth, and a computational unit that estimates the 3D (lat-lon-el) position of the receiver on earth. The computation is based on the time it takes each signal to reach the receiver, which necessitates very precise system clocks. For various reasons, including ill-conditioned geometric positions of the satellites at any one moment, buildings or trees that block or reflect the radio signals, and the intentional injection of controlled error (to deny enemies useful accuracy), the error in the 3D position reported by a GPS receiver can vary significantly over time, e.g., typically 3–10 meters, in the best case 1–3 meters, and in the worst case more than 10 meters. In general, if one knows the 3D position of a fixed object in

the earth's coordinate frame, e.g., a particular grocery store, then a system can use GPS to estimate the position *relative* to that point, e.g., to help one navigate to the grocery store.

66. Position and orientations estimations can also be aided by other sensors, e.g., inertial sensors and/or an electromagnetic compass. However, inertial sensors, e.g., linear accelerometers and angular rate gyros, only measure changes in position or orientation over time, and so the measured values must be integrated (summed over time) to produce estimates of change in position or orientation. For example, linear accelerometers measure the second derivative of the position with respect to time along the primary axis of the sensor, and angular rate gyros measure the first derivative of the orientation with respect to time around the primary axis of the sensor. Devices that make use of an approach like this (e.g., dead-reckoning modules), along with a history of position, speed, and direction estimates, to continually estimate the *change* in position, from a starting point, over time.

67. A significant problem with the integration of the measured accelerations and rates in all such systems is that inevitable measurement noise is integrated along with the true inertial values (which are unknown/unmeasurable), which results in the estimates drifting over time. In the case of linear accelerometers, the measured values must be integrated twice over time (they produce the second derivative of the position over time), which means both the estimates and the

uncertainty in the estimates can drift at a super-linear rate, e.g., quadratically with time. As such, accelerometers and gyros cannot practically be used alone to estimate the position and orientation of a device for any application, including location-based gaming. In fact, every measurement device has problems. For example, electromagnetic compasses can be affected by significant magnetic interference from objects around the device, and even the device itself.

68. These issues with GPS, inertial, and magnetic sensors are some of the reasons why one will always see systems employing multiple modalities, i.e. hybrid systems. For example, today's VR and AR systems typically combine GPS, inertial sensor measurements, electromagnetic compass measurements, and camera imagery to estimate the position and orientation of the device. Sensors that calculate a device's position when GPS signals are unavailable (e.g., dead-reckoning modules) typically do the same, although without camera imagery.

69. Modern devices, including both handheld devices and VR/AR HMDs, benefit tremendously from the commoditization of the smart phone, and the competition that has driven the quality of displays, tracking, and computing upwards, while driving the size, weight, and power requirements downwards. To a large extent, and sometimes literally, today's HMD-based VR/AR systems actually use smart phones internally. At the very least, they use the components and algorithms from smart phones, as they are being continually refined.

E. Navigation and Spatial Awareness.

70. As reported by Darken and Cevik in 1999, when navigating a virtual world using a map, the way one navigates depends on the orientation of the map or displayed representation with respect to the user's frame of reference, either an egocentric reference frame (ERF) or a world reference frame (WRF). EX1011, 1. The authors report that the two most common relationships are *north-up* and *forward-up*. *Id*. This is also true for most navigation devices or smart phones. The north-up approach fixes the orientation of the map such that the direction corresponding to north is always towards the top of the display. Even if a user rotates to the right, for example, the orientation of the map remains fixed such that north is up (with respect to the display), east is to the right, etc. The forward-up approach continuously adjusts the orientation of the map such that it is always congruent with the forward direction of the user. So if the user is facing north, the map is oriented so that north is up. However, if the user rotates to the right, the map also rotates, so that now east is up (with respect to the display), south is to the right, etc. As the user rotates, the map continuously re-orients to match the direction they are facing. Both modes typically include a "you are here" (YAH) indicator, e.g., a small dot or symbol that indicates your position in the map. In either case, the YAH marker can be chosen to convey the orientation of the devices, e.g., a cone. *Id.*, 3.

71. Some users prefer one, and some the other. Users might even switch between the two, depending on the task or circumstances. For example, Darken and Cevik report that targeted search tasks, e.g., looking for a particular item, rely on the user's immediate perspective (egocentric reference frame), and are thus more efficient with forward-up maps. *Id.*, 5. On the other hand, tasks that are intended to develop an understanding of the overall environment in the world reference frame benefit from north-up maps. The authors also indicate that one's ability to mentally rotate objects can play a significant role in navigation efficiency: users with strong mental rotation skills perform better across both map types, whereas users with lower spatial abilities perform better with forward-up maps as they reduce the need for mental rotation during navigation. *Id*.

72. Darken and Cevik discuss first-person games such as DOOM™. They report that "[w]hile searching tasks are most prevalent in games such as DOOM™* and its derivatives, there is also a strong demand for configuration knowledge†. Players who learn optimal paths and alternate paths through these environments have an advantage over those who are unfamiliar with the space." *Id.*, 1. This makes sense, as those who learn the space better, and the surprises it holds, will likely fare better in the game. They also report that "[w]hen in map mode, DOOM™ players can move themselves in the environment by manipulating the YAH marker on the map (see figure 1)." *Id.*, 2.

73. As I indicated above in the previous section, the root of the coordinate system of a virtual world can be moved around in the coordinate system of the real world. In my example above, the user could start the game while standing near the southwest corner of Central Park or standing in the Bronx Zoo; in either case the game would start from the same place in the virtual world, but different places in the real world. This same principle applies to orientation: if a game always starts with north facing upward on the display, one could start the game facing north in the real world, in which case the north of the real and virtual worlds would be colinear (the same), or one could start the game facing some other direction, e.g., east, in which case eastward movement in the real world would cause northern movement in the virtual world.

74. If one was playing a location-based game in an infinitely large space, the relative orientations of the real and virtual world coordinate systems would not matter — the user could walk as far as desired in any direction in the virtual world and never face the issue of running out of space, or running into something, in the real world. However, in the real world, we do not have infinite space. Any location-based game that seeks to correlate real world movement with virtual world movement must contend with the limitations of the real world, even if the virtual world has no such limitations. For example, one might hope to walk for a long distance in the virtual world displayed on the device, but encounter something in the

real world that precludes forward motion, e.g., a dead end or a building. In such a situation, if the user wants to continue forward in the virtual world, they or the system needs to change the relative orientation of the real and virtual worlds — in effect they need to change the notion of what "forward" means in the real world. For example, if a user is walking down an alley in the real world, and reaches a dead end, if they want to continue "forward" in the virtual world the only option is to rotate the virtual world by 180° so that the user is able to turn around and walk in the reverse direction down the alley, while seemingly continuing to walk "forward" in the virtual world.

75. As early as 1990 (at least), researchers were developing mechanisms to interactively change one's viewpoint. For example, Colin Ware and Steven Osborne wrote that "[i]t is also possible to use the "scene in hand" metaphor to change viewpoints; by selecting the root object in the heirarchical [sic] scene and twisting the bat, the virtual environment is rotated about the center of the root object." EX1029, 176. The authors describe this as "akin to having an invisible mechanical linkage which converts all hand translations and rotations into translations and rotations of the scene (see Figure 2)." *Id.*, 177. I have reproduced Figure 2 from that 1990 paper below.

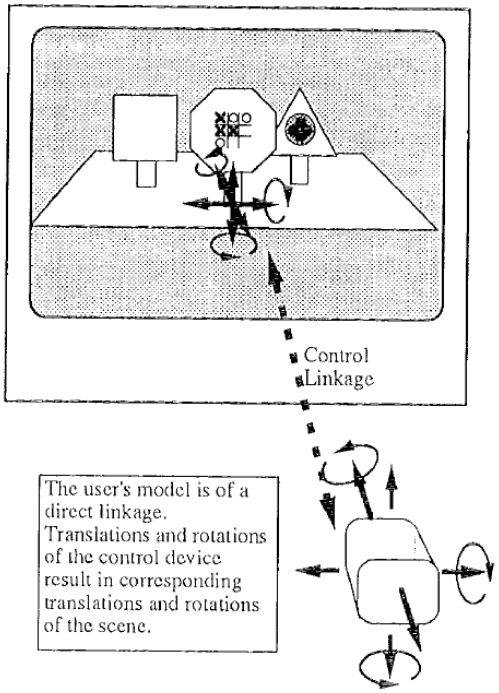


Figure 2. Scene in hand metaphor

76. In his 1999 Ph.D. dissertation, Doug Bowman included "Indicate Orientation" (and "Indicate Position") as a top-level technique in his "Alternate Taxonomy for Travel Techniques." EX1030, Figure 4.7. He described specifying viewpoint orientation (and position), writing "[w]e recognize that the task of viewpoint motion control consists mainly of two parts: setting viewpoint position and **setting viewpoint orientation**. Within each of these parts, there are two quite different methods one might employ. **One might specify the destination or target** position/**orientation**. This is a discrete, one-time selection." *Id.*, 44 (emphasis added).

77. In her 2002 Ph.D. dissertation titled "A new taxonomy for locomotion in virtual environments," Laura Arns writes: "[s]ince we are still subject to this physical limitation while using the VR system, and unable to fully rotate our body with respect to the virtual world, we can instead rotate the virtual world with respect to us." EX1031, 56. Arns went on to describe how this is "most commonly performed," saying "[r]otation of the virtual world is most commonly performed using an interaction device such as a wand. Generally, there is a "home" orientation for the device, so that when the device is in the home position no rotation of the virtual world occurs. However, when the interaction device is changed to a new orientation, it causes the virtual world to rotate around the user or the interaction device." *Id*.

78. Because necessary manual interventions by the user to change their orientation were found to be disruptive, by 2001 Sharif Razzaque et al. had been working on ways to automatically rotate the virtual world without the user being aware. The approach, which they called *redirected walking* (EX1032, 1), allowed for the continuous imperceptible rotation of the virtual world to address the issue of real-virtual conflicts.

VI. BACKGROUND.

A. The '270 Patent.

79. I understand that the '270 patent claims priority to two provisional applications, U.S. Provisional Application No. 60/499,810, filed September 2, 2003 ("the '810 provisional") and U.S. Provisional Application No. 60/603,481, filed August 20, 2004 ("the '481 provisional"). A patent application claiming priority to those provisional applications was filed on September 1, 2004 and eventually issued as U.S. Patent No. 11,033,821. The '270 patent application was filed as a continuation of the '821 patent application and claims priority to the '821 patent and the '810 and '481 provisional applications.

80. The '270 patent describes well-known systems that employ wireless communication devices with locating and directional devices to allow multi-user gameplay in a virtual world. *See generally* EX1001. The '270 patent generally focuses on "an actual, reality-based video game in which a user's physical (actual) location on a playfield, reflects a virtual game character's virtual location in a video game environment." EX1001, 2:28-31. For example, the '270 patent describes a multiplayer virtual PACMAN game as an example of a reality-based video game, where one player may "[c]ontrol…PACMAN…by changing the location of the wireless [device]" and "[a] different player could use a different game system…to control a ghost in the same game." *Id.*, 3:48-55. Each "user may look down at a

display screen, see his/her character, and run around his/her physical environment in order to similarly run his/her virtual character through a virtual maze." *Id.*, 3:57-60.

81. The '270 patent explains that the "[m]ultiple type[s] of displays are provided that realize a variety of different types of location-based games." *Id.*, 2:38-39. For example, a user's gaming device may be a wireless telephone with a display screen (*id.*, 10:29-33) or a device incorporating a head-mounted display (*id.*, 2:52-59). "Location information may be utilized, for example, to determine a virtual character's location (e.g., a particular first-person perspective) in the virtual realm." *Id.*, 3:16-19. "Locating devices" and "directional devices" enable the collection of a user's location information during gameplay. *Id.*, 3:43-4:35. For example, a GPS device may be used as a locating device to obtain a user's location (*id.*, 3:45-48, 4:8-11), while a "directional electronic compass…provided through the configuration of two location devices (e.g., two GPS devices)" may be provided on a head-mounted display as a directional device that determines the direction a user's head is pointing (*id.*, 4:15-28).

B. The Challenged Claims.

82. The '270 patent has twenty claims, and I understand that only five of these claims—independent claim 4 and dependent claims 5, 16, 17, and 19—are challenged. Independent claim 4 generally covers a system with a device that has a

display and graphical user interface ("GUI") that receives two manual inputs—one for setting an origin location for a location reference for gameplay, and a second for setting a directional reference for a direction of gameplay based on the direction of the device. Dependent claims 5, 16, 17, and 19 further require features including resetting of the directional reference during gameplay (claim 5); a power source (claim 16); a wireless communications device through which location information is communicated (claim 17); a head-mounted display and a multiple player location-based game (claim 19).

1. Priority of the '270 Patent.

83. In my opinion, neither the '810 provisional nor the '481 provisional provides written description for independent claim 4 of the '270 patent. Claim 4 requires a "first manual input for setting a origin location" and a "second manual input for setting a directional reference for a direction of gameplay for a virtual character of a location-based game." EX1001, 24:44-49. The first and second "manual input" for both the origin location and directional reference are completely absent from the '810 provisional and the '481 provisional—there is no discussion of "manual input" at all in either. Indeed, the '481 provisional, which describes a flexible keyboard and monitor, does not relate to location or directional setting in a virtual or mixed reality game at all, let alone a manual input for those settings. In

my opinion, then, there is no written description support for the manual input limitations of claim 4. *See also generally* EX1036; EX1037.

84. Because, in my opinion, neither the '810 provisional nor the '481 provisional have any written description support for the manual input limitations of claim 4, I understand that challenged claim 4 and its challenged dependent claims (claims 5, 16, 17, and 19, *see* Sec. VI.B. *infra*) are not entitled to claim the benefit of priority to either '810 provisional or the '481 provisional. I understand that this means that the earliest effective priority date for the claims 4, 5, 16, 17, and 19 is no earlier than September 1, 2004.

C. The Prosecution History.

85. I understand that the initial application for the '270 Patent is U.S. Patent Application No. 11/841,889, which was filed on August 20, 2007, and the U.S. Patent Office rejected the claims in a series of non-final rejections from 2007 until 2019. EX1002, 256-69, 287-93, 315-28, 349-63, 387-402, 426-45, 465-85, 506-22, 540-55, 578-87, 611-20, 642-50, 674-79, 697-704.

86. I understand that issued claims 4 and claim 5 (corresponding to prosecution claims 23 and 24, respectively) appeared in the original set of claims but initially only recited limitations concerning the manual input of a *directional*

reference. *Id.*, 718.[1] Claims 4 and 5 were subject to minimal amendments until March 20, 2019, when Mullen amended claim 4 to additionally recite a manual input for setting an *origin location setting*. *Id.*, 278-78 (adding origin location setting limitations); *see also id.*, 300-01, 334-35, 366-67, 408, 448, 491, 527, 566, 600, 630, 662, 686 (previous amendments). I understand that, despite Mullen substantively amending independent claim 4, the Examiner rejected claim 4 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent App. Pub. No. 2004/0058732 to Piccionelli ("Piccionelli") in view of U.S. Patent App. Pub. No. 2004/0172481 to Engstrom ("Engstrom") and U.S. Patent App. Pub. No. 2003/0224855 to Cunningham ("Cunningham"), and rejected claim 5 under pre-AIA 35 U.S.C. § 103(a) as being unpatentable over Piccionelli and Engstrom and further in view of U.S. Patent App. Pub. No. 2002/0128063 to Kunieda et al. *Id.*, 265-68. However, Mullen was not able to overcome this rejection until Mullen amended claim 4 to

[1] I understand that the claims presented on August 20, 2007, appear to be incorrectly numbered, as there are two claims numbered as "22." EX1002, 717-18. I understand that the second claim 22 (i.e., claim 23) and subsequent claim 23 (i.e., claim 24) are correctly referred to as claims 23 and 24 elsewhere in the prosecution history. *See id.*, 686 (correcting numbering).

further recite that "*said directional reference is operable to be updated during said gameplay*." *Id.*, 244.

87. I understand that on September 10, 2019, both claims were allowed, with the Examiner noting that "[t]he prior art relied upon…teaches that the movement of the character afford a change in the direction of the camera but is silent that this is also an update in an origin of the camera to be equivalent to a reset of the position of the camera." *Id.*, 229. Mullen then requested continued examination and submitted additional claims, including issued claims 16 (corresponding to prosecution claim 34), 17 (corresponding to prosecution claim 35), and 19 (corresponding to prosecution claim 37). *Id.*, 68-69. These additional claims were allowed on August 18, 2020, and the '270 patent issued on April 6, 2021. *Id.*, 43-49; EX1001, 1.

VII. LEVEL OF SKILL IN THE ART AND PERSPECTIVE APPLIED IN THIS DECLARATION.

88. I understand that certain issues relating to validity must be judged from the perspective of a person of ordinary skill in the relevant art, as I discussed below.

89. The purported invention of the '270 patent generally relates to well-known systems and methods of using wireless communication devices with locating and directional devices to allow multi-user gameplay in a virtual world.

90. In determining the level of ordinary skill, I have been asked to consider, for example, the types of problems encountered in the field, prior solutions to those problems, the rapidity with which innovations are made, the sophistication of the technology, and the educational level of active workers in the field. In my opinion, it would have taken at least two years of experience in the field for a person to become familiar with the problems encountered in the field and the prior and current solutions to those problems.

91. A person of ordinary skill in the art ("POSITA") in 2004 would have had at least a bachelor's degree in electrical engineering, computer science, or a similar field, with at least two years of relevant experience working with VR and AR systems. Additional experience could substitute for less education, and additional education could likewise substitute for less experience.

92. My opinions do not turn on the precise definition, and the challenged claims would be unpatentable from the perspective of any reasonable POSITA.

93. I believe that I would have qualified as a person of at least ordinary skill in the art as of the earliest September 1, 2004 priority date of the '270 patent. I believe that I have a sufficient level of knowledge, experience, and education to provide an expert opinion in the field of the '270 patent.

VIII. OVERVIEW OF THE PRIOR ART.

A. Cheok (EX1006).

94. I understand that Cheok, A. et al., *Human Pacman: A Sensing-based Mobile Entertainment System with Ubiquitous Computing and Tangible Interaction* (May 2003) ("Cheok") is a research paper authored by Adrian D. Cheok et al. of National University of Singapore, published in the NetGames'03: Proceedings of the 2nd workshop on Network and system support for games, a conference held on May 22-23, 2003 in Redwood City, California.

95. In my opinion, Cheok discloses many of the features disclosed in independent claim 4, except that it does not expressly disclose *a first manual input for setting a origin location setting for a location reference for gameplay*, as recited in limitation 4[a]-1, or *a second manual input for setting a directional reference for a direction of gameplay*, as recited in limitation 4[a]-2. However, as I show in this declaration, these features were well known and ubiquitous especially in early augmented reality (AR) and virtual reality (VR) gaming systems. Cheok is presented as a primary reference below.

96. Generally, Cheok discloses a "Human Pacman" AR and VR gaming system like the '270 patent. *Compare* EX1006, 106-108, *with* EX1001, 3:12-5:15, FIGs. 4-5. Cheok's Human Pacman game "allows players to…physically and immersively role-play the characters of the Pacmen and Ghosts as they move about

freely in the real world over wide area outdoor spaces." EX1006, 106. Human Pacman closely resembles original Pacman, such that "the goal of the Pacman team is to collect all virtual plain cookies and hidden ingredients in Pac-World while avoiding the Ghosts," while "the aim of the Ghost team is to devour all Pacmen in the Pac-World." *Id.*, 110. As shown below in Figures 5 and 6, the virtual Pac-World is designed to closely correspond to the outdoor area chosen for gameplay. *Id.*, 110-111.

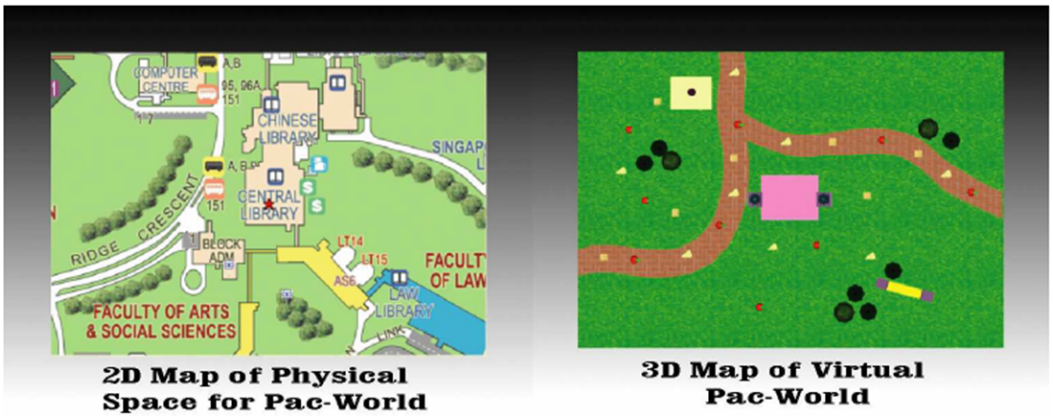


Figure 5. 2D map of game play area and its corresponding 3D map of Pac-world



Figure 6. Correspondence between the physical world and the virtual Pac-world

97. Cheok's Human Pacman comprises an "interactive ubiquitous and mobile entertainment system that is built upon position and perspective sensing via Global Positioning System and inertia sensors; and tangible human-computer interfacing with the use of Bluetooth and capacitive sensors." *Id.*, 106. Cheok's system features "Pacmen and Ghosts" as "real human players in the real world experiencing mixed computer graphics fantasy-reality provided by using wearable computers that are equipped with GPS and inertia sensors for players' position and perspective tracking." *Id.*, 106. An example of a user's wearable computer is shown in Figure 4 below. *Id.*, 110.



Figure 4. Detail configuration of wearable computer

Id., FIG. 4. The wearable computer also incorporates a head-mounted display which enables users to switch between AR and VR modes. *Id.* Figure 11 below shows an example of the two modes available to users.



Figure 11: HMD display and the corresponding label under VR mode when Pacman gains power

Id., FIG. 11.

98. Cheok states that "[v]irtual cookies and actual tangible physical objects with Bluetooth devices and capacitive sensors are incorporated into the game play to provide novel experiences of seamless transitions between real and virtual worlds." *Id.*, 106. For example, Pacmen players collect virtual cookies and collect "Ingredients" that are Bluetooth embedded objects. *Id.*, 106, 109. As shown in Figure 9 below, when a player collects a cookie, the cookie disappears from the virtual world in real-time. *Id.*, 112.

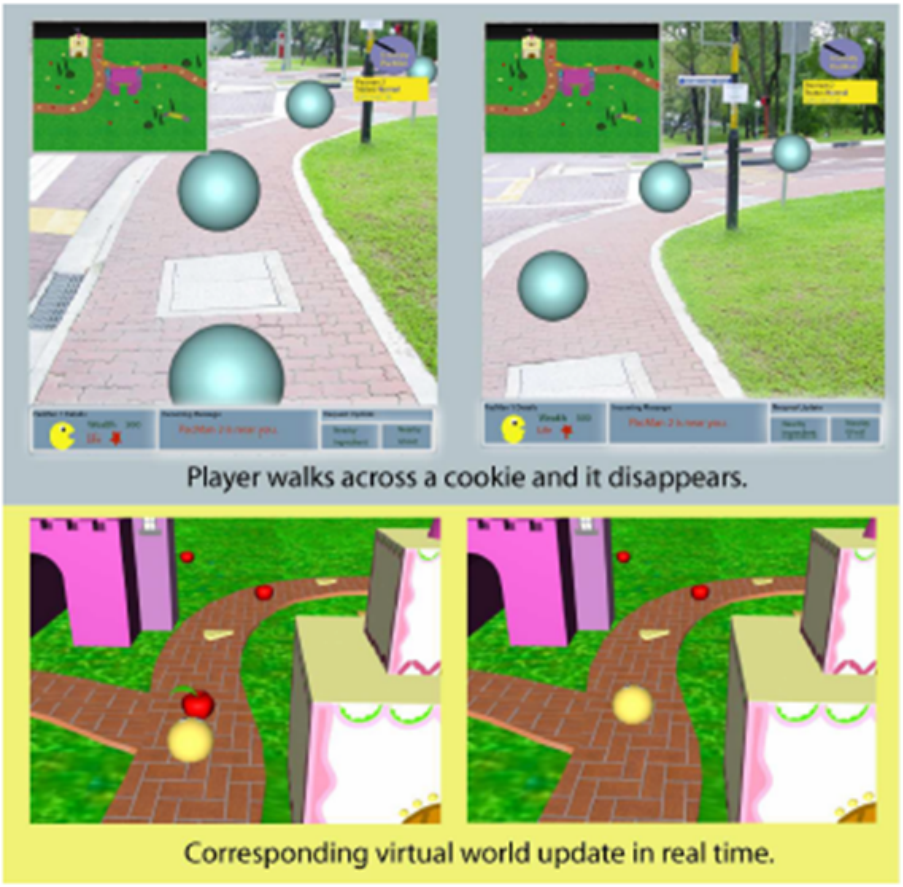


Figure 9: Pacman collecting cookies

Id., FIG. 9.

99. While Cheok's Human Pacman largely resembles original Pacman, it also introduces a third type of player—Helpers. As shown in Figure 8 below, Helpers participate in the game remotely via a computer terminal and exclusively use the VR mode to help Pacmen and Ghosts with identifying enemy mobile units and hidden ingredients. *Id.*, 106, 111.



Figure 8. Close collaboration between the outdoor Pacman and her Helper

Id., FIG. 8.

100. The above-described Human Pacman system "features a centralized architecture that is made up of four main entities, namely the central server, wearable computers, Sony VAIO laptops, and Bluetooth embedded objects," as shown in Figure 3 below. *Id.*, 109. Cheok discloses that "[t]he Wireless Lan serves as a communication highway between the wearable computers, the helper computers (Sony VAIOs laptops), and the server desktop computer." *Id.* "The underlying program is built on a client/server model with wearable computers and helper laptops as clients, and the desktop computer as a central server." *Id.*, 109-10. "The server

maintains up-to-the minute players' information (location, status etc.), and presides over any communication between Bluetooth objects and the wearable computers." *Id.*, 110.

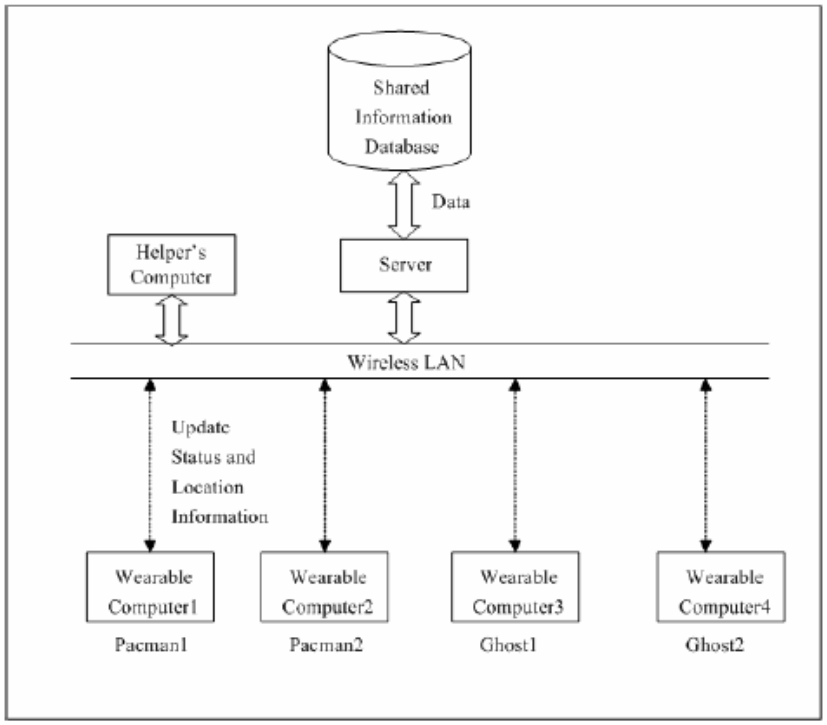


Figure 3. Complete system overview of Human Pacman

Id., FIG. 3.

101. As I discuss in my opinions on Ground 1 (*see* Sec. X), Cheok, like the '270 patent, discloses a *system* comprising a wireless communication *device* with a *display* that has a *graphical user interface*, as recited in independent claim 4. *See also* Secs. VI.A-C (overview of '270 patent and challenged claims). Indeed, as I discussed above, Cheok discloses a gaming system comprising a wireless-enabled wearable computer device that incorporates a head-mounted display.

102. Also like the '270 patent, Cheok discloses an *origin location setting* and a *direction of gameplay*, as recited in independent claim 4. Cheok explains that its wearable computer device has GPS and inertial sensors, in which a user's location is tracked in the real world and their corresponding virtual character (e.g., a Pacman or Ghost) is shown in corresponding positions in the virtual world displayed on the user's head-mounted display. EX1006, 108-09. However, Cheok recognizes that there are vast sensor tracking issues that its paper does not address and would lead one to look to other sources that have addressed these issues. *Id.*, 108, 115.

B. Nakamura (EX1007).

103. I understand that Japanese Patent Application Publication No. JP2001070658A to Nakamura ("Nakamura") was published on March 21, 2001.

104. In my opinion, Nakamura discloses many of the features disclosed in independent claim 4, except that it does not expressly disclose *a second manual input for setting a directional reference for a direction of gameplay*, as recited in limitation 4[a]-2, or *said display is a head-mounted display*, as recited in claim 16. Nakamura is presented as a primary reference and also as a secondary reference in combination with Cheok.

105. Generally, Nakamura discloses "a system for controlling a computer based on location information," which involves a virtual role-playing game with virtual characters on a virtual playfield with virtual locations. EX1007, [0001]. As

such, "new scenes or worlds automatically open depending on certain conditions." EX1007, [0005]. For example, "by utilizing current location information, which can be obtained through technologies such as GPS, a new virtual world is opened." *Id.* A user walks, runs, or bicycles through the real world, and the user's current location in the real world is reflected in the virtual world, allowing the role-playing game to progress. *Id.*, [0015]. This enhances the game playing environment by combining real location information with conventional gaming methods. *Id.*, Abstract.

106. Nakamura implements its system on a mobile terminal equipped with a GPS unit for acquiring the user's current location. *Id.*, [0016], [0019]. The mobile terminal "connect[s] to a server system 20 that provides the role-playing game through the general internet 1 as the computer network." *Id.*, [0018]. Nakamura further explains that "[i]n the role-playing game executed by the game system 10, a position icon (such as an illustration resembling a human figure) displayed on the screen moves in response to the movements of the user holding terminal 6." *Id.*, [0031]. This display of virtual position allows the user to feel as if they are "entering and moving through the virtual world of the role-playing game screen." *Id.* The virtual world also allows for the display of "event icons representing other users who are accessing the same role-playing game," as well as "communication (chat) through the screen" with the other users of the role-playing game. *Id.*, [0029].

107. As I discuss in my opinions on Ground 2 (*see* Sec. XI), Nakamura, like the '270 patent, discloses a *system* comprising a wireless communication *device* with a *display* that has a *graphical user interface* to receive *a first manual input for setting a origin location setting for a location reference for gameplay*, as recited in independent claim 4. *See also* Secs. VI.A-C (overview of '270 patent and challenged claims). In fact, as I discussed above, Nakamura discloses a gaming system comprising a mobile terminal with a display with a GUI, on which the user may manually arrange a movable position icon (representing a virtual character) in order to set a desired initial position for gameplay. Nakamura discloses that the mobile terminal has a GPS unit, and that a user's location is tracked in the real world, based on the initial position set by the user, and their corresponding position icon (a human figure illustration) is shown in corresponding positions in the virtual world displayed on a mobile terminal. EX1007, [0005], [0009], [0015]-[0016], [0019], [0025], [0034]-[0036].

C. Foxlin077 (EX1008).

108. I understand that U.S. Patent No. 5,645,077 to Foxlin ("Foxlin077") published on July 8, 1997 from an application filed on June 16, 1994. EX1008, 1. I personally know the inventor (Eric Foxlin). I remember his related M.S. work at the Massachusetts Institute of Technology (MIT), which served as the basis for Foxlin077, and is embodied in the commercial InertiaCube2 that I discuss below.

109. Foxlin077 discloses an inertial sensor for use in VR and AR applications. EX1008, Abstract, 1:16-22, 5:7-9, 6:20-22. It is my opinion that Foxlin077 discloses features associated with *a second manual input for setting a directional reference for a direction of gameplay*, as recited in limitation 4[a]-2, and *wherein said directional reference is reset during play of said location-based game*, as recited in claim 5. Foxlin077 is presented as a secondary reference in combination with Cheok.

110. Foxlin077's inertial sensor addresses drift issues and "track[s] the orientation of a body to which it is mounted, without interaction with radiation, energy, signals, or physical connections from any other apparatus." *Id.*, 1:63-66. In particular, Foxlin077 recognizes "[a] difficulty with using gyroscopes for head-orientation tracking is drift," which "arises from integrating over time, a signal that is noisy, or has a bias." *Id.*, 2:56-58. Foxlin077 explains that "[d]rift would make the virtual world appear to gradually rotate about the user's head even when the user is not moving." *Id.*, 2:58-60. Foxlin077 resolves this with a "drift compensator" component that automatically corrects drift. *Id.*, 6:27-32, 9:1-23.

111. Drift compensation requires using parameters measured during an initialization process, as shown in red in Figure 4A below. *Id.*, 11:1-7; *see also id.*, 9:61-67.

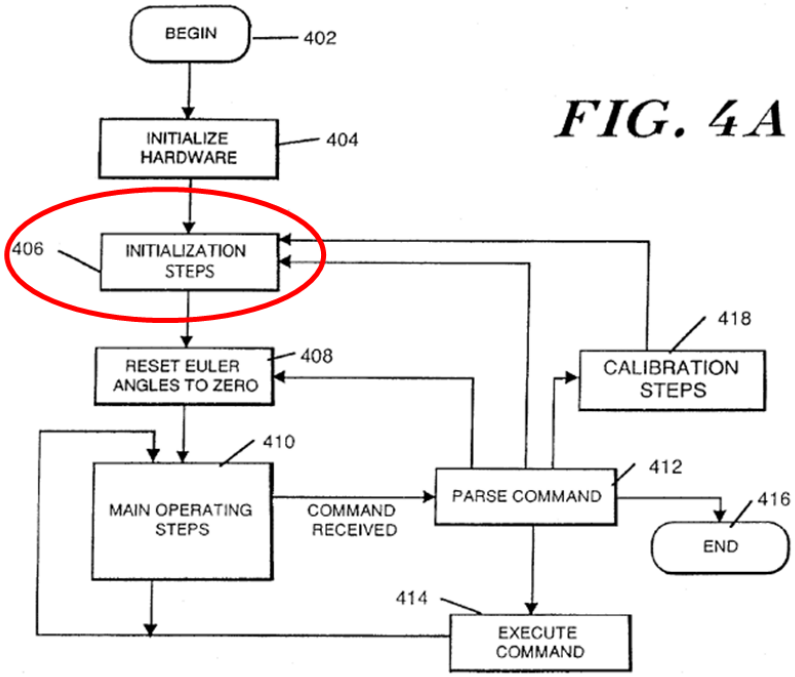


FIG. 4A

Id., FIG. 4A (annotated). The initialization steps "establish the rest position, from which orientation is measured and measure biases for the rate sensors," after which "the main operating steps 410 are performed." *Id.*, 9:67-10:7. Foxlin077 explains that "[i]nitialization must be conducted with the sensor assembly held stationary in a known reference orientation." *Id.*, 10:29-31. Foxlin077 explains that a "user is instructed [ ] to place the sensor assembly in such a position by a message delivered to the apparatus input/output devices or implicitly by the fact of starting the tracker." *Id.*, 10:31-35. After initialization, the operating steps are repeated until a command is received. *Id.*, 10:9-11. The command can be user-generated and includes operations such as a reinitialization process. *Id.*, 10:17-20.

112. As I discuss in my opinions on Ground 1 (*see* Sec. X), Foxlin077, like the '270 patent, discloses *a second manual input for setting a directional reference for a direction of gameplay…based on the direction of said device*, as recited in independent claim 4, because as I discussed above, a user is prompted by a message to manually place the inertial sensor assembly in a known reference orientation in order to establish the rest position from which orientation is measured. *See also* Secs. VI.A-C (overview of '270 patent and challenged claims).

113. Also, like the '270 patent, Foxlin077 discloses that the *directional reference is updated during said gameplay*, as recited in independent claim 4, and *reset during play of said location-based game*, as recited in dependent claim 5, because Foxlin077 discloses that the same initialization process can be performed in the middle of the main operating steps in response to a manual reinitialization command. *See also* Secs. VI.A-C (overview of '270 patent and challenged claims).

D. Benini (EX1009).

114. I understand that Benini, L. et al., *Palmtop Computer for managing Interaction with Immersive Virtual Heritage* (2002) ("Benini") is an article authored by Benini et al. of the University of Bologna and CINECA Supercomputing Centre, published in the Euromedia'2002 Conference Proceedings for the 7th Annual Euromedia Conference, held April 15-17, 2002 in Modena, Italy. EX1009, 1.

115. Benini discloses wireless portable devices for exploring virtual environments. EX1009, 1-4. Specifically, it is my opinion that Benini discloses features associated with *a second manual input for setting a directional reference for a direction of gameplay*, as recited in limitation 4[a]-2, and discloses *wherein said directional reference is reset during play of said location-based game*, as recited in claim 5. Benini is presented as a secondary reference in combination with Nakamura.

116. Benini discloses a "hardware/software system for PDA-based interaction with IVEs [(immersive virtual environments)] realized in the field of Virtual Heritage (VH): Virtual Reality applied to Cultural Heritage." EX1009, 2. Benini aims to "reconstruct[] cultural heritage objects and environments" in an immersive virtual reality environment. *Id.*, 2. For example, "Virtual Heritage" applications may allow scholars to explore an archaeological site or the general public to explore a virtual museum. *Id.*, 2. Benini discloses the use of "standard, consumer-market wearable interactive terminals, such as palmtop computers (Pocket PC and PDAs), as the preferred interfacing device with IVEs…in the field of Cultural Heritage." *Id.* As shown below in Figure 3, the system consists of portable terminals for interfacing with the virtual environment (e.g., a virtual theatre) over a wireless network, along with client-server software that runs on the terminals (client) and virtual reality engine (server). *Id.* at 4.

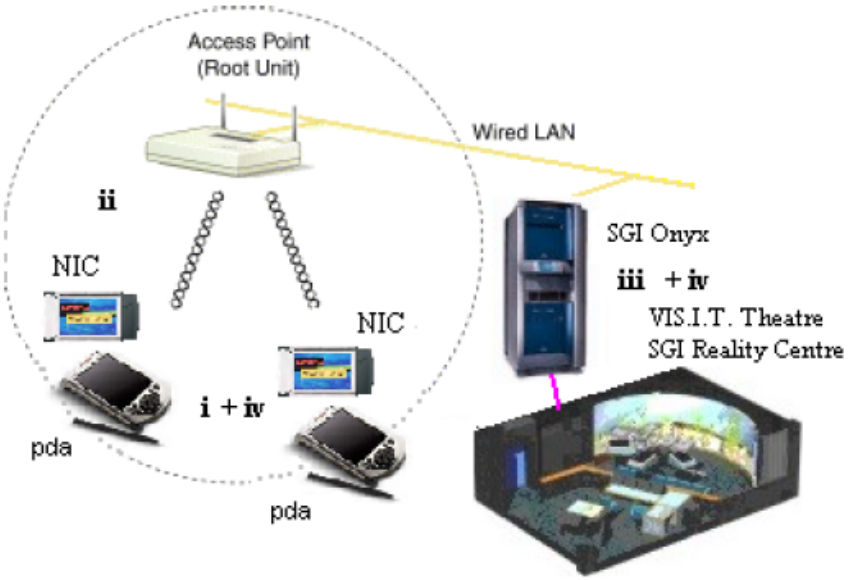


Figure 3: Components of the interactive system: portable terminals(i), wireless network(ii), virtual theater (iii), client-server software (iv).

Id., FIG. 3.

117. Benini additionally explains how the portable palmtop computers/PDAs can be used to support the basic interaction tasks in the field of 3D user interfaces—navigation, selection/manipulation, and system controls. *Id.*, 2-3. For example, a PDA may incorporate a "'2D map' in which the users visualize their position and orientation in the virtual world," to allow users to see "which regions can be reached by their current position." *Id.*, 3. Benini explains that "[t]he UI features a two-dimensional map abstraction of the VR world, augmented with various navigation controls," including "eight arrows to more intuitively navigate in the environment." *Id.*, 3. The 2D map reproduces a view of the virtual environment,

"enabl[ing] the user to visualize his/her position in the virtual world with a red rectangle and the direction of observation with a green rectangle…." *Id*. "[F]our arrows realizes the metaphor of moving forward, backward, left and right the avatar in the VE as if it is walking into it; and four arrows are used to turn around and to look up and down…." *Id*. Figure 2 below shows an example PDA with arrows (in green) for visualizing position and direction in the virtual environment.



Figure 2: The User Interface developed for interacting via PDA with the Nu.M.E. VE

Id., FIG. 2 (annotated). Benini further discloses that the user interface arrows can be used to "change [the] camera's position and orientation (interacting with the 2D map or with the arrows)," thereby changing the view in the virtual environment. *Id.*,

4. When "requesting to change camera's position and orientation" according to interaction with the map/arrows, the portable terminal (client) has to send to the server (virtual reality engine) "a 6-dimensional vector that includes world coordinates (*x, y, z*) and the three angles: heading – the rotation about the Z axis – pitch – the rotation about the X axis – and roll – the rotation about the Y axis." *Id.*, 5. This allows the server "to increment [the] current camera's position and orientation" to show a new view in the virtual environment. *Id.*

118. As I discuss in my opinions on Ground 2 (*see* Sec. XI), Benini, like the '270 patent, discloses *a second manual input for setting a directional reference*, as recited in independent claim 4 because, as discussed above, the portable terminal has directional arrows that allow a user to manually change the position and orientation of a virtual world on the display. *See also* Secs. VI.A-C (overview of '270 patent and challenged claims). Also, like the '270 patent, Benini discloses that the *directional reference is updated during said gameplay*, as recited in independent claim 4, and *reset during play of said location-based game*, as recited in dependent claim 5, because Benini discloses that the directional arrows can be used while actively exploring a virtual environment. *Id.*; *see also* EX1009, 3-5.

E. Foxlin068 (EX1010).

119. I understand that U.S. Patent No. 6,757,068 to Foxlin ("Foxlin068") published on June 29, 2004, from an application filed on January 26, 2001. EX1010, 1.

120. Foxlin068 relates to wireless location tracking technologies for use in virtual reality games. Specifically, it is my opinion that Foxlin068 discloses using a *head-mounted display*, as recited in claim 16, to perform such wireless tracking. Foxlin068 discloses that its "invention may combine a sourceless head orientation tracker 30 with a head-worn tracking device 12 that tracks a hand-mounted 3D beacon 14 relative to the head 16." EX1010, 5:5-8. Foxlin068 discloses that its "new tracking technique is essentially 'sourceless' in that it can be used anywhere with no set-up of a source, yet it enables a much wider range of virtual environment-style navigation and interaction techniques than does a simple head-orientation tracker, including manual interaction with virtual objects." *Id.*, Abstract. For example, Foxlin068 discloses that its tracking device may be used in virtual environments such as virtual reality games. *Id.*, 13:28-32, 14:5-42. Foxlin068 explains that the tracking device may incorporate an "inertial orientation tracker" and "position tracker" to perform wireless tracking. *Id.*, 5:45-50. Foxlin068 is presented as a secondary reference in combination with Nakamura.

121. Foxlin068's "fully integrated wearable VR system" is shown in greater detail in Figure 1 below. As shown, the system has "only three parts (a wearable computer 10, a headset 15 with an integrated tracking system, and a hand-mounted beacon 14) and one cable connection 18." *Id.*, 5:14-18. Foxlin068 explains that the headset component (in red) may be a head-mounted display ("HMD"). *Id.*, 5:45-62, 6:30-38, 6:61-63.

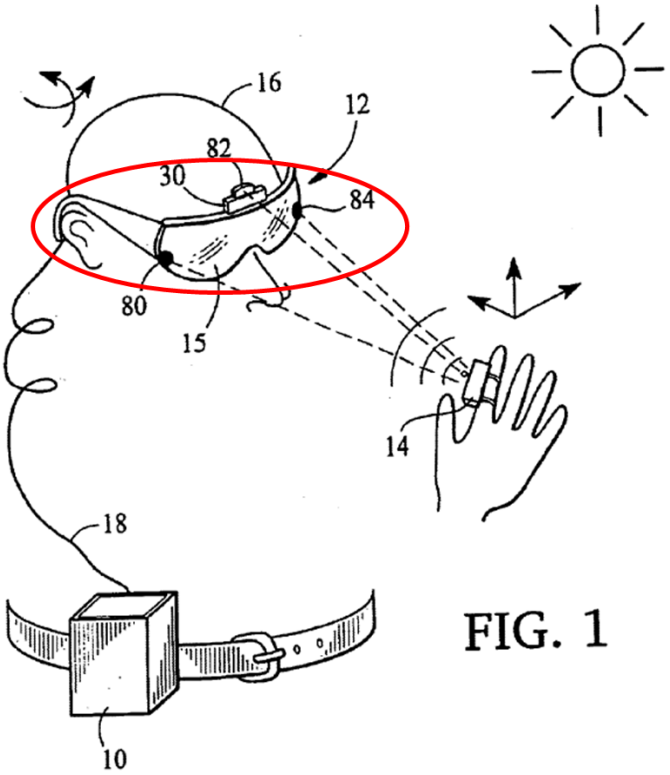


FIG. 1

Id., FIG. 1 (annotated).

122. As I discuss in my opinions on Ground 3 (*see* Sec. XII), Foxlin068, like the '270 patent, discloses a *head-mounted display*, as recited in claim 16 because, as I discussed above, the headset of the tracking device may take the form of a head-

mounted display. *See also* Secs. VI.A-C (overview of '270 patent and challenged claims).

IX. CLAIM CONSTRUCTION.

123. I have applied the plain meaning of the terms and phrases in the claims in my analysis, as a POSITA would have understood those terms and phrases at the relevant time (around 2003). I understand that the Board will construe the claims using the same claim construction standard that would be used in district courts. My declaration will establish that the prior art meets each of the claim limitations under any reasonable construction. I have not been asked to consider any express constructions.

X. OPINIONS ON GROUND 1: CHEOK IN VIEW OF NAKAMURA AND FOXLIN077 RENDERS OBVIOUS CLAIMS 4, 5, 16, 17, AND 19.

A. A POSITA Would Have Been Motivated to Combine.

124. In my opinion, a POSITA would have been motivated to implement the Cheok Human Pacman system based on the teachings of Nakamura, for example, to implement an initialization process to set an initial location. It is my opinion that a POSITA would have been motivated to perform these teachings for the following reasons, as I explain further in Sec. X.C.3.b. Cheok discloses that when tracking real-time position of a player, the system determines location with respect to an initialization point, but Cheok does not disclose the specific processes for an

initialization step to set an initial location reference. *See* EX1006, 106, 108-109. A POSITA would have thus been motivated to rely on the teachings of Nakamura's initialization step, in which a user manually inputs an initialization point because a POSITA would understand that establishing an initialization point is a necessary step in any such system. In particular, the manual process of Nakamura would give a user further flexibility to create a more immersive experience in Cheok. A POSITA also would have also been motivated to implement the teachings of Nakamura's manual initialization feature in Cheok's system because it would have helped to better establish the real and virtual world correspondence given that all location measurement devices have accuracy issues. *See* Sec. V.D.

125. In my opinion, a POSITA would have been further motivated to modify the Cheok Human Pacman system based on the teachings of Foxlin077, for example, to implement an inertial sensor initialization/reinitialization process for improved accuracy and reduced drift, as I explain further in Sec. X.C.4.b. Cheok suggests that its wearable computer's sensors, including the inertial sensor, are subject to an initialization process, but does not disclose any specific initialization processes. EX1006, 108-09. A POSITA would have thus been motivated to rely on Foxlin077's initialization/reinitialization process, in which a user manually sets an orientation in response to a prompt. Indeed, recognizing that establishing an initialization/reinitialization process would be necessary for the system, a POSITA

would have been motivated to consult Foxlin077 for its inertial sensor features because both Cheok and Foxlin077 describe using an InertiaCube2 inertial sensor. *See* Sec. X.C.4.b; EX1006, 109, 116; EX1013, 6; *see also* Sec. V.D-E. It would have been natural for a POSITA using the InertiaCube2 inertial sensor of the system of Cheok to look at other references that provided greater details on how that inertial sensor functions.

126. A POSITA would have also been motivated to implement the Cheok system based on Foxlin077's initialization/reinitialization teachings because Cheok states that its sensors may be subject to tracking issues not addressed by the scope of the Cheok paper. *See* EX1006, 108, 115. Foxlin077 explains how to handle one common issue with inertial sensors—drift—with a drift compensation component that requires an inertial sensor initialization/reinitialization process. A POSITA would have also recognized that Foxlin077's initialization/reinitialization process would have improved user experience when interacting with the real environment. *See* Sec. V.D-E.

B. A POSITA Would have Had a Reasonable Expectation of Success.

127. In my opinion, a POSITA would have had a reasonable expectation of success in combining the teachings of Cheok and Nakamura, as I explain further in Sec. X.C.3.c. Specifically, a POSITA would have relied on Nakamura's initialization process for setting an origin location to improve Cheok's Human

Pacman system. Such a combination would have involved implementing the Cheok system in a manner that Cheok suggests is feasible—implementing the real-time tracking system such that it operates with respect to an initialization point. *See* EX1006, 106, 108-109; Sec. IV, ¶¶96-98. Indeed, any real-time tracking system—in particular systems employing inertial sensors such as the InertiaCube2 (described in Foxlin077)— would require an initialization process to set reference locations and directions. Cheok suggests that a POSITA would necessarily look to other references like Foxlin077 for greater details on how to implement that initialization process. Further, a POSITA would have recognized that Cheok already includes a GUI system with manual inputs (e.g., see Sec. VIII.A), and thus a combination to include Nakamura's manual initialization feature would only require an additional input, making the combination relatively straightforward and low risk.

128. In my opinion, a POSITA would have also had a reasonable expectation of success in combining the teachings of Cheok and Foxlin077, as I explain further in Sec. X.C.4.c. Specifically, a POSITA would have relied on Foxlin077's inertial sensor initialization/reinitialization process to improve Cheok's Human Pacman system. Implementing such a combination would have involved modifying the Cheok system in a manner that Cheok suggests is feasible—implementing the real-time tracking system such that an inertial sensor initialization process is performed. *See* EX1006, 106, 108-109; Sec. V, ¶¶96-98.

C. Independent Claim 4.

1. Preamble: "A system comprising:".

129. To the extent the preamble is limiting, it is my opinion that Cheok discloses the preamble. As I discussed further above in Sec. VIII.A (Cheok overview), Cheok discloses a "Human Pacman" gaming *system*[2] that brings existing iterations of Pacman into an augmented and virtual reality environment, allowing for human players representing Pacmen and Ghosts to engage in a physical role-playing game in a wide outdoor physical area. *See* Sec. VIII.A; EX1006, 106-108. Human Pacman supports both augmented reality (AR) and virtual reality (VR) modes, with Pacman and Ghosts equipped with wearable computers and head-mounted displays to enable them to switch between the two modes. *Id.* The wearable computers are also equipped with GPS and inertial sensors to track players' position and orientation. *Id.* Unlike original Pacman, Human Pacman also introduces a third type of player—Helpers, who participate in the game remotely via a computer terminal and exclusively use the VR mode to help Pacmen and Ghosts with identifying enemy mobile units and hidden ingredients. *Id.*

[2] When mapping the prior art to the language in the claims, I use italics to indicate the recited claim language.

130. As shown in Figure 3 (which I have reproduced below), "Human Pacman features a centralized architecture that is made up of four main entities, namely the central server, wearable computers, Sony VAIO laptops, and Bluetooth embedded objects." EX1006, 109. Cheok discloses that "[t]he Wireless Lan serves as a communication highway between the wearable computers, the helper computers (Sony VAIOs laptops), and the server desktop computer." *Id.* "The underlying program is built on a client/server model with wearable computers and helper laptops as clients, and the desktop computer as a central server." *Id.*, 109-10. "The server maintains up-to-the minute players' information (location, status etc.), and presides over any communication between Bluetooth objects and the wearable computers." *Id.*, 110.

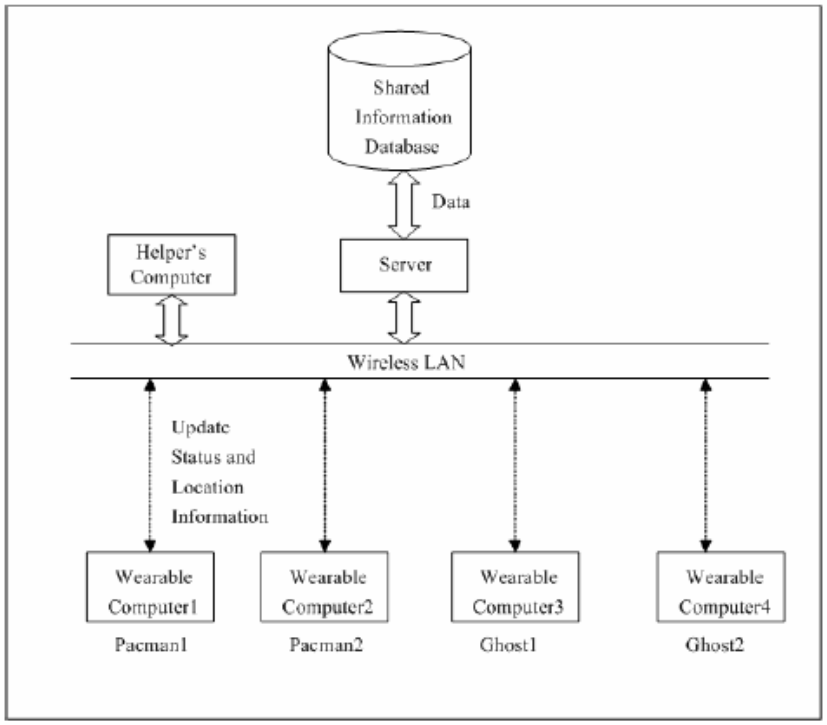


Figure 3. Complete system overview of Human Pacman

Id., FIG. 3.

2. 4[a]: "a device having a display, wherein a graphical user interface is provided on said display to receive".

131. In my opinion, Cheok discloses this limitation.

132. **First**, Cheok discloses *a device having a display*. Cheok discloses that each human player, whether playing as a Pacman or a Ghost, wears a wearable computer *device* that tracks movement through the real world. Sec. VIII.A., EX1006, 106 ("Pacmen and Ghosts are now real human players in the real world experiencing mixed computer graphics fantasy-reality provided by using **wearable computers** that are equipped with GPS and inertia sensors for players' position and perspective tracking."), 107 ("In Human Pacman, players are provided with custom-

built **wearable computers** that are designed, built, and developed in our lab especially for this application."), 107 ("Coupling [ubiquitous games] with the development in Wireless LAN technology and mobile computing using **wearable computers**, we have combined connected mobility with elements in ubicomp (i.e., natural interfaces, context-awareness, and automated capture and access) for realizing social gaming components in Human Pacman."), 108 ("The real-time position of each mobile user is sent periodically to the server through wireless LAN. Upon receiving the position data, the server sends an update to each **wearable computer** the position of other mobile players, as well as the positions of all 'non-eaten' plain cookies"), 109 ("Human Pacman features a centralized architecture that is made up of four main entities, namely the central server, **wearable computers**, Sony VAIO laptops, and Bluetooth embedded objects. An overview of the system is shown in Figure 3.").

133. I have reproduced below Figure 4, which shows a detailed configuration of a wearable computer. As shown, each wearable computer has a Cy-Visor Head Mounted Display (*a device having a display*), which I have circled in red. *Id.*, 110 ("Since the wearable computers were designed and developed in the lab, we proceed to discuss its detail configuration as seen in Figure 4. The main components are Transmeta Single Board Computer (PC104 plus compliant motherboard running on Crusoe processor), Twiddler2 (handheld keyboard and

mouse), **Cy-Visor Head Mounted Display (video see-through HMD)** with FireWire camera attached, two Sony F960 InfoLithium batteries, InertiaCube2 (inertia sensor), DRMIII module (GPS and Dead-Reckoning device from Point Research Corporation), and JVC Bluetooth device."). I have also reproduced below Figure 8, which shows the game player donning the wearable computer installed on a vest and the HMD on the player's head. *Id.*, 111-12.



Figure 4. Detail configuration of wearable computer



Figure 8. Close collaboration between the outdoor Pacman and her Helper

Id., FIG. 4 (annotated), FIG. 8.

134. **Second**, Cheok discloses *wherein a graphical user interface is provided on said display*. I have reproduced Figure 7 below, which shows a first person view as presented in a user's HMD display. As shown in Figure 7, Cheok discloses that a Pacman or Ghost player can see through the HMD a view of the

virtual world (i.e., the Pac-World view in the upper left corner), as well as a view of the real world overlaid with virtual cookies. *Id.*, 111.



Figure 7. First person view as presented in HMD display of Pacman

Id., FIG. 7 (annotated).

135. As shown above in Figure 7, the head-mounted display shows various graphical features (several of which I have circled) in addition to the visual representation of the virtual and real worlds. For example, as shown in the red circle, the display includes a panel showing incoming alert messages, such as those indicating nearby Ghost players, nearby ingredients, or recently acquired special

powers. *Id.*, 109 ("When a player is within range of [a virtual ingredient] Bluetooth object…**an alert message will be shown on the player's HMD display**."), 114 ("When a Pacman consumes a special cookie, she will see **an alert message in her HMD**, informing her of the power she acquired.").

136. As shown in the green circle, the display also includes clickable buttons that allow a Pacman user to request updates from Helpers on nearby ingredients or nearby Ghosts. *Id.*, 114 ("Pacman players can collaborate through transferring of ingredient between them, even if they are physically far from each other with the support of Wireless LAN. For example Pacman A can **initiates request for the list of unused ingredients** Pacman B has. Upon approval, A can **request for transfer of ingredient** from B, subjected to approval by B."), 115 ("The Pacman/Ghost **click on preset messages** to be sent to Helpers.").

137. Cheok also discloses that virtual ingredients (shown in the blue circle in Figure 7 above) may be clicked on in order to be exchanged or dumped. *Id.*, 115 ("Pacmen click on graphical representation of 'Ingredient' to be exchanged."), 115 ("Pacman right-click on virtual ingredient in order to dump the ingredient."). Cheok discloses that the wearable computer user interacts with the display (e.g., by clicking) by using the wearable computer's Twiddler2 component which consists of a handheld keyboard and a mouse. *Id.*, 110 ("The main components [of the wearable computer] are…Twiddler2 (handheld keyboard and mouse)…."), 115 ("Keyboard

and mouse are used for messaging and selection of the 'Ingredients' to be exchanged between Pacmen.").

138. Thus, it is my opinion that a POSITA would have understood that the head-mounted display provides a GUI (*wherein a graphical user interface is provided on said display*) because it provides a visual interface allowing Pacman or Ghost users to user their wearable computers to interact with other users, Helpers, or the environment through the use of buttons and clickable icons. Indeed, a POSITA would have readily understood that such a GUI that receives manual input through buttons and clickable icons would have been configured to receive manual inputs such as the first and second manual inputs recited in limitations 4[a]-1 and 4[a]-2, which I discuss further below. *See* Sec. X.C.3-4.

3. 4[a]-1: "a first manual input for setting a origin location setting for a location reference for gameplay and".

139. In my opinion, Cheok in view of Nakamura renders obvious this limitation.

140. Cheok discloses *a[n] origin location setting for a location reference for gameplay*. Cheok discloses that the wearable computer (*device*) incorporates a dead-reckoning module and GPS, among other sensors, to enable location tracking of users. EX1006, 106 ("There is a seamless merging of the fantasy computer digital world with the real physical world realized using **location and body tracking**

technologies, namely the Global Positioning System (GPS), Dead-Reckoning module (DRM), and inertia sensors, to provide the necessary context-awareness of the system for the game play."), 108 ("**Numerous sensors and tracking devices that are used in the system—dead reckoning module (DRM) with GPS and digital compass, inertia sensor, Bluetooth device, and capacitive sensor**—are vital to the manifestation of Human Pacman."), 110 ("The main components [of a wearable computer] are…**[a] DRMIII module (GPS and Dead-Reckoning device from Point Research Corporation)**….").

141. Cheok further discloses that the dead-reckoning module and GPS track the device's position (*location*) in real time with respect to an initialization point (*origin location setting*). *Id.*, 108 ("**The DRM measures the displacement of the user from an initialization point by measuring the direction (with data obtained from the compass), and distance traveled (using accelerometer data) with each footstep taken.** Although the DRM is a self-contained navigation unit, **when GPS position data is available, it can be used to correct both the distance and direction calculations** with the help of a Kalman filter algorithm.").

142. Cheok discloses that by calculating the location with respect to an initialization point, the real-time position data of each user may be communicated to the server and other players. *Id.*, 108 ("**The real-time position of each mobile user is sent periodically to the server** through wireless LAN. Upon receiving the

position data, **the server sends an update to each wearable computer the position of other mobile players**, as well as the positions of all 'non-eaten' plain cookies."). Cheok discloses that this real-time tracking of a player's movement in the physical world is reflected in the corresponding virtual character's movement in the virtual Pac-World. *Id.*, 112 (describing that a Pacman's movement (e.g., when walking through a cookie), is "**reflected in the virtual Pac-World in real time**…in the corresponding location"), 112 ("[A] Pacman['s]…**physical interaction with the real world (i.e. movement) can be digitally reflected in the virtual world**….").

143. Thus, it is my opinion that a POSITA would have understood that the Human Pacman system tracks location data for each user with respect to an initialization point (*origin location setting*), where the initial location data provides a location reference for the virtual character's gameplay (*a location reference for gameplay*).

144. Cheok does not explicitly disclose that the initialization point is set by having the GUI of the device's display receive *a first manual input*. *See* EX1006, 106, 108-109. However, in my opinion, a POSITA would have been motivated and found it obvious to implement this feature in view of Nakamura. *See* Sec. X.A., ¶120; *see also* Sec. V.D.

a. Teachings of Nakamura.

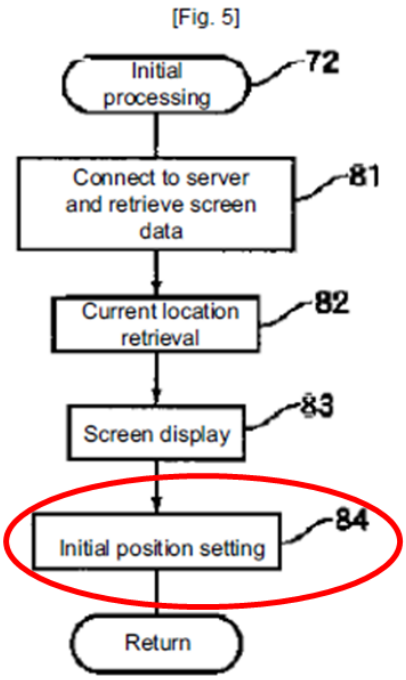
145. Like Cheok, Nakamura relates to a wireless location-based gaming system for interacting with a virtual space. *See* Secs. VIII.A-B. Nakamura discloses a system for providing a role-playing game in a virtual world. EX1007, [0005], [0018]. In the role-playing game, a user moves "through the real world, and the user's current location in the real world is reflected in the virtual world, allowing the role-playing game to progress." *Id.*, [0015]. Further, a GPS receiver may be used as the positioning system to track the location of a user's device (e.g., a mobile phone or some computer-readable recording medium) and that communication with the server system may occur wirelessly. *Id.*, [0016]. Nakamura also discloses that the role-playing game may be played by multiple "users who are accessing the same role-playing game" (*id.*, [0029]), and that users may compete with each other (*id.*, [0009]). Thus, Nakamura is similar to Cheok, which as I discussed for Sec. VIII.A (Cheok overview) and claim 4's preamble, discloses an interactive multi-person gaming system in a virtual environment where users role play as Pacmen, Ghosts, or Helpers and locations are tracked in real-time and communicated wirelessly. *See* Secs. VIII.A, X.C.1; EX1006, 106. A POSITA would have therefore been motivated to consider the teachings of Nakamura when implementing Cheok's Human Pacman system.

146. Nakamura explains that as a user moves, "new scenes or worlds automatically open depending on certain conditions." EX1007, [0005]. For example, "by utilizing current location information, which can be obtained through technologies such as GPS, a new virtual world is opened." *Id.* Nakamura explains that this system for displaying virtual worlds may be provided on a mobile terminal equipped with a GPS unit to track the user's current location. *Id.*, [0016] ("A system for displaying such a virtual world…can be installed on a **mobile terminal equipped with positioning systems such as a GPS unit**, methods for acquiring the user's current location (e.g., through PHS units, mobile phones, etc. that utilize location information from base stations), and communication means for connecting to a server system via wireless, PHS, mobile phones, dial-up Internet, or other computer networks."), [0019] ("[T]he **mobile terminal** 6 in this example is equipped with a system for obtaining data indicating its current location (typically coordinates including latitude and longitude information). There are several such systems, and the one currently considered to have the highest accuracy uses a **GPS unit**….").

147. Nakamura further explains that "initial settings [can] be configured to reflect movements in the real world within the virtual world." *Id.*, [0009]. Nakamura discloses that "it is desirable to perform an initial setup that defines the correspondence between the current location and the virtual position, as well as the

ratio for converting actual displacement into virtual displacement, prior to starting the role-playing game." *Id.*, [0025]. Nakamura discloses a feature for manually setting on a display interface a user's current location in the real world as a predetermined initial position in the virtual world. The "function 33 for performing the initial setup is provided as one of the features of the display control unit 30, and the settings defined there are stored in a memory such as ROM or RAM." *Id.*

148. As part of this initial setup, "it is desirable to set the current location in the real world as a predetermined position (the initial value of the virtual position) within the first virtual world." *Id.*, [0009]. The initial position may represent "the starting point of the game or, if the game was interrupted, the point where it was paused." *Id.* While it is possible "to use the parameters that are set by default" (*id.*, [0025]), it is also possible to manually set (*first manual input*) the initial position setting (*origin location setting*). For example, as shown in red circle in Figure 5, which I have reproduced below, Nakamura explains that "[i]n step 84, the function 32 for displaying the virtual position and virtual displacement displays the position icon 113 corresponding to the current location at the initial position 112 of the screen 111." *Id.*, [0035].



Id., FIG. 5 (annotated). After the position icon is initially displayed on the screen, the "position icon 113, or position display icon, can be arranged according to the user's preference." *Id.*, [0035]. Once the user has chosen a suitable initial position, the user performs an operation on the display to trigger an initial setting function that sets the current location as the initial position parameter. *Id.*, [0036] ("If the position icon 113 is displayed at a virtual position that is appropriate to be set as the initial position, the user can perform a suitable operation, and the initial setting function 33 will set that current location as the initial position 112 on the screen 111 and store it as the parameter 13.").

b. Motivation to Combine Cheok and Nakamura.

149. In my opinion, a POSITA would have been motivated to rely on Nakamura's initialization features to enhance Cheok's Human Pacman system. As discussed above, Cheok discloses that when tracking the real-time position of a player, the system determines location with respect to an initialization point. *See* EX1006, 108. However, Cheok does not disclose the specific processes for an initialization step to set an initial location reference. A POSITA would have thus found it beneficial to modify Cheok based on Nakamura's teachings of an initialization step wherein a player uses the display interface to manually input an initialization point because a POSITA would understand that establishing an initialization point is a required step for any such system. *See* Sec. X.A., ¶120; *see also* Sec. V.D; *see also* EX1006, 106, 108-109.

150. As further discussed above, Nakamura also discloses that its initialization function is desirable because it allows for the alignment of real and virtual worlds—that is, the initial location setting provides a *location reference for gameplay* that helps establish the real and virtual world correspondence. EX1007, [0025]. Thus, a POSITA would have recognized that Nakamura's initialization function would be a natural fit with Cheok's system, which also relies on a real and virtual world correspondence during gameplay. Consistent with the above and in such a combined system, for example, the GUI of the wearable computer's head-

mounted display would have been configured to receive manual input for setting an initial position that serves as a location reference for further gameplay (*a first manual input for setting a origin location setting for a location reference for gameplay*). *Id.*

c. Reasonable Expectation of Success.

151. In my opinion, a POSITA would have also had a reasonable expectation of success combining the teachings of Cheok and Nakamura. As I discussed above, both references are in the same field of art. *See* Sec. X.C.3.a. Furthermore, it is my opinion that a POSITA would have understood that implementing the combination would have involved modifying the Cheok system in a manner that Cheok suggests is feasible—implementing the real-time tracking system such that it operates with respect to an initialization point. *See* Sec. X.A, D; *see also* EX1006, 106, 108-109. Indeed, any real-time tracking system would require an initialization process to set reference locations and directions. Cheok suggests that a POSITA would necessarily look to other references like Foxlin077 for greater details on how to implement that initialization process. A POSITA would have also had the skill to implement and reasonable expectation of success in achieving such a combination, because it would have involved a combination of known technologies (e.g., known system of real-time tracking with respect to an initialization point (Cheok)) according to known methods (e.g., known methods of initialization (Nakamura)) to yield the predictable result of a system with a graphical interface that receives a manual input for origin

location to serve as a location reference for gameplay, as discussed above. Accordingly, Cheok in view of Nakamura renders obvious *a first manual input for setting a origin location setting for a location reference for gameplay*.

152. *See also* Sec. X.B, where I provide a higher level overview of a POSITA's reasonable expectation of success in combining Cheok and Nakamura.

4. 4[a]-2: "a second manual input for setting a directional reference for a direction of gameplay for a virtual character of a location-based game provided on said device based on the direction of said device and said location-based game is provided on said device with respect to said directional reference and said directional reference is operable to be updated during said gameplay.".

153. In my opinion, Cheok in view of Foxlin077 renders obvious this limitation.

154. Cheok discloses *a direction of gameplay for a virtual character of a location-based game provided on said device based on the direction of said device*. Cheok discloses that its dead-reckoning module includes component parts such as a dead-reckoning device, GPS, digital compass, and inertial sensors to enable tracking of users. EX1006, 106 ("There is a seamless merging of the fantasy computer digital world with the real physical world realized using **location and body tracking technologies,** namely the Global Positioning System (GPS), **Dead-Reckoning module (DRM)**, and inertia sensors, to provide the necessary context-awareness of the system for the game play."), 108 ("**Numerous sensors and tracking devices**

that are used in the system—dead reckoning module (DRM) with GPS and digital compass, inertia sensor, Bluetooth device, and capacitive sensor—are vital to the manifestation of Human Pacman.), 110 ("The main components [of a wearable computer] are…**[a] DRMIII module (GPS and Dead-Reckoning device from Point Research Corporation)**….").

155. Cheok further discloses that it uses the inertial sensor and digital compass of the dead-reckoning module to determine the direction the user (and the user's wearable computer (*device*)) is facing on the physical playfield (*the direction of said device*). *Id.*, 108 ("**The DRM measures the displacement of the user from an initialization point by measuring the direction (with data obtained from the compass)**, and distance traveled (using accelerometer data) with each footstep taken. Although the DRM is a self-contained navigation unit, **when GPS position data is available, it can be used to correct** both the distance and **direction calculations** with the help of a Kalman filter algorithm."), 109 ("Since augmented reality is implemented as an interface feature between the players and their wearable computers, **head tracking for the calculation of view perspective of each player is important. We use Inertiacube2 from InterSense [InterSense01] for this purpose.** It is an inertial three degree-of-freedom orientation tracking system that gives yaw, pitch and roll of the object that it is attached on. **By placing the sensor**

on the cap of each player, her head movement and orientation is tracked to high accuracy.").

156. Cheok explains that "the point-of-view of each mobile player is sent to the computer of a helper through the server, and the corresponding view in the virtual PacWorld can be displayed." *Id.*, 109. In other words, the direction/orientation of a user's Ghost or Pacman virtual character (*a direction of gameplay for a virtual character of a location-based game provided on said device*) is established based on the direction the user (who is wearing a wearable computer *device*) is facing on the physical field (*based on the direction of said device*).

157. While Cheok does not explicitly disclose *a second manual input for setting a directional reference for a direction of gameplay for a virtual character of a location-based game provided on said device based on the direction of said device and said location-based game is provided on said device with respect to said directional reference and said directional reference is operable to be updated during said gameplay*, it is my opinion that a POSITA would have been motivated and found it obvious to implement the underlined features in view of Foxlin077.

a. Teachings of Foxlin077.

158. Like Cheok, Foxlin077 relates to motion tracking in VR and AR applications. *See* Secs. VIII.A, VIII.C. Foxlin077 discloses an "inertial angular orientation tracking apparatus" (EX1008, 6:20-22) which may be used, for example,

in applications in which "it is important to track the motions of parts of a human body,' such as "virtual reality ('VR') applications" and "for other head-mounted display ('HMD') applications" (*id.*, 1:16-22). For example, Foxlin077 explains that the inertial sensor may be incorporated in "an apparatus for simulating a virtual environment that is displayed to a user." *Id.*, 5:7-9. The apparatus "can be used with opaque virtual environments, where the entire environment is presented to a display," as well as "in a see-through environment, where the user has visual access to the real environment, but in addition, a virtual environment is superimposed on the real environment," i.e., an AR environment. *Id.*, 22:1-18; *see also* Sec. V.A-B (describing VR and AR environments). Foxlin077 explains that its inertial sensor is a "self contained sensor apparatus [that] generates a signal that corresponds to at least two of the three orientational aspects of yaw, pitch and roll of a human-scale body, relative to an external reference frame." EX1008, Abstract. Foxlin077's inertial sensor "track[s] the orientation of a body to which it is mounted, without interaction with radiation, energy, signals, or physical connections from any other apparatus." *Id.*, 1:63-66. Thus, in my opinion, Foxlin077 relates to similar concepts as Cheok, which as I discussed further above, discloses a virtual environment gaming system, compatible with both VR and AR modes, in which inertial sensors are incorporated into users' wearable computer devices in order to facilitate orientation/direction tracking. EX1006, 108-10. Indeed, it is my opinion that a

POSITA would have understood that the inertial sensor described in Foxlin077 is the same sensor as the InertiaCube2 inertial sensor described in Cheok, since the InertiaCube2 manual cited in Cheok identifies that the product is covered by the Foxlin077 patent. EX1006, 109 ("We use Inertiacube2 from InterSense [InterSense01]…."), 116 (citing InertiaCube 2 manual); EX1013, 2 (identifying the Foxlin077 patent as covering the InertiaCube2). A POSITA would have therefore been motivated to consider the teachings of Foxlin077 when implementing Cheok's Human Pacman system.

159. Foxlin077 further discloses that its inertial sensor is designed to address drift issues. In particular, Foxlin077 explains that "[a] difficulty with using gyroscopes for head-orientation tracking is drift," which "arises from integrating over time, a signal that is noisy, or has a bias." EX1008, 2:56-58. Foxlin077 explains that "[d]rift would make the virtual world appear to gradually rotate about the user's head even when the user is not moving." *Id.*, 2:58-60. To address this issue, Foxlin077 discloses that its inertial angular orientation tracking apparatus incorporates a "drift compensator" component that attempts to automatically correct drift. *Id.*, 6:27-32 ("To correct this drift, compensating sensors, such as gravimetric tilt sensors and sometimes also geomagnetic heading sensor(s) periodically measure the angular position, and this directly measured position signal is used to correct the drift of the integrated position signal."), 9:1-23 ("[T]he compensating angular

position sensors and compass are used periodically, at times when the user's head is not moving….This compass information and inclinometer information is used to reset the signals that are output from the drift compensator 108, which signals represent the angular orientation of the head. Thus all of the drift that has accumulated since the beginning, or last reset, is removed. To prevent sudden orientation shifts from jarring the user, the drift is removed from the output gradually, rather then all at once. Thus, the drift compensator 108 generates a set of signals over time that gradually approach the correct signal.").

160. Drift compensation requires using parameters measured during an initialization process, which I have annotated in a red circle in Figure 4A reproduced below. *Id.*, 11:1-7 ("Compensation is made 464 for certain types of 'errors' typical of angular rate sensors. These types of errors include temperature sensitivity, acceleration sensitivity, bias, scale factor, misalignment, cross-axis sensitivity, nonlinearity, hysteresis, etc. **Compensation is made using parameters measured during the calibration 418 and initialization 406 steps.**"); *see also id.*, 9:61-67 ("An overall view of the operating steps of the invention is shown by the flow chart of FIG. 4A. The process begins 402 and initializes 404 the hardware….Next, **initialization steps 406 are conducted**, shown in more detail in FIG. 4B.").

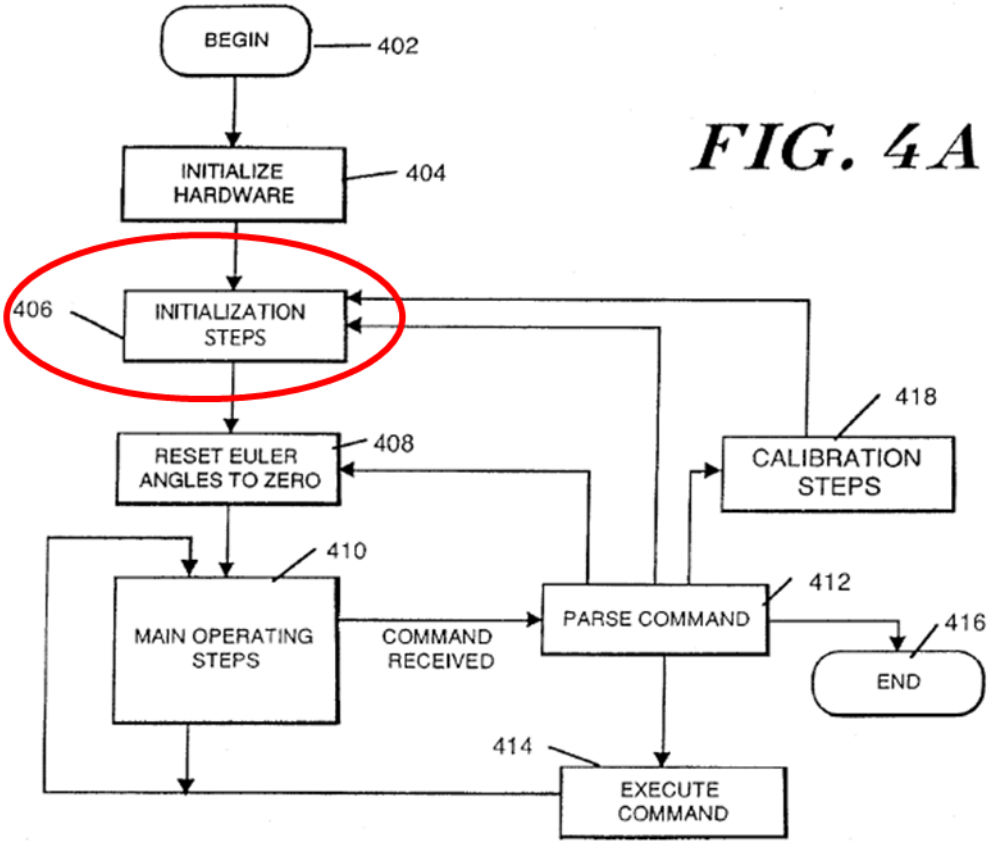


FIG. 4A

Id., FIG. 4A (annotated). The initialization steps "establish the rest position, from which orientation is measured and measure biases for the rate sensors," after which "the main operating steps 410 are performed." *Id.*, 9:67-10:7. Foxlin077 explains that "[i]nitialization must be conducted with the sensor assembly held stationary in a known reference orientation." *Id.*, 10:29-31. Foxlin077 explains that a "user is instructed 432 to place the sensor assembly in such a position by a message delivered to the apparatus input/output devices or implicitly by the fact of starting the tracker." *Id.*, 10:31-35.

161. In my opinion, a POSITA would have readily understood that in such an initialization process, the user is establishing a reference orientation (*a directional reference for a direction of gameplay*) by providing a manual orientation (e.g., by holding the sensor assembly stationary in a certain direction) (*a second manual input for setting a directional reference*) in response to a message delivered to the apparatus. A POSITA would have further understood that the main operating steps are performed with respect to this reference orientation (*said location-based game is provided on said device with respect to said directional reference*) because as discussed above, the operation of the device and its drift compensator component require using parameters (e.g., an orientation rest position) that are measured during an initialization process. EX1008, 9:67-10:7, 11:1-7. In my opinion, Foxlin077's process for manually setting a directional reference is consistent with that described in the '270 patent. Indeed, the '270 patent explains that a "user may be prompted to select a direction for gameplay," which "may be determined by the device prompting the user to point the device in a particular direction…and recording this direction." EX1001, 16:2-8.

162. After the initialization process described in Foxlin077 is complete, the operating steps are repeated until a command is received, where a command may be user-generated and includes operations such as a reinitialization process. EX1008, 10:9-11 ("Typically, the **operating steps are repeated again and again through a**

loop, until a command has been received. During the execution of the operating steps, **the user may generate commands**, or a command may be generated by the host computer to which the orientation tracker is connected."), 10:17-20 ("**Typical commands include:…**resetting the origin; **reinitializing the operation**….Execution of some of the commands are indicated in the flow chart [of Figure 4A] as separate steps….[or] are indicated by routings to stages in the overall operation already identified, such as: **to reinitialize 406**; reset Euler angles 408….").

I have reproduced Figure 4A below and annotated several steps to show this process. For example, as shown in Figure 4A below, a command may be received and parsed while the main operating steps (circled in blue) are being performed.

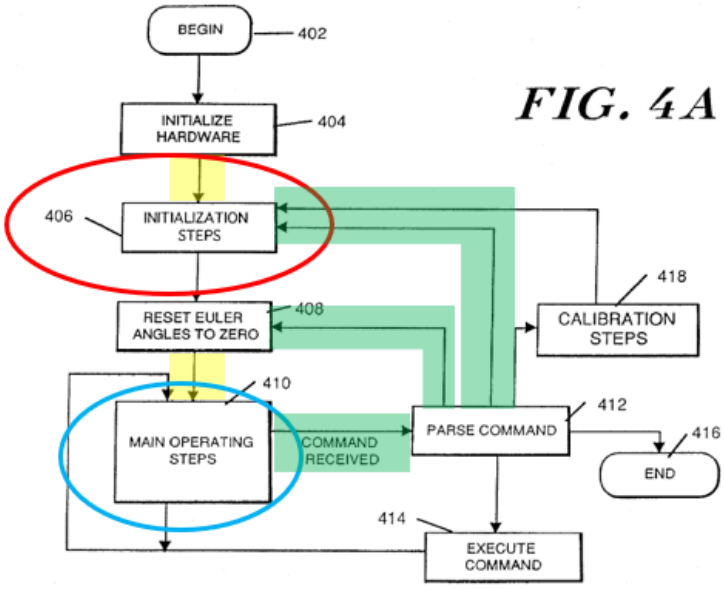


FIG. 4A

Id., FIG. 4 (annotated). As shown by the highlighted green arrows, when a command for "reinitializing the operation" is received, *see id.*, 10:17-20, the same initialization

steps (circled in red) that I discussed above (i.e., those involving the initialization of an inertial sensor to establish a reference orientation) are performed again, and the Euler angles are reset to zero. Or if a command for "resetting the origin" is received, *see id*., the Euler angles are reset to zero. And as shown by the highlighted orange arrows, the main operating steps resume when the reinitialization process is complete. In other words, the inertial sensor is reinitialized, thereby updating the reference orientation (*said directional reference is operable to be updated*), in the middle of the performance of the main operating steps (*during said gameplay*).

163. Accordingly, it is my opinion that Foxlin077 discloses *a second manual input for setting a directional reference for a direction of gameplay for a virtual character of a location-based game provided on said device based on the direction of said device and said location-based game is provided on said device with respect to said directional reference and said directional reference is operable to be updated during said gameplay*.

b. Motivation to Combine Cheok and Foxlin077.

164. In my opinion, a POSITA implementing Cheok's Human Pacman system would have been motivated to rely on the teachings of Foxlin077's initialization features to enhance Cheok. As I discussed above, Cheok discloses that an Intersense InertiaCube2 inertial sensor is used and cites to the product manual, which further cites to Foxlin077 as covering the product. *See* Sec. X.C.4.a; EX1006,

109, 116; EX1013, 2. Thus, a POSITA looking to implement the InertiaCube2 inertial sensor in Cheok's wearable computer would have looked to Foxlin077 and been instructed that the inertial sensor must be initialized through Foxlin077's described procedures.

165. Furthermore, Cheok discloses that its wearable computer uses "an inertial three degree-of-freedom orientation tracking system that gives yaw, pitch and roll of the object that it is attached on" and is "plac[ed]…on the cap of each player" to track head movement and orientation. EX1006, 109. Cheok also discloses that the wearable computer's dead-reckoning module "measures the displacement of the user from an initialization point by measuring the direction…and distance traveled…with each footstep taken." *Id.*, 108. Because Cheok discloses tracking movement with respect to an "initialization" point, Cheok suggests that the sensors must be initialized prior to use. *See id*. However, Cheok does not specifically disclose any particular initialization processes for the inertial sensors. A POSITA would have thus found it beneficial to modify Cheok based on Foxlin077's teachings to implement an inertial sensor initialization/reinitialization where a user can manually set an orientation in response to a prompt. *See id.*, 108, 115. A POSITA would have consulted Foxlin077's initialization/reinitialization process since they both describe the InertiaCube2 inertial sensor. *Id*; EX1008, ¶¶9-20.

166. In my opinion, POSITA would have been further motivated to rely on Foxlin077's teachings in order to address the sensor issues discussed by Cheok. Cheok suggests that the sensors incorporated in the wearable computer may have tracking issues, including unaddressed issues that exceed the scope of the paper. EX1006, 115 (discussing "sensor tracking issues" but noting that those sensor issues not related to "Human Computer Interface design" exceed the scope of the paper); *see also id.*, 108 (disclosing that GPS position data can be used to correct direction calculations from the dead-reckoning module), 115 (noting that GPS further "suffers from accuracy and selective availability"). Thus, Cheok provides express motivation for a POSITA to explore avenues to compensate for potential sensor issues, including issues associated with the inertial sensor. As I discussed above, Foxlin077 explains that drift is a problem associated with inertial trackers and offers a solution—a drift compensator, which uses parameters measured during an initialization/reinitialization process to help correct drift. *See* Sec. X.C.4.a. A POSITA would have thus recognized it would be beneficial to improve the Cheok system by implementing a similar inertial sensor initialization/reinitialization process to address any potential accuracy or user experience issues associated with drift.

167. A POSITA would have also understood that Foxlin077's initialization/reinitialization process would have improved user experience when

interacting with the real environment. Foxlin077 discloses that while drift rates associated with certain embodiments are "tolerable for opaque VE applications with no interaction with the real environment," that same drift rate may result in "drift accumulated after several minutes [that] would be enough to make contact with the real environment confusing." EX1008, 17:30-35. Thus, in a virtual environment application like the Cheok system, in which a user must interact with the real environment, a POSITA would have understood that Foxlin077's manual reinitialization process would be beneficial to address accumulated drift when an automatic drift compensator component is not sufficiently removing drift.

168. *See also* Sec. X.A, where I provide a higher level overview of the motivation to combine Cheok and Foxlin077.

c. Reasonable Expectation of Success.

169. In my opinion, a POSITA would have also had a reasonable expectation of success combining the teachings of Cheok and Foxlin077. As I discussed above, both references are in the same field of art. *See* Sec. X.C.4.a. Indeed, as I also discussed above, Cheok discloses using an InertiaCube2 inertial sensor, which is the very same product discussed in Foxlin077. *Id.* Furthermore, a POSITA would have understood that implementing the combination would have involved modifying the Cheok system in a manner that Cheok suggests is feasible—implementing the real-time tracking system such that an initialization process for the inertial sensors is

performed. Indeed, any real-time tracking system would require an initialization process to set reference locations and directions. Cheok suggests that a POSITA would necessarily look to other references like Foxlin077 for greater details on how to implement that initialization process. And as I discussed above, a POSITA would have further recognized that Cheok already includes a GUI system with manual inputs (*see, e.g.*, Sec. VIII.A and ¶ 134 above), and thus a combination to include an InertiaCube2 reset/initialization feature would only require adding an additional GUI element, making the combination relatively straightforward and low risk. It is my opinion that a POSITA would have also had the skill to implement and reasonable expectation of success in achieving such a combination, because it would have involved a combination of known technologies (e.g., known system of real-time tracking with respect to an initialization point (Cheok)) according to known methods (e.g., known methods of inertial sensor initialization (Foxlin077)) to yield the predictable result of a system in which inertial sensors are initialized and reinitialized by manually setting a directional reference for a direction of gameplay based on the direction a user is facing.

170. Accordingly, Cheok in view of Foxlin077 renders obvious *a second manual input for setting a directional reference for a direction of gameplay for a virtual character of a location-based game provided on said device based on the direction of said device and said location-based game is provided on said device*

with respect to said directional reference and said directional reference is operable to be updated during said gameplay.

171. *See also* Sec. X.B, where I provide a higher level overview of a POSITA's reasonable expectation of success in combining Cheok and Foxlin077.

D. Dependent Claims.

1. Claim 5: "The system of claim 4, wherein said directional reference is reset during play of said location-based game and said location-based game is provided after reset with respect to said reset directional reference."

172. In my opinion, Cheok in view of Foxlin077 renders obvious this limitation. As I discussed for limitation 4[a]-2, a POSITA would have found it obvious to implement the Cheok-Foxlin077 combination such that an inertial sensor may be reinitialized during gameplay—that is, when the main operating steps of the sensor unit are being performed. *See* Sec. X.C.4. As I also discussed, in such a reinitialization process, the reference orientation may be reset (*wherein said directional reference is reset*) in response to a manual reinitialization command received during gameplay (*during play of said location-based game*). *Id.* Following reinitialization, the inertial sensors use the new parameters measured during reinitialization in order to perform drift compensation (*said location-based game is provided after reset with respect to said reset directional reference*). *Id.* Accordingly, it is my opinion that Cheok in view of Foxlin077 renders obvious

wherein said directional reference is reset during play of said location-based game and said location-based game is provided after reset with respect to said reset directional reference. *Id.*

173. A POSITA would understand that the automatic drift correction taught by Foxlin077 and embodied in the InertiaCube2 used by Cheok, depends on the user being still for sufficient periods of time such that the gravimetric sensors are not being affected by the user's movement. *Id.*, 16:65–67 ("All possible orientations are tracked, although for drift correction to occur the user must occasionally pause.") Accordingly, a POSITA would also understand that if a user is in motion (not still) for long enough, the sensor drift will accumulate to a point where it becomes problematic for the user. *Id*., 2:58–60 ("Drift would make the virtual world appear to gradually rotate about the user's head even when the user is not moving."). And yet, a POSITA would understand that the location-based Human Pacman game of Cheok would be characterized by high energy, spatial awareness, and periods of constant motion. For example, Cheok remarks that "[t]o add to the excitement of game play, after 'eating' certain special ingredients, a Pacman gains Ghost-devouring capability and henceforth can attack her enemy head on for a limited period of time." EX1006, 110. Further, Foxlin077 discloses that when a user does pause, any drift correction is applied relatively slowly. EX1008, 12:14-20 ("A preferred method to generate the fractional error signal is to set an increment δ (in degrees). … This

provides a slow linear correction at a rate of nδ °/sec until the error is gone, where n is the number of operating mode cycles per second."). Further still, Foxlin077 also discussed how orientation drift correction depends on the electromagnetic compass, and that the device is "affected significantly by power lines, electrical equipment and nearby large amounts of iron or steel." *Id*., 19:25-45.

174. Moreover, if a user using Cheok's system encounters a physical obstacle in the real world that is not represented in the virtual word, the user is unable to avoid the obstacle without the avoidance (e.g., moving around the obstacle) being reflected in the virtual world. The combination of Cheok with Foxlin077 improves and enhances Cheok by permitting the user to adjust the virtual world so that the desired virtual route is aligned with the real world route a user is able or wants to take, so they can start walking again yet remain aligned with the virtual world.

175. For all of the foregoing reasons, a POSITA would understand that orientation misalignment is likely to occur during every-day use and thus would have found it advantageous to provide a mechanism for user-initiated orientation corrections during gameplay, e.g., by having the user look in a particular direction and then press a virtual button. A POSITA would have had an expectation of success because Cheok already has a GUI in the HMD (EX1006, 110) and Foxlin077 both discloses a mechanism for initialization and teaches that the Euler angles can be initialized to a known reference orientation. EX1008, 10:29-31.

176. Accordingly, it is my opinion that Cheok in view of Foxlin077 renders obvious *wherein said directional reference is reset during play of said location-based game and said location-based game is provided after reset with respect to said reset directional reference*.

2. Claim 16: "The system of claim 4, wherein said display is a head-mounted display and said device includes a power source.".

177. In my opinion, Cheok discloses this limitation.

178. **First**, Cheok discloses that *said display is a head-mounted display*. Indeed, as I discussed above for limitation 4[a], the wearable computer's display is a Cy-Visor Head-Mounted Display (video see-through HMD). *See* Sec. X.C.2; *see also* EX1006, 110.

179. **Second**, Cheok discloses that *said device includes a power source*. Cheok discloses that the wearable computer (*device*) receives power via two Sony F960 InfoLithium batteries (*said device includes a power source*), which I have circled in red in Figure 4 reproduced below. EX1006, 110 ("Since the wearable computers were designed and developed in the lab, we proceed to discuss its detail configuration as seen in Figure 4. The main components are Transmeta Single Board Computer (PC104 plus compliant motherboard running on Crusoe processor), Twiddler2 (handheld keyboard and mouse), Cy-Visor Head Mounted Display (video see-through HMD) with FireWire camera attached, **two Sony F960 InfoLithium**

batteries, InertiaCube2 (inertia sensor), DRMIII module (GPS and Dead-Reckoning device from Point Research Corporation), and JVC Bluetooth device.").



Figure 4. Detail configuration of wearable computer

Id., FIG. 4 (annotated).

3. Claim 17: "The system of claim 4, wherein said device includes a wireless communications device and location information associated with said location-based game is communicated through said wireless communications device.".

180. In my opinion, Cheok discloses this limitation.

181. **First**, Cheok discloses *wherein said device includes a wireless communications device*. Cheok discloses that the wearable computer (*device*) includes a wireless LAN card (*wireless communications device*), which is circled in

red in Figure 4 below. Cheok explains that the wireless LAN card enables *wireless* LAN *communication* in the system (e.g., between users' wearable computers, helpers' laptops, and the server). EX1006, 109 ("**The Wireless LAN serves as a communication highway between the wearable computers**, the helper computers (Sony VAIOs laptops), and the server desktop computer.").



Figure 4. Detail configuration of wearable computer

Id., FIG. 4 (annotated).

182. **Second**, Cheok discloses *location information associated with said location-based game is communicated through said wireless communications device*. For example, as further discussed for limitation 4[a]-1, Cheok explains that the real-time position of each Pacman or Ghost player (*location information associated with said location-based game*) is communicated to the server through

wireless LAN. *See* Sec. X.C.3; EX1006, 108 ("The real-time position of each mobile user is sent periodically to the server through wireless LAN. Upon receiving the position data, the server sends an update to each wearable computer the position of other mobile players, as well as the positions of all 'non-eaten' plain cookies."). A POSITA would have understood that the wireless LAN communication happens through the wireless LAN card of the wearable computer (*communicated through said wireless communications device*).

4. Claim 19: "The system of claim 4, wherein said display is a head-mounted display, said device includes a wireless communications device and location information associated with said location-based game is communicated through said wireless communications device, and said location-based game is a multiple player location-based game.".

183. In my opinion, Cheok in view of Nakamura renders obvious this limitation.

184. **First**, Cheok *wherein said display is a head-mounted display* for the same reasons as I discussed for claim 16 above. *See* Sec. X.D.2.

185. **Second**, Cheok discloses *said device includes a wireless communications device and location information associated with said location-based game is communicated through said wireless communications device* for the same reasons as I discussed for claim 17 above. *See* Sec. X.D.3.

186. **Third**, Cheok discloses *said location-based game is a multiple player location-based game*. As I further discussed for Sec. VIII.A (Cheok overview) and claim 4's preamble, the Human Pacman game incorporates multiple players representing Pacmen, Ghosts, and Helpers (*said location-based game is a multiple player location based game*). *See* Secs. VIII.A, X.C.1. For example, Cheok explains that a possible gameplay arrangement may include eight players "assigned to two opposing teams, namely the Pacman team and the Ghost team," where "[t]he former consists of two Pacman and two Helpers; [and] correspondingly, the latter consists of two Ghosts and two Helpers." EX1006, 110.

XI. OPINIONS ON GROUND 2: NAKAMURA IN VIEW OF BENINI RENDERS OBVIOUS CLAIMS 4, 5, AND 17.

A. A POSITA Would Have Been Motivated to Combine.

187. In my opinion, a POSITA would have been motivated to modify the Nakamura system based on the teachings of Benini, for example, to implement a method of manually rotating the virtual environment map on a mobile terminal display to align real and virtual displacement. *See, e.g.*, Sec. V.D-E. It is my opinion that a POSITA would have been motivated to implement these teachings for the following reasons, as I explain further in Sec. XI.C.4.b. A POSITA would have been motivated to rely on the teachings of Benini, which discloses a method for manually changing the view of a virtual world map (e.g., to rotate the map), because Nakamura

discloses a display rotation feature to align real and virtual displacement, but does not disclose the specific processes for rotating the display. *See* Sec. XI.C.4.a. A POSITA would have also found it obvious to rely on Benini's teachings to improve Nakamura's system because both systems use similar components, e.g., a mobile terminal with directional buttons which displays a 2D map of a virtual world. *See id.*, ¶¶130-131; *see also* Secs. VIII.B, D, XI.C.4.a.

188. Furthermore, it is my opinion that a POSITA would have been motivated to modify Nakamura's system to implement a manual rotation feature because it would have given users a choice in alignment, consistent with Nakamura's disclosures and a POSITA's knowledge of alignment modes at the time of the alleged invention. *Id.* Further, although Nakamura states that the user can select a starting position (EX1007, ¶[0036] ("[o]f course, it is also possible to select a starting position")), Nakamura does not disclose any particular mechanism for doing so. A POSITA would understand that Benini's directional arrows would offer a mechanism for setting the starting position, or repositioning at any time during a game if it became necessary or was desired, in the same way that Benini describes movement. EX1009, 3 ("[F]our arrows realizes the metaphor of moving forward, backward, left and right the avatar in the VE as if it is walking into it; and four arrows are used to turn around and to look up and down….").

B. A POSITA Would have Had a Reasonable Expectation of Success.

189. In my opinion, a POSITA would have had a reasonable expectation of success in combining the teachings of Nakamura and Benini, as I explain further in Sec. XI.C.4.c. Specifically, a POSITA would have relied on Benini's method for manually changing the view (e.g., rotating) of a mobile terminal's 2D map display to improve Nakamura's system. Nakamura and Benini use similar features, such as 2D maps on mobile terminals that have directional buttons, and thus a POSITA would have had a reasonable expectation of success in combining these teachings. *See* Secs. VIII.B, D; XI.C.4.a.

C. Independent Claim 4.

1. Preamble: "A system comprising:".

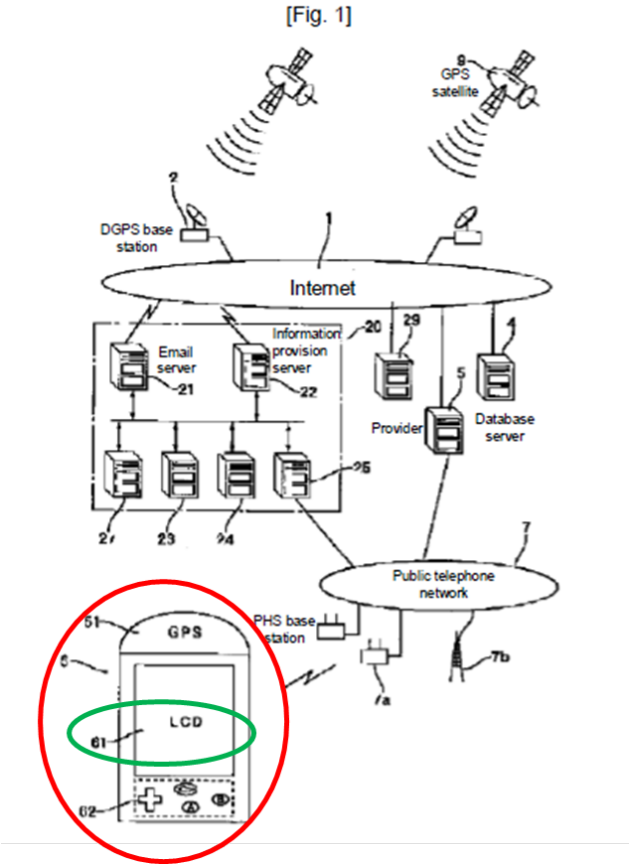
190. To the extent limiting, it is my opinion that Nakamura discloses the preamble. As I discussed further above in Sec. VIII.B (Nakamura overview), Nakamura discloses a *system* for controlling a computer which involves a virtual role-playing game in which new virtual scenes or worlds open depending on certain conditions. *See* Sec. VIII.B. Nakamura explains that the system is provided on a mobile terminal equipped with a GPS unit for acquiring the user's current location. *Id.* The user's current location is tracked and reflected in real-time in the virtual world (i.e., on the mobile terminal's display), allowing the role-playing game to progress as the user moves through the real world. *Id.*

2. 4[a]: "a device having a display, wherein a graphical user interface is provided on said display to receive".

191. In my opinion, Nakamura discloses this limitation.

192. **First**, Nakamura discloses *a device having a display*. Nakamura discloses a mobile terminal *device* which runs the game system according to the present invention, and which further has an LCD display (*a device having a display*) and an operational panel with a touch panel or pointing device and switches. EX1007, [0018] ("Figure 1 shows an example of the environment in which the **mobile terminal 6**, on which the virtual world (described here with a role-playing game as an example) according to the present invention is displayed, operates."), [0022] ("Furthermore, as an input/output mechanism, **the terminal is equipped with an LCD 61** and an operational panel 62 consisting of a touch panel or pointing device and switches."). Nakamura explains that the mobile terminal's game system operates using a "display control unit 30 for displaying the virtual world, and this display control unit 30 has several functions" for operating the game system in conjunction with the display. *Id.*, [0024]; *see also id.*, [0024]-[0031] (describing functions of the display control unit, including those to acquire and display screen information based on current location information).

193. I have reproduced Figure 1 below, which shows the mobile terminal *device* (circled in red) having an LCD *display* (circled in green).

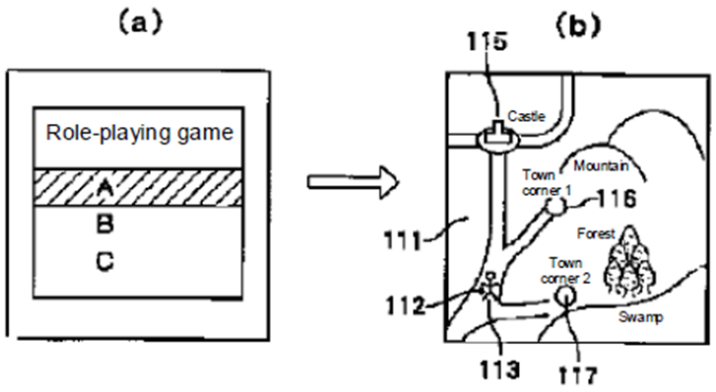


Id., FIG. 1 (annotated).

194. **Second**, Nakamura discloses *wherein a graphical user interface is provided on said display*. Nakamura discloses that the mobile terminal's LCD and operation panel (e.g., a touch panel) together form an input/output mechanism. EX1007, [0022] ("Furthermore, **as an input/output mechanism, the terminal is equipped with an LCD 61 and an operational panel 62 consisting of a touch panel** or pointing device and switches."). Nakamura further describes several inputs that may be provided to the display. For example, as shown in Figure 9(a), which I have reproduced below, a user uses the display interface to select one of several role-

playing games. *Id.*, [0033] ("For example, as shown in Figure 9(a), when the connection is made to the server system 20, **a screen to select the role-playing game is displayed. The user selects one of the games**, and the information for the selected role-playing game is sent from the server system 20.").

[Fig. 9]

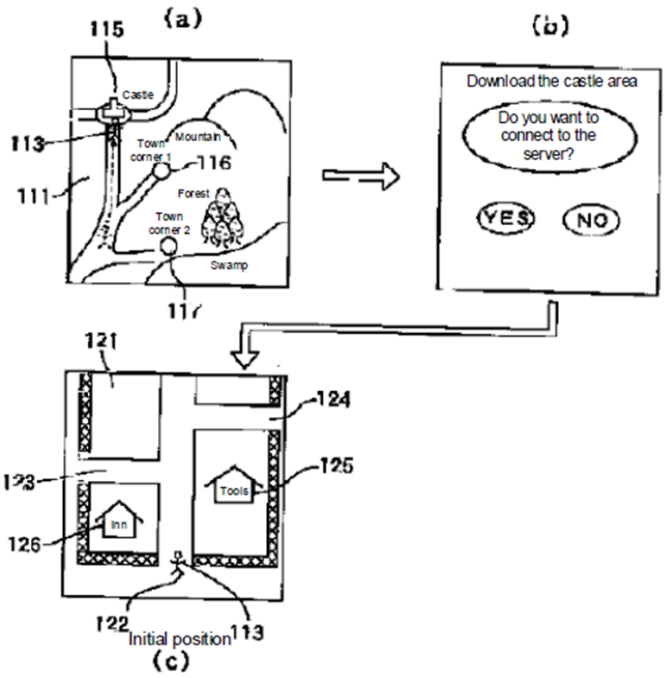


Id., FIG. 9.

195. Similarly, in Figure 10(b), which I have reproduced below, a user is able to choose one of several options on the display interface to determine whether or not to display the virtual world information corresponding to a certain part of the virtual world (e.g., a castle). *Id.*, [0042] ("As shown in Figure 10(a), when the position icon 113 overlaps with the event icon 115, which represents a castle, step 85 involves connecting to the server system. During this process, the server connection screen, as shown in Figure 10(b), is displayed. **If the user selects 'YES,'** the dial-up connection function 53 establishes communication with the server system

20, and the function for obtaining and displaying the virtual world information 31 retrieves the next screen. **If the user selects 'NO' on the screen shown in Figure 10(b)**, the following steps will not be executed, and the game will return to the original screen, i.e., the screen shown in Figure 10(a), allowing the user to continue the role-playing game.").

[Fig. 10]



Id., FIG. 10.

196. In my opinion, a POSITA would have thus understood that Nakamura's mobile terminal display provides a GUI (*wherein a graphical user interface is provided on said display*) because as described above, it provides a visual interface allowing users to provide input to control game play, such as the manual inputs

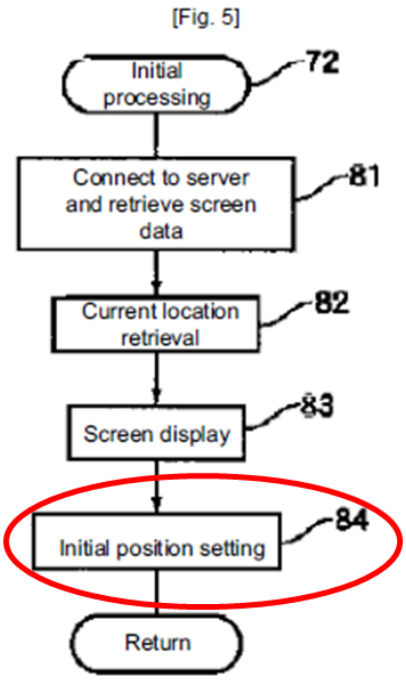
recited in limitations 4[a]-1 and 4[a]-2, which I discuss further below. *See* Sec. XI.C.3-4.

3. 4[a]-1: "a first manual input for setting a origin location setting for a location reference for gameplay and".

197. In my opinion, Nakamura discloses this limitation. Nakamura explains that new virtual worlds are displayed by tracking a user's current location information using technologies such as GPS and opening new worlds based on whether certain location conditions are met. EX1007, [0005] ("[N]ew scenes or worlds automatically open depending on certain conditions….[B]y utilizing current location information, which can be obtained through technologies such as GPS, a new virtual world is opened."), [0016] ("The system can be installed on a mobile terminal equipped with positioning systems such as a GPS unit…."), [0019] ("[T]he mobile terminal 6 in this example is equipped with a system for obtaining data indicating its current location (typically coordinates including latitude and longitude information). There are several such systems, and the one currently considered to have the highest accuracy uses a GPS unit…."). Nakamura further explains that "initial settings [can] be configured to reflect movements in the real world within the virtual world." *Id.*, [0009]. Nakamura discloses that "it is desirable to perform an initial setup that defines the correspondence between the current location and the virtual position, as well as the ratio for converting actual displacement into virtual

displacement, prior to starting the role-playing game." *Id.*, [0025]. The "function 33 for performing the initial setup is provided as one of the features of the display control unit 30, and the settings defined there are stored in a memory such as ROM or RAM." *Id.*

198. As part of Nakamura's initial setup, "it is desirable to set the current location in the real world as a predetermined position (the initial value of the virtual position) within the first virtual world." *Id.*, [0009]. The initial position may represent "the starting point of the game or, if the game was interrupted, the point where it was paused." *Id.* While it is possible "to use the parameters that are set by default" (*id.*, [0025]), it is also possible to manually set (*first manual input*) the initial position setting (*origin location setting*). For example, as I have circled in red in Figure 5, which I have reproduced below, "[i]n step 84, the function 32 for displaying the virtual position and virtual displacement displays the position icon 113 corresponding to the current location at the initial position 112 of the screen 111." *Id.*, [0035].



Id., FIG. 5 (annotated). Nakamura discloses that the "position icon 113, or position display icon, can be arranged according to the user's preference." *Id.*, [0035]. Once the user has chosen a suitable initial position, the user performs an operation on the display to trigger an initial setting function that sets the current location as the initial position parameter. *Id.*, [0036] ("If the position icon 113 is displayed at a virtual position that is appropriate to be set as the initial position, the user can perform a suitable operation, and the initial setting function 33 will set that current location as the initial position 112 on the screen 111 and store it as the parameter 13.").

199. As I have described above for limitation 4[a], a POSITA would have understood that the mobile terminal's display has a GUI to receive user input. *See* Sec. XI.C.2. In my opinion, a POSITA would have similarly understood that the

initial setting function, including the initial position setting, is performed by manual input to the display's GUI. Indeed, as I discussed above, the initial setting function is a feature of the display control unit (EX1007, [0025]) and a user is able to arrange a position display icon on the screen (i.e., manually) according to the user's preference (*id.*, [0036]). Thus, the display's GUI may receive a manual user input to set an initial position setting (*a first manual input for setting a[n] origin location setting*). In my opinion, Nakamura's *manual input for setting a[n] origin location setting* is also consistent with that disclosed by the '270 patent, which similarly describes a user using a display screen to select a physical location as the start of a game. EX1001, 8:66-9:11.

200. In my opinion, a POSITA would have also recognized that the initial position setting provides a *location reference for gameplay*. Indeed, Nakamura discloses that "[w]hen the selected role-playing game is first executed, the starting position of the game will be the initial position 112" (EX1007, [0036]) and that the initial setup process helps "define[] the correspondence between the current location and the virtual position" (*id.*, [0025]). The initial position setting thus provides a location reference that allows for a correspondence between real and virtual worlds as a user's movement is tracked and gameplay proceeds through the virtual world.

201. Accordingly, it is my opinion that Nakamura discloses *a first manual input for setting a origin location setting for a location reference for gameplay*.

4. 4[a]-2: "a second manual input for setting a directional reference for a direction of gameplay for a virtual character of a location-based game provided on said device based on the direction of said device and said location-based game is provided on said device with respect to said directional reference and said directional reference is operable to be updated during said gameplay.".

202. In my opinion, Nakamura in view of Benini renders obvious this limitation.

203. Nakamura discloses *setting a directional reference for a direction of gameplay for a virtual character of a location-based game provided on said device based on the direction of said device and said location-based game is provided on said device with respect to said directional reference*. Nakamura discloses that the mobile terminal is a "device equipped with a direction sensor." EX1007, [0017]. Nakamura explains that with such a device, "it is possible to rotate the display of the virtual world so that the direction of real displacement aligns with the direction of virtual displacement." *Id.* Rotating the displayed virtual world allows for the "virtual displacement [to] always[] points upwards, based on the direction of movement (actual displacement) obtained from the GPS unit 51." *Id.*, [0024]. In other words, Nakamura discloses rotating a display to set the directions of real and virtual displacement in alignment with one another (*setting a directional reference*), thereby establishing the direction of gameplay (*for a direction of gameplay*) for a user's virtual character on a mobile terminal (*for a virtual character of a location-*

based game provided on said device). Nakamura discloses that this *directional reference* is set based on the direction a user (holding a mobile terminal *device*) is facing in the real world (*based on the direction of said device*) because it relies on the device's direction sensor in order to determine the direction of real displacement. When the display has been rotated, the game progresses such that the corresponding virtual character's virtual displacement always points upward (*said location-based game is provided on said device with respect to said directional reference*).

204. While Nakamura does not explicitly disclose *a second manual input for . . . and said directional reference is operable to be updated during said gameplay*, it is my opinion that a POSITA would have been motivated and found it obvious to implement the underlined features in view of Benini.

a. Teachings of Benini.

205. Like Nakamura, Benini relates to the use of wireless portable devices for exploring virtual environments. *See* Secs. VIII.B, D. For example, Benini discloses a "hardware/software system for PDA-based interaction with IVEs [(immersive virtual environments)] realized in the field of Virtual Heritage (VH): Virtual Reality applied to Cultural Heritage." EX1009, 2. Benini aims to "reconstruct[] cultural heritage objects and environments" in an immersive virtual reality environment. *Id.*, 1. For example, "Virtual Heritage" applications may allow scholars to explore an archaeological site or the general public to explore a virtual

museum. *Id.*, 2. Benini discloses the use of "standard, consumer-market wearable interactive terminals, such as palmtop computers (Pocket PC and PDAs), as the preferred interfacing device with IVEs…in the field of Cultural Heritage." *Id.* As shown in Figure 3, which I have reproduced below, Benini's system consists of portable terminals for interfacing with the virtual environment (e.g., a virtual theatre) over a wireless network, along with client-server software that runs on the mobile terminals (client) and a virtual reality engine (server). *Id.* at 4.

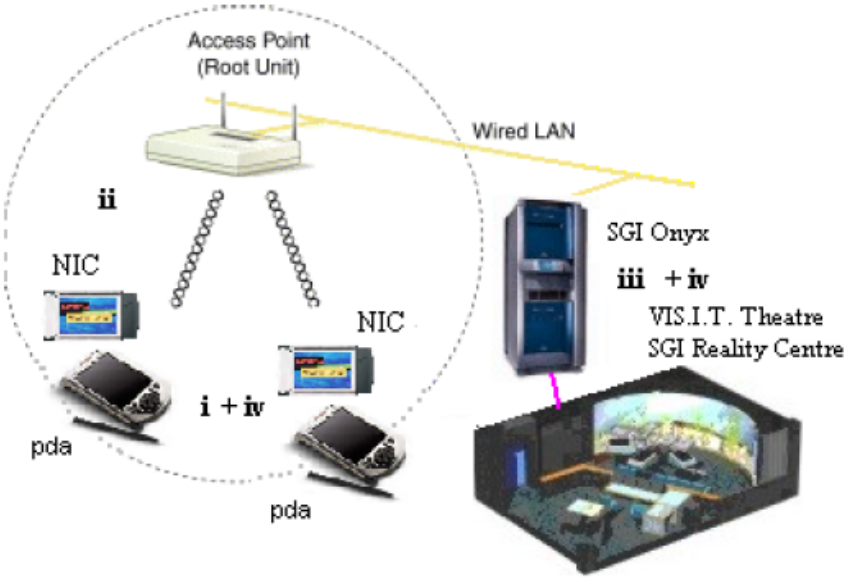


Figure 3: Components of the interactive system: portable terminals(i), wireless network(ii), virtual theater (iii), client-server software (iv).

Id., FIG. 3. Thus, in my opinion, that Benini's use interface device is similar to Nakamura's, which as I discussed in Sec. VIII.B (Nakamura overview) and Ground 2, limitation 4[a], discloses portable mobile terminals for interfacing with a virtual

environment. *See* Secs. V.B; XI.C.2. A POSITA would have therefore been motivated to consider the teachings of Benini when implementing the Nakamura system.

206. Benini additionally explains how the portable palmtop computers/PDAs can be used to support the basic interaction tasks in the field of 3D user interfaces—navigation, selection/manipulation, and system controls. EX1009, 2-3. For example, a PDA may incorporate a "'2D map' in which the users visualize their position and orientation in the virtual world," to allow users to see "which regions can be reached by their current position." *Id.*, 3. Benini explains that "[t]he UI features a two-dimensional map abstraction of the VR world, augmented with various navigation controls," including "eight arrows to more intuitively navigate in the environment." *Id.*, 3. The 2D map reproduces a view of the virtual environment, "enabl[ing] the user to visualize his/her position in the virtual world with a red rectangle and the direction of observation with a green rectangle…." *Id.*, 4. "[F]our arrows realizes the metaphor of moving forward, backward, left and right the avatar in the VE as if it is walking into it; and four arrows are used to turn around and to look up and down…." *Id.*, 3. I have reproduced Figure 2 below, which shows an example PDA mobile terminal with arrows (circled in green) for visualizing position and direction in the virtual environment.



Figure 2: The User Interface developed for interacting via PDA with the Nu.M.E. VE

Id., FIG. 2 (annotated). As shown above in green, the display prompts a user to use four of the arrows to "walk," i.e., change position, and four of the arrows to "look," i.e., change orientation/direction. *Id.*, FIG. 2.

207. Benini further discloses that the user interface arrows can be used to "change [the] camera's position and orientation (interacting with the 2D map or with the arrows)," thereby changing the view in the virtual environment. *Id.*, 4. When "requesting to change camera's position and orientation" according to interaction with the map/arrows, the portable terminal (client) has to send to the server (virtual reality engine) "a 6-dimensional vector that includes world coordinates (*x, y, z*) and

the three angles: heading – the rotation about the Z axis – pitch – the rotation about the X axis – and roll – the rotation about the Y axis." *Id*., 5. This allows the server "to increment [the] current camera's position and orientation" to show a new view in the virtual environment. *Id.*

208. Thus, Benini discloses a user interface for manually providing a direction (*a second manual input for setting a directional reference*) that establishes the direction of exploration in the virtual environment (*for a direction of gameplay*), where the direction can be updated during exploration of the virtual environment to show new virtual views (*said directional reference is operable to be updated during said gameplay*).

b. Motivation to Combine Nakamura and Benini.

209. In my opinion, a POSITA implementing Nakamura's system would have been motivated to rely on Benini's user interface features to enhance Nakamura. As I discussed further above, Nakamura discloses a rotation feature to align the directions of real and virtual displacement so that virtual displacement always points upwards, based on the direction the user (and the user's device with a direction sensor) is moving. *See* Sec. VIII.B. However, Nakamura does not disclose the specific processes for rotating the display of the virtual world. A POSITA would have thus been motivated to rely on the teachings of Benini's user interface with 2D map, in which a user uses arrows to manually change the view of a virtual world

map (e.g., to rotate the map) in order to establish a new viewing direction. *See* Sec. VIII.D. In my opinion, a POSITA would have understood that the 2D map feature of Benini would have been a natural complement to Nakamura's system since both systems use a portable/mobile terminal to display a 2D map of a virtual world. For example, I have reproduced Nakamura's Figure 1 and Figure 9 below, where Figure 9(b) (which I have circled in green) shows a particular screen displayed on Nakamura's mobile terminal, which is shown in Figure 1. I have also reproduced below Benini's Figure 2, which similarly shows a mobile terminal display screen.

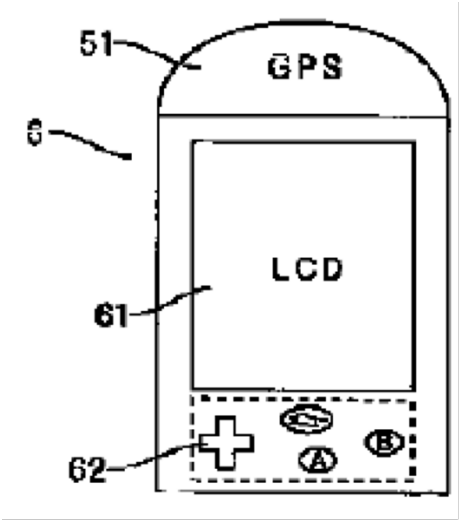


Figure 1 (excerpted)

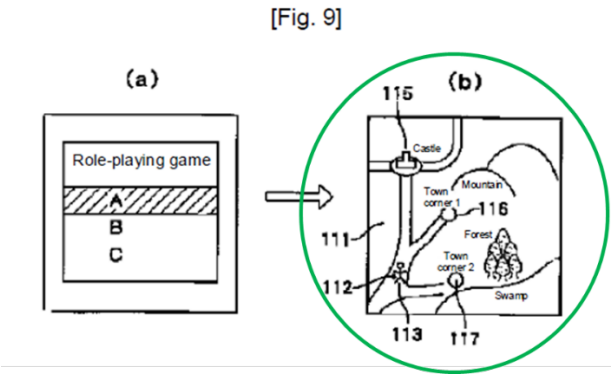




Figure 2: The User Interface developed for interacting via PDA with the Nu.M.E. VE

EX1007, FIG. 1 (excerpted), FIG. 9 (annotated); EX1009, FIG. 2 (annotated); *see also* EX1007, [0008] ("The first virtual world may simply be a world represented by a map corresponding to the real world (including deformed or stylized maps) that shows a destination or target area."); EX1009, 3 ("The UI features a two-dimensional map abstraction of the VR world…."). Moreover, as I discussed above, Benini uses manual directional arrows to manipulate position and orientation on the map, similar to the prior art systems described in Nakamura, in which "players progress in the game by moving through the virtual world using directional buttons, joysticks, or other pointing devices." EX1007, [0005]. In my opinion, a POSITA would have thus recognized that Nakamura's system would have been easily

improved by relying on features similar to Benini's map user interface, since Benini uses components already disclosed by Nakamura.

210. For example, if a user using Nakamura's system encounters a physical obstacle in the real world that is not represented in the virtual world, the user is unable to avoid the obstacle without the avoidance (e.g., turning around) being reflected in the virtual world. The combination with Benini improves and enhances Nakamura by permitting the user to adjust the virtual world map so that the avoidance of the physical obstacle is not reflected in the virtual world.

211. Similarly, a POSITA would understand that just as a user might start a Nakamura game that has a pre-determined initial virtual position, and that the possible gameplay associated with that virtual position might not be compatible with the user's real-world position, the game might also choose a pre-determined initial virtual rotation, and the possible gameplay associated with that virtual rotation might not be compatible with the user's real world position. The combination with Benini improves and enhances Nakamura by permitting the user to adjust the virtual world map so that the direction of virtual game play is compatible with the directions they are able to safely walk in the real world.

212. Further, a POSITA would understand that while in some places Nakamura focuses on position, Nakamura refers to both position and displacement (direction) together throughout and discloses an optional rotation feature to align the

directions of real and virtual displacement. A POSITA would therefore understand that if they were to implement that optional rotation feature to align the directions of real and virtual displacement, it would make sense to also allow the user to manually choose a rotation during initialization and at other times, just as Nakamura discloses for position. EX1007, [0036] ("If the position icon 113 is displayed at a virtual position that is appropriate to be set as the initial position, the user can perform a suitable operation, and the initial setting function 33 will set that current location as the initial position 112 on the screen 111 and store it as the parameter 13."). Indeed, a POSITA would understand that setting the appropriate position and direction for a particular user's circumstances would be crucial to making the game enjoyable and safe.

213. Because Nakamura already includes the ability to rotate the virtual scene content by some specified angle (*id.*, [0017], [0024]), including the mathematical rotations of the coordinate frames, a POSITA would have understood that all they would need to add was some suitable input mechanism, such as the screen-based arrows disclosed by Benini, to let the user control the value of an angular offset to the existing Nakamura virtual scene rotation function. This ability to adjust the direction would nicely match the ability to adjust position as disclosed by Nakamura. *See, e.g.*, EX1007, [0035] ("This position icon 113, or position

display icon, can be arranged according to the user's preference. It could be an icon in the shape of a human figure or even an icon representing the user's face.").

214. It is my opinion that a POSITA would have further understood that a manual method to rotate the display, such as the method disclosed by Benini, would have been one of only several options available for displaying Nakamura's map display. *See, e.g.*, Sec. V.D-E. Indeed, a POSITA would have understood that at the time of the alleged invention of the '270 patent (i.e., 2003), virtual maps used for navigation in virtual environments could be displayed in either a north-up configuration, in which north is always at the top of the map, or a forward-up configuration, in which the map is rotated to correspond to the forward direction. EX1011, 2 ("The two primary categories of map orientation are *north-up* which, as the name implies, always has north at the top, and *forward-up* (or *track-up*) which is always rotated so as to be congruent with the forward direction."); EX1012, 2-3 (describing a "reader aligned" or "north-up aligned" map where "north is presented up on the map" and an "environment aligned" or "forward-up (or track-up) aligned" map as a map that is "oriented consistently with regard to the environment"); *see also* Secs. V.A-B. A POSITA would have understood that Nakamura's rotated display feature, in which virtual displacement is always pointing up, would have corresponded to a forward-up map configuration. A POSITA would have also understood that during the relevant timeframe (i.e., 2003), the alignment (e.g.,

forward-up) could be set automatically or could be updated manually by a user, and that it was beneficial to give a user a choice between automatic and manual modes. EX1012, 3 (describing alignment that is either "automatic" or "static until the user manually updates the map"), 3 ("Our results showed that neither automatic nor manual mode should be preferred….Therefore, the users should be offered both methods."), 10 ("In the manual orientation mode, the user had to align the map to forward-up manually, whereas in the automatic orientation mode the map was continuously aligned to forward-up."). Thus, manually aligning a display in a forward-up configuration, as contemplated by the Nakamura-Benini combination, would have been obvious because it would have been one of only several alignment options available (e.g., north-up or forward-up, and further set manually or automatically).

215. Nakamura also describes the rotation feature as an optional feature, and thus, in my opinion, a POSITA would have understood that implementing the feature with manual rotation, so as to give users a choice in alignment (between forward-up and north-up alignment), would have been beneficial. EX1007, [0017] ("[I]t is **possible** to rotate the display of the virtual world so that the direction of real displacement aligns with the direction of virtual displacement."), [0024] ("[I]t is **possible** to add a feature that rotates and displays the virtual world so that virtual displacement always points upwards."). Indeed, a POSITA would have recognized

that allowing a user to manually manipulate the viewpoint of a map (e.g., to rotate it from one orientation to another), similar to the method disclosed by Benini, would have beneficially provided a user of the Nakamura system with the option to change/update the alignment direction during gameplay (*said directional reference is operable to be updated during said gameplay*), depending on user preference and environmental constraints (e.g., a dead end). For example, because of the constraints of the physical world compared to the virtual world, a user would encounter a situation where one cannot or does not want to proceed in a particular physical world direction that is necessary or desired in the virtual world, thus necessitating a rotation to change/update the alignment direction during gameplay.

c. Reasonable Expectation of Success.

216. In my opinion, a POSITA would have also had a reasonable expectation of success combining the teachings of Nakamura and Benini. As I discussed above, both references are in the same field of art. *See* Sec. XI.B. Furthermore, as I discussed above, Nakamura and Benini have similar features, such as 2D maps on mobile terminals that have directional buttons, and thus a POSITA would have had a reasonable expectation of success in combining these teachings. *See id.*; Sec. XI.C.4.c. It is my opinion that a POSITA would have also had the skill to implement and reasonable expectation of success in achieving such a combination, because it would have involved a combination of known technologies (e.g., known system of

exploring and displaying virtual environments using a map on a mobile terminal and rotating the display to align real and virtual displacement (Nakamura)) according to known methods (e.g., known methods of rotating/changing the orientation of a map viewpoint on a mobile terminal (Benini)) to yield the predictable result of a gaming system for exploring a virtual environment where a rotation feature to align real and virtual displacement (e.g. in a forward-up alignment) is implemented by manually rotating the map (e.g., with directional buttons) to the appropriate orientation. *Id.* Accordingly, Nakamura in view of Benini renders obvious *a second manual input for setting a directional reference for a direction of gameplay for a virtual character of a location-based game provided on said device based on the direction of said device and said location-based game is provided on said device with respect to said directional reference and said directional reference is operable to be updated during said gameplay*.

D. Dependent Claims.

1. Claim 5: "The system of claim 4, wherein said directional reference is reset during play of said location-based game and said location-based game is provided after reset with respect to said reset directional reference.".

217. In my opinion, Nakamura in view of Benini renders obvious this limitation. As I discussed above for Ground 2, limitation 4[a]-2, a POSITA would have found it obvious to implement the Nakamura-Benini combination such that

Nakamura's rotation feature to align real and virtual displacement is achieved by allowing a user to manually rotate Nakamura's mobile terminal display (e.g., with directional buttons) to the appropriate orientation. *See* Sec. XI.C.4. As further discussed, such a rotation feature allows for the setting and resetting during gameplay of an orientation for viewing the virtual environment (*wherein said directional reference is reset during play of said location-based game*). *Id.* As I further discussed, following rotation, the game is provided according to the aligned direction, e.g., by showing the virtual world such that virtual displacement is always pointing up (*said location-based game is provided after reset with respect to said reset directional reference*). *Id.*

2. Claim 17: "The system of claim 4, wherein said device includes a wireless communications device and location information associated with said location-based game is communicated through said wireless communications device.".

218. In my opinion, Nakamura discloses this limitation.

219. **First**, Nakamura discloses *wherein said device includes a wireless communications device*. Nakamura discloses that the system for displaying virtual world information is installed on a mobile terminal (*device*), which may be equipped with a wireless communication means (*wireless communications device*) to enable communication with a server system. EX1007, [0012] ("[I]t is desirable to include means or steps for obtaining virtual world information via **communication with a**

server system through wireless or computer networks."), [0016] ("A system for displaying such a virtual world can be provided on a computer-readable recording medium, which contains a program with instructions to implement each step of the method. **The system can be installed on a mobile terminal equipped with** positioning systems such as a GPS unit, methods for acquiring the user's current location (e.g., through PHS units, mobile phones, etc. that utilize location information from base stations), and **communication means for connecting to a server system via wireless**, PHS, mobile phones, dial-up Internet, or other computer networks.").

220. **Second**, Nakamura discloses *location information associated with said location-based game is communicated through said wireless communications device*. For example, as I further discussed for claim 4's preamble and limitation 4[a]-1, Nakamura discloses that a user's location (*location information associated with said location-based game*) is tracked to enable display of corresponding virtual world screens. *See* Secs. X.C.1, X.C.3.

221. Nakamura further discloses that this location information is transmitted to the server in order to retrieve and display corresponding virtual world information. EX1007, [0012] ("Enabling communication with a server system to retrieve virtual world information allows the **transmission of the current location information to the server system** and the retrieval of virtual world information relevant to that

location from the server system."), [0013] ("Furthermore, when the user reaches a destination or target area in the first virtual world, where information relevant to their current location is available, **the system may send the current location information to the server system**. In response, the server system can provide information about the second virtual world that is relevant to the user's current location."), [0014] ("Additionally, information related to the current location can include information about other users' terminals within a designated range from the user's current location, accessed through the server system, within the first virtual world."), [0043] ("Once the dial-up connection is established, first, in step 86, the data of the event icon 115 that overlapped with the position icon 113 is sent to the server system 20. Next, in step 87, it is determined whether the event icon is requesting information related to the current location. If the event icon is requesting information related to the current location, in step 88, **the current location information corresponding to the position icon 113 that overlapped with the event icon is sent to the server system 20**.").

222. In my opinion, a POSITA would have thus recognized that the user's current location (*location information associated with said location-based game*) is *communicated* to the server *through said wireless communications device* because as I discussed above, the wireless communications means (*wireless communications device*) is the device used to communicate information to the server.

XII. OPINIONS ON GROUND 3: NAKAMURA IN VIEW OF BENINI AND FOXLIN068 RENDERS OBVIOUS CLAIMS 16 AND 19.

A. A POSITA Would Have Been Motivated to Combine.

223. In my opinion, a POSITA would have been motivated to modify the Nakamura system based on the teachings of Foxlin068, for example, to implement a head-mounted display as part of the user's gaming device. It is my opinion that a POSITA would have been motivated to implement these teachings for the following reasons, as I explain further in Sec. XII.C.1.b. Foxlin068 explains that it enables both hand- and head-tracking while still keeping a user's hands free to perform tasks, which a POSITA would have understood would have been beneficial to the Nakamura system, which requires a user to hold the mobile terminal. *See id.*; EX1010, 7:27-33. A POSITA would have also recognized that Foxlin068's tracking device would have enabled an increased range of virtual and augmented reality applications, allowing for both fully immersive virtual experiences as well as manual interaction with the environment. *See* Sec. XII.C.1.b; EX1010, 1:23-32, 5:39-41.

B. A POSITA Would have Had a Reasonable Expectation of Success.

224. In my opinion, a POSITA would have also had a reasonable expectation of success in combining the teachings of Nakamura and Foxlin068, as I explain further in Sec. XII.C.1.c. Specifically, a POSITA would have relied on Foxlin068's teachings in modifying the Nakamura system to implement a wearable computer

tracking device which has a head-mounted display to enable position and orientation tracking. *Id.* Such a combination would have been easily achieved in the Nakamura system for tracking position and direction/orientation since both the Nakamura and Foxlin068 systems track these attributes. *Id.*

C. Dependent Claims.

1. Claim 16: "The system of claim 4, wherein said display is a head-mounted display and said device includes a power source.".

225. In my opinion, Nakamura in view of Foxlin068 renders obvious this limitation.

226. **First**, Nakamura in view of Foxlin068 renders obvious *wherein said display is a head-mounted display*. As I discussed above for Ground 2, limitation 4[a], Nakamura discloses that the mobile terminal *device* has a LCD *display*. *See* Sec. XI.C.2; *see also* EX1007, [0022]. While Nakamura does not explicitly discloses *wherein said display is a head-mounted display*, it is my opinion that a POSITA would have been motivated and found it obvious to implement this feature in view of Foxlin068.

a. Teachings of Foxlin068.

227. Like Nakamura, Foxlin068 relates to a wireless location tracking technologies for use in virtual reality games. *See* Secs. VIII.B, E. For example, Foxlin068 discloses that its "invention may combine a sourceless head orientation

tracker 30 with a head-worn tracking device 12 that tracks a hand-mounted 3D beacon 14 relative to the head 16." EX1010, 5:5-8. Foxlin068 discloses that its "new tracking technique is essentially 'sourceless' in that it can be used anywhere with no set-up of a source, yet it enables a much wider range of virtual environment-style navigation and interaction techniques than does a simple head-orientation tracker, including manual interaction with virtual objects." *Id.*, Abstract. Foxlin068 explains that the tracking device may incorporate an "inertial orientation tracker" and "position tracker." *Id.*, 5:45-50. Foxlin068 further discloses that its tracking device may be used in virtual environments such as virtual reality games. *Id.*, 13:28-32, 14:5-42. Thus, in my opinion, Foxlin068 is similar to Nakamura, which as I discussed for Ground 2, claim 4's preamble and limitation 4[a]-2, discloses a gaming system in a virtual environment that enables tracking of a user's location (through GPS) and orientation (through a direction sensor). *See* Secs. XI.C.1, XI.C.4. It is my opinion that a POSITA would have therefore been motivated to consider the teachings of Foxlin068 when implementing the Nakamura system.

228. Foxlin068 additionally discloses that its "fully integrated wearable VR system" has "only three parts (a wearable computer 10, a headset 15 with an integrated tracking system, and a hand-mounted beacon 14) and one cable connection 18." EX1010, 5:14-18. I have reproduced Figure 1 below, which shows the components of the wearable VR system.

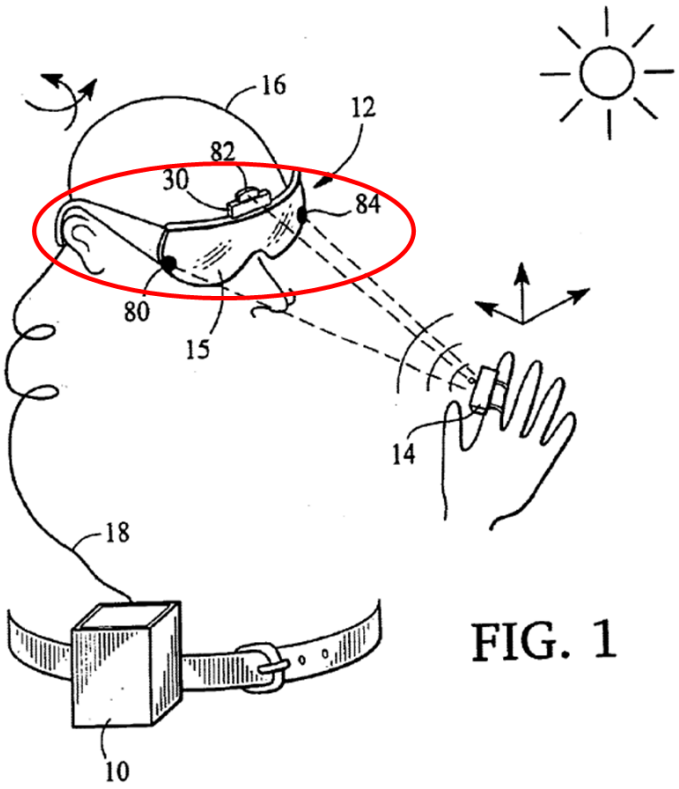


FIG. 1

Id., FIG. 1 (annotated). Foxlin068 explains that its headset may be a head-mounted display (*wherein said display is a head-mounted display*), as circled in red in Figure 1 above. *Id.*, 5:45-62 ("[A] simple proof-of-concept implementation…mount[s] the InertiaCube and the L-shaped receiver bar on the visor 60 of a **V-Cap 1000 see-through HMD** (available from Virtual Vision of Seattle, Wash.)."), 6:30-38 ("The simple implementation just described is wearable, but cannot be integrated into an HMD elegantly, largely due to the size and power consumption of the IS-300 processing unit. A low-cost wearable version using available technologies could be implemented as follows: The core of

this implementation is an inertial head orientation module called InterTrax 2 (available from InterSense and **designed for use with consumer HMDs such as the Sony Glasstron and Olympus EyeTrek**). Using tiny piezoelectric camcorder gyros, and solid-sate accelerometers and mangetometers, **InterTrax 2 is designed as a single long narrow circuit board 30 (FIG. 1) to lie across the top of the head mounted display unit along the brow line.**"), 6:61-63 ("In some embodiments, all components would be embedded inside the **HMD display unit** while sharing the HMD's cable 18, but in others, the added components are clipped on….").

b. Motivation to Combine Nakamura and Foxlin068.

229. In my opinion, a POSITA implementing Nakamura's system would have been motivated to rely on Foxlin068's head-mounted display features to enhance Nakamura. Foxlin068 explains that it enables both hand- and head-tracking while still keeping a user's hands free to perform tasks. EX1010, 7:27-33 ("A goal of a wearable computer is to keep the user's hands free to perform tasks. For this reason, the system uses a wireless 3-DOF ring pointer for interaction. The FreeD ring-mouse previously described is approximately the right size. In some implementations of the system, the tracker will need to be triggered by a unique IR code from the headset, so that multiple beacons can be tracked."). Nakamura, however, requires a user to hold the mobile terminal. EX1007, [0055] (describing a

"user holding terminal 6"). A POSITA would have thus recognized the benefits of a tracking device that allows a user's hands to remain free while tracking the hands.

230. Foxlin068 also explains that, in contrast to previous sourceless tracking devices, its device is suitable for the "emerging fields of wearable computing and augmented reality (AR)" because it "allow[s] enough control to look around the virtual environment and fly through it," and also "enable[s] the 'reach-out-and-grab' interactions that make virtual environments so intuitive and which are needed to facilitate computer interaction." EX1010, 1:23-32. Foxlin068's system thus "enables immersive visualization and intuitive manual interaction using a wearable system in arbitrary unprepared environments." *Id.*, 5:39-41.

231. Thus, in my opinion, a POSITA would have recognized that Foxlin068's tracking device would have enabled an increased range of virtual and augmented reality applications, allowing for both fully immersive virtual experiences as well as manual interaction with the environment.

c. Reasonable Expectation of Success.

232. In my opinion, a POSITA would have also had a reasonable expectation of success combining the teachings of Nakamura and Foxlin068. As I discussed above, both references are in the same field of art. *See* Sec. XII.C.1.a-b. As I further discussed above, Foxlin068's tracking device also tracks position and direction, and thus it would have been obvious to rely on these features to improve the Nakamura

system for tracking position and direction. *See* Secs. XII.C.1.a-b. A POSITA would have also had the skill to implement and reasonable expectation of success in achieving such a combination, because it would have involved a combination of known technologies (e.g., known system of real-time tracking in virtual environments (Nakamura)) according to known methods (e.g., known methods of tracking with a head-mounted display (Foxlin068)) to yield the predictable result of a gaming system for exploring a virtual environment where real-time tracking incorporates a head-mounted display tracking device. *See, e.g.*, IV.D. Accordingly, Nakamura in view of Foxlin068 renders obvious *wherein said display is a head-mounted display*.

233. **Second**, Nakamura in view of Foxlin068 renders obvious *said device includes a power source*. Indeed, Foxlin068 discloses that its wearable computer device with head-mounted display incorporates "computer and batteries…contained in [a] backpack." EX1010, 5:5-14. Accordingly, the Nakamura-Foxlin068 system described above would have had a wearable computer (*device*) powered by a battery pack (*power source*).

2. Claim 19: "The system of claim 4, wherein said display is a head-mounted display, said device includes a wireless communications device and location information associated with said location-based game is communicated through

said wireless communications device, and said location-based game is a multiple player location-based game.".

234. In my opinion, Nakamura in view of Foxlin068 renders obvious this limitation.

235. **First**, Nakamura in view of Foxlin068 renders obvious *wherein said display is a head-mounted display* for the same reasons as I discussed for Ground 3, claim 16. *See* Sec. XII.C.1.

236. **Second**, Nakamura discloses *said device includes a wireless communications device and location information associated with said location-based game is communicated through said wireless communications device* for the same reasons as discussed for Ground 2, claim 17. *See* Sec. XI.D.2.

237. **Third**, Nakamura discloses *said location-based game is a multiple player location-based game*. Nakamura discloses that its role-playing game may be played with multiple users, such that users can compete and communicate with each other. EX1007, [0009] ("Different settings can also be applied to **users with various physical abilities, enabling competitive gameplay** tailored to their capabilities."), [0014] ("[I]nformation related to the current location can include information about **other users' terminals within a designated range from the user's current location**, accessed through the server system, within the first virtual world….[I]n the system and method for displaying a virtual world according to the

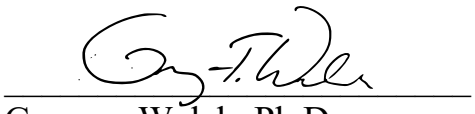
present invention, by combining the virtual world with real location information obtained from GPS, **it becomes easy to create opportunities for meeting others who are both virtually and physically nearby**, thus facilitating spontaneous interactions."), [0029] ("[B]y accessing the server system 20, it becomes possible to obtain information about the virtual world with event icons representing **other users who are accessing the same role-playing game**, using the function 31 for acquiring and displaying the virtual world. Then, **a connection can be established with that user, allowing for communication (chat) through the screen**.").

XIII. CONCLUSION.

238. For all the reasons stated above, it is my opinion that the challenged claims of the '270 patent are unpatentable.

This declaration and my opinions are made to the best of my knowledge and understanding, and based on the material available to me at the time of singing this declaration. All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. Further, I am aware that these statements are made with the knowledge that willful false under 18 U.S.C. § 1001. I declare under penalty of perjury that the foregoing is true and correct.

Executed this 25th day of March 2025 in Longwood, FL.



Gregory Welch, Ph.D.

APPENDIX A: DOCUMENTS CONSIDERED

Exhibit No.	Description
1001	U.S. Patent No. 10,967,270 to Mullen ("the '270 patent")
1002	File History of U.S. Patent No. 10,967,270
1003	Declaration of Gregory Welch, Ph.D. ("Welch")
1004	Curriculum Vitae of Gregory Welch, Ph.D.
1005	Declaration of Scott Delman ("Delman")
1006	Cheok, A. et al., *Human Pacman: A Sensing-based Mobile Entertainment System with Ubiquitous Computing and Tangible Interaction* (May 2003) ("Cheok")
1007	Japanese Patent Application Publication No. JP2001070658A to Nakamura ("Nakamura")
1008	U.S. Patent No. 5,645,077 to Foxlin ("Foxlin077")
1009	Benini, L. et al., *Palmtop Computer for Managing Interaction with Immersive Virtual Heritage* (2002) ("Benini")
1010	U.S. Patent No. 6,757,068 to Foxlin ("Foxlin068")
1011	Darken, R. & Cevik, H., *Map Usage in Virtual Environments: Orientation Issues* (1999)
1012	Lehikoinen, J. & Suomela, R., *WalkMap: Developing an Augmented Reality Map Application for Wearable Computers* (2002)

Exhibit No.	Description
1013	InterSense Inc, *Inertia Cube2 Bringing 3D To Life – Manual for Serial Port Model* (2001)
1014	RESERVED
1015	Sutherland, I., *A Head-Mounted Three Dimensional Display* (1968)
1016	Fitzmaurice, G., et al., *Virtual Reality for Palmtop Computers* (1993) ("Fitzmaurice")
1017	Fitzmaurice, G., *Situated Information Spaces and Spatially Aware Palmtop Computers* (1993) ("FitzmauriceB")
1018	Schilit, B. and Theimer, M., *Disseminating Active Map Information to Mobile Hosts* (1994)
1019	Björk, S. et al., *Pirates! Using the Physical World as a Game Board*, (2001)
1020	Falk, J. et al., *Pirates!: Proximity-Triggered Interaction in a Multi-Player Game* (2001)
1021	Thomas, B. et al., *First Person Indoor/Outdoor Augmented Reality Application: ARQuake* (2002)
1022	Azuma, R., *A Survey of Augmented Reality* (1997)
1023	Young, W.R., *Advanced Mobile Phone Service: Introduction, Background, and Objectives* (1979)
1024	Gratschew, S. et al., *A Multimedia Messaging Platform for Content Delivering* (2003)

Exhibit No.	Description
1025	Kamerman, A. and Monteban, L., *WaveLAN®-II: A High-Performance Wireless LAN for the Unlicensed Band* (1997)
1026	Ramanujan, R. et al., *Active Network Services for Mobile Wireless Environments* (2000)
1027	Hewlett-Packard Singapore (Pte) Ltd., *HP Jornada 600 Series Handheld PC User's Guide* (2000)
1028	Welch, G., *Motion Tracking: No Silver Bullet, but a Respectable Arsenal* (2002)
1029	Ware, C. and Osborne, S., *Exploration and Virtual Camera Control in Virtual Three Dimensional Environments* (1990)
1030	Bowman, D., *Interaction Techniques for Common Tasks in Immersive Virtual Environments Design, Evaluation, and Application* (1999)
1031	Arns, L., *A new taxonomy for locomotion in virtual environments* (2002)
1032	Razzaque, S. et al., *Redirected Walking* (2001)
1033	Cheok, A. et al., *Touch-Space: Mixed Reality Game Space Based on Ubiquitous, Tangible, and Social Computing* (2002)
1034	Declaration of Mark Claypool ("Claypool")
1035	Declaration of Philippe Geril ("Geril")
1036	U.S. Provisional Application No. 60/499,810 ("the '810 provisional")

Exhibit No.	Description
1037	U.S. Provisional Application No. 60/603,481 ("the '481 provisional")
1038	Declaration of Ayman K JP2001070658A Translation
1039	RESERVED