Method and Apparatus for Pseudo Interaction with a Surface by Interaction with an Interacting Mechanism Using a Wireless Positioning System

Reference to Related Applications

Reference is made to our co-pending Singapore patent applications numbers:

200504866-5 filed 12 July 2005 for the invention "Positioning Methods & Systems for UWB Devices" (the "UWB positioning system"),

200602425-1 filed 11 April 2006 for the invention "A Method for estimating One or More Parameters of an Ultra Wideband Signal and a Receiver System for Receiving Ultra Wideband Signals",

200603968-9 filed 14 June 2006 for the invention "Method, System and Apparatus for Mixed Reality", and

[number yet to be advised] filed 27 June 2006 for the invention "Method for Counteracting Multipath Effect for UWB Mono-pulse System"

the contents of which are incorporated herein by reference as if disclosed herein in their entirety.

Field of the Invention

This invention relates to a method and apparatus for pseudo interaction with a surface by interaction with an interacting mechanism using a wireless positioning system and refers more particularly, though not exclusively, to such a method and apparatus using the UWB positioning system.

Background to the Invention

It has been proposed to use a scanning laser finder to detect the position of a user's hand(s) and further use this information to interact with a personal computer. However, such a system has difficulty in adding other information such as, for example, the "click" of a mouse. It has been proposed to use gestures such as, for example, "moving one's hand quickly in and out of the scan plane or pulsing the non-tracked other hand rapidly in and out of the beam". However, they are not natural or intuitive ways of overcoming the problem. The use of "acoustic tap tracking" has been proposed to overcome the problem. Also, multiple users are difficult to handle as there is no ability to have identifiers for them included in the data. Another problem is that the updating rate is limited by the mechanical scanning that involves a rotating mirror.

It is also known to use surfaces as a continuation of a computer display and a place to transfer digital data with other PCs or devices. Such systems are an augmented environment that allows users to smoothly interchange digital information among their portable computers, table and wall displays, and other physical objects. Supported by a camera-based object recognition system, users can easily integrate their portable computers with the pre-installed PCs in the environment. Users can use displays projected on tables and walls as a spatially continuous extension of their portable computers. By using an interaction technique called hyperdragging, users can transfer information from one computer to another, by only knowing the physical relationship between

them. It also provides a mechanism for attaching digital data to physical objects, such as a videotape or a document folder, to link physical and digital spaces.

US patent 6,614,422 proposes a system for a user to input digital data to a companion system such as a PDA, a cellular telephone or an appliance using a virtual input device such as an image of a keyboard. A sensor captures three-dimensional positional information of the location of the user's fingers in relation to where keys would be on an actual keyboard. This information is processed with respect to finger locations and velocities and shape to determine when and which virtual keys would have been struck. The processed digital information is output to the companion system. The companion system can display an image of a keyboard; including an image of a keyboard showing user fingers, and/or alphanumeric text as such data is input by the user on the virtual input device.

With system proposed by US patent application No 2005/0240871 A1, a coded pattern applied to an object is identified when the object is placed on a display surface of an interactive display. The coded pattern is detected in an image of the display surface produced in response to reflected infrared (IR) light received from the coded pattern by an IR video camera disposed on an opposite side of the display surface from the object. The coded pattern can be a circular, linear, matrix, variable bit length matrix, multi-level matrix, black/white (binary), or gray scale pattern. The coded pattern serves as an identifier of the object and includes a cue component, and a code portion disposed in a predefined location relative to the cue component. A border region encompasses the cue

component and the code portion and masks undesired noise that might interfere with decoding the code portion.

US patent application 2005/0253780 proposed an interactive surface for enabling user interaction with software in a computer system via a sensing device. The interactive surface comprises visual information relating to a drawing field and the computer software, and coded data indicative of an identity of the interface and reference points on the surface. The coded data is readable by the sensing device in order to generate indicating data that is indicative of the identity of the interactive surface and one of: movement data, and position data. The movement data is indicative of the sensing device's movement relative to the interface surface. The position data is indicative of the sensing device's position relative to the interface surface. The interface surface is identified by the computer system. The movement data and the position data is used to identify the drawing field. The computer software is operated at least partly in reliance on the movement data and the position data, and in accordance with instructions associated with the drawing field.

US patent application 2002/0033803 A1 discloses a system for controlling a computer display in a workspace using an input unit/output unit. A train of electromagnetic ("EM") waves flood the workspace. EM waves are reflected from the input unit/output unit. A "relative distance moved" information signal is created using the EM waves that are reflected from the input unit/output unit. Algorithms are used to convert the relative distance moved information signal to

a display signal. The computer display is controlled in response to the display signal.

US patents 6,354,946 B1 and 6,585,597 B2 discloses an interactive wireless gaming system which utilizes impulse radio technology to enable gaming system enhancements. The interactive wireless gaming system has plural impulse radio wireless gaming units operating alternately as a host device and a guest device. Each impulse radio wireless gaming unit includes an impulse radio receiver for receiving impulse radio wireless messages including gaming information from a game server, a display for displaying the received gaming information, a processor for generating updated gaming information, and an impulse radio transmitter for transmitting impulse radio wireless messages including the updated gaming information to the game server. The game server then uses impulse radio technology to interact with and provide the updated gaming information to the other impulse radio wireless gaming units.

Summary of the Invention

In accordance with a first preferred aspect there is provided apparatus for pseudo interaction with a surface by interaction with an interacting mechanism using wireless positioning. The apparatus includes at least one tag adapted to be placed relative to the surface for enabling interaction with the interacting mechanism; and a reader able to communicate wirelessly with the at least one tag for receiving a tag signal from the at least one tag for enabling the reader to determine the position of the at least one tag relative to the reader. The at least

one tag has an input system for input of communication data to be sent to the reader.

According to a second preferred aspect there is provided a method for pseudo interaction with a surface by interaction with an interacting mechanism using wireless positioning. The method includes placing at least one tag relative to the surface for enabling interaction with the interacting mechanism. A tag signal is sent from the at least one tag to a reader by wireless communication. The reader uses the tag signal to determine the position of the at least one tag relative to the reader. An input system of the at least one tag is used for input of communication data that is sent to the reader.

For both aspects the reader may be a single reader. The least one tag may further comprise a radio frequency system, an antenna, and a baseband system. The antenna may be an omni-directional antenna. The reader may comprise an antenna array. The antenna array may comprise a plurality of directional antennas. The antenna array may be locatable at a projector for projecting a display on the surface, on the surface, or adjacent the surface. The antenna array may be for producing at least one beam over the surface, the at least one beam being a relatively wide angle beam on the surface and a relatively narrow angle beam in a direction perpendicular to the surface. The surface may form a boundary for the at least one beam. The input system may comprise at least one of: a mechanical input, an electrical input, and a mechanical/electrical input. The input system may also be for receiving and outputting output data from the

receiver. The wireless communication may be by ultra-wide-band pulses. The reader may be for operative connection to the interacting mechanism. The interacting mechanism may be selected from: a microprocessor, a computer, a personal computer, a portable computer, and a projector. The reader may also be for estimation of direction of arrival, and time of flight for estimating a range of the at least one tag. There may be a plurality of tags, each tag having a unique identifier that forms part of the communication data. The surface may be substantially flat. The tag signal may comprise coded UWB pulses.

The tag signal may be sent in response to a range request sent by the reader. The communication data may be sent from the at least one tag to the reader whenever required.

Brief Description of the Drawings

In order that the present invention may be fully understood and readily put into practical effect there shall now be described by way of non-limitative example only preferred embodiment of the present invention, the description being with reference to the accompanying illustrative drawings.

In the drawings:

Figure 1 is a schematic illustration of a prior art system in a basic form;

Figure 2 is an illustration of the system architecture of a first embodiment;

Figure 3 is a graph illustrating multi-path problems when operating near a large reflector;

Figure 4 is an illustration of packet format of pulses;

Figure 5 is a schematic illustration of a second embodiment;

Figure 6 is a block diagram of the second embodiment;

Figure 7 is the system architecture of the second embodiment;

Figure 8 is an illustration of the positioning system based on a mono-pulse method;

Figure 9 is an illustration of three functions at the positioning system reader; and

Figure 10 is an illustration of co-ordinate transformation.

Detailed Description of the Preferred Embodiments

Figure 1 illustrates a prior art system that aims to turn large, generally flat, passive surfaces, such as walls, floors, tables or windows, into pseudo interactive interfaces. By capturing the user's various manners of gestures, these surfaces (or related systems) will be appear to interact with the user. The user's hand position on the passive surface is detected by a scanning laser range finder and this information is input to a personal computer ("PC"). As a result, the projected image can "respond" according to the position of the user's hand (e.g. highlighting the pointed area, and so forth). As such the user appears to be interacting with the surface, but is in fact interacting with the PC. However, such a system lacks the ability to communicate. Except for the position, no other information can be transferred between the user and the range finder.

As shown in Figure 2, the first preferred embodiment consists of a single or multiple UWB positioning system tags 20 and a UWB positioning system reader

21. Preferably, there is only one reader 21. Each user places a tag 20 relative to a passive surface 31 such as, for example, by holding the tag 20 in the hand they move relative to the passive surface 31. There may be a display on the surface 31. The reader 21 is installed at a fixed position and is connected to the interacting mechanism 22.

Each tag 20 has a user input 23 that may be mechanical, electrical or mechanical/electrical, a baseband system 24, a radio frequency system 25 and an antenna 26. The antenna 26 may be an omni-directional antenna. The tag 20 and the reader 21 communicate between each other using UWB pulses 27.

The reader 21 has a radio frequency system 29, a baseband system 30 and an antenna array 28 that has multiple directional antennas, two antennas being illustrated. However, any number of antennas may be used in the array.

The antenna array 28 is for producing at least one beam over the surface 31. The beam is a relatively wide angle beam in the two dimensions of the surface 31 so that it covers at least a substantial portion of the surface 31; and is a relatively narrow beam in a direction perpendicular to the surface 31. The tag 20 must be within the beam for communication between the tag 20 and the reader 21.

The surface 31 may be any suitable passive surface such as, for example, a wall, floor, table, window, screen, white board, display surface, monitor screen,

television screen, map of the world, large poster, blackboard, display of a vending machine, game board such as a chess board, and so forth. It is preferably substantially flat. However, it may be slightly concave and/or slightly convex about either or both of the vertical and horizontal axes of the surface.

The UWB tags 20 are preferably small, simple, inexpensive, and have low power consumption. Each tag 20 responds to the ranging request from the reader 21 and transmits communication data when necessary (e.g. ID information or the "clicking" of the button 23). They may be embedded within, attached to, or form part of, an article. For example, they may be in a pen or like article for interacting with a vending machine display for selecting items to be purchased; in the pieces of a chess set for true "computer chess"; or a control for pseudo interaction with a television or computer screen for selecting or operating functions of appliances.

The interacting mechanism 22 may be a microprocessor, a computer, a personal computer, a portable computer, or a projector. It may form part of a larger article.

When a ranging request from the reader 21 is received, the tag 20 sends back a tag signal being coded UWB pulses 27 through the RF system 25 controlled by the baseband system 24. Based on the responding pulses received at the reader 21, the position of the tag 20 relative to the reader 21 can be estimated in accordance with the UWB positioning system. As the position of the antenna

array 28 relative to the surface 31 is known, the coordinates of the tag 20 relative to the surface 31 can easily be determined. The coordinates can be passed to the interacting mechanism 22.

As such the user appears to be interacting with the surface 31, but in fact the tag 20 is interacting with the interacting mechanism 22 by use of the wireless positioning system of the tag 20 and reader 21. In that way the interaction with the surface 31 is a pseudo interaction.

Besides the tag signal, communication may also be implemented at the same time. For example, by adding identity information to each tag 20 it is possible to include ID data in the pulses 27 so the reader 21 can discriminate between pulses 27 from several tags 20.

As shown in Figure 3, one technical challenge is the mirror reflection from the surface 31. Normally the UWB tag 20 will be working near the surface 31. It's well known that a big surface is normally a good reflector. Thus the reflected signal is a strong multi-path signal and will be mixed with the direct path signal. The graph shows waveforms collected at two antennas (with 60 degree squint angle) when the system is operating 40 cm distance from an office wall. The waveform is different from the line-of-sight waveform and thus processing is needed for accurate ranging and direction of arrival ("DOA") estimation.

To combine ranging, waveform capturing and communication functions, a packet format can be used in the tag 20. An example is illustrated in Figure 4. The acquisition preamble is a coded sequence of pulses for the reader 21 to detect and synchronize with the tag 20. For each part of this packet, different pulse rate and coding methods may be applied.

In Figure 5, an embodiment is shown that is for a natural interaction between the user and a PC 52 through the user's hand's actions on or over a projection screen 50. Alternatively, the interaction may be between the user and a PC projector 51. A more natural interaction between the user and the PC 52 is provided via the user's interaction with a projected display 53 on the projection screen 50.

The display of a PC is projected onto the screen 50 and the movement of the user's hand (holding a UWB tag 20) controls the cursor. Being different from a mouse, the cursor is able to follow the user's hand accurately due to the high accuracy of the UWB positioning system, and to do so in real time. It also enables control in a more natural way.

Extra functions and applications such as, for example, the single click and double click of a normal mouse, is provided by the communications ability of the UWB positioning system. When the user input the clicks to a push button on the UWB tag 20, the action is detected by mechanical/electrical system 23 and the

data is encoded and sent on top of UWB pulses 27. The reader 21 decodes the data and provides an input to the PC 52 for standard mouse responses.

As illustrated, the antenna 26 of the UWB tag 20 and the antenna array 28 of the reader 21 are located in a plane parallel to the projection screen 50, this is not always required. For example, the antenna array 28 of the reader 21 may be integrated into a projector 51 to provide a simpler system setup.

Though here the application is targeted to replace a normal mouse, the capability of the system extends well beyond that simple use. As more data can be transferred to the reader 21 than just the clicking, the nature of the use of the system is limited only by the imagination of the user.

Due to the wide bandwidth, the UWB positioning system has the capability of both high-accuracy positioning (centimeter level) and high-data-rate communication (>100Mbps). Utilizing these two capabilities, the intention of the user can be accurately interpreted by the UWB reader 21 in real-time, by tracking the natural movement and actions of the hand holding the UWB tag 20. With both ranging and communication capabilities, the UWB positioning system is able to relatively accurately interpret the user's movement and action on or over the surface 50. Using such information, the PC 52 can react in real-time.

It is preferred that the tag 20 be located on or just over the surface 50. Movement should also be on or just over the surface 50. The UWB reader 21

locates the relative position of UWB tag 20 using the UWB positioning system. In addition, more functions can be added or used through wireless communication between the tag 20 and the reader 21. At the reader 21, the received data is demodulated and decoded before it is sent to the PC 52, together with the extracted position information.

In certain applications, the reader 21 can also send data to the tag 20 using the UWB bi-directional communication ability. The data will be output to the user by a mechanical/electrical system 23.

The communication data can be modulated on the UWB pulses using, for example, pulse position modulation or binary phase shift keying in most UWB communication systems. The reader 21 decodes the data and passes it to the PC 52 for appropriate action.

Figure 6 shows the block diagram consisting of at least one UWB tag 20, a UWB reader 21 and an interactive surface 50. An object 54 such as, for example, a robotic toy, may also be involved. The user 55 may control the object, which will interface with the UWB tag 20, to effect the interaction with the interacting mechanism 52. The data exchange between UWB tag 20 and UWB reader 21 is through coded UWB pulses 27. The interacting mechanism 52 may interact with the user 55 directly in many possible ways or through the interactive surface 50 and/or the display 53 on the surface 50.

Figure 7 illustrates one physical setup for the proposed system. The user 55 moves and operates on the UWB tag 20 near to or on top of the interactive surface 50. Position and other coded information 70 (e.g. ID or "clicking") is received by the UWB reader 21 and passed to the responding mechanism 51 or 52, which responds to the user's movement in a natural and pre-set way. For example, the surface 50 may be divided into several regions with names of different music titles indicated in each region. Moving the tag into one specific region combined with a "clicking" (by pressing a button 23 on the tag 20) causes the responding mechanism 51, 52 to play the selected title. The antenna array 28 for the reader 21 is located near to the interactive surface 50. However, it may be located wherever required or desired. For example, it may be integrated into the projector 51.

Figure 8 illustrates the setup of the UWB positioning system based on mono-pulse system. The UWB tag 20 is a mobile tag whose position is to be determined. The tag signal being UWB pulses sent by the omni-directional antenna 26 are received by each antenna of the antenna array 28. The signals received by each antenna of the array 28 are compared to determine the DOA. Range and DOA are estimated separately.

Figure 9 shows the three of the functions performed at the UWB reader 21. Range estimation is based on time of flight ("TOF") measurement of a round trip between the reader 21and the tag 20. The DOA estimation is based on mono-pulse method. The communication data is firstly coded and modulated on top

on the UWB pulses at the tag 20 and then demodulated and decoded by the UWB reader 21.

Figure 10 shows the coordinate transformation among different systems. This is necessary to build up a one-to-one mapping between the position of the tag 20 and the coordinate system of the PC 52.

With the use of UWB technology, the updating rate is only confined by the electronics (RF transmitting/receiving and switching). Thus the system may be able to reach a much higher updating speed, which is important to track fast movement of users.

Whilst there has been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design, construction or operation may be made without departing from the present invention.

LIST OF REFERENCE NUMERALS

20	tags
21	reader
22	interacting mechanism
23	user input
24	baseband system of 20
25	RF system of 20
26	antenna of 20
27	UWB pulses
28	antenna array of 21
29	RF system of 21
30	baseband system of 21
31	surface
50	projection screen
51	projector
52	computer
53	display
54	object
55	user

The Claims:

1. Apparatus for pseudo interaction with a surface by interaction with an interacting mechanism using a wireless positioning system, the apparatus comprising:

at least one tag adapted to be placed relative to the surface for enabling interaction with the interacting mechanism;

a reader able to communicate wirelessly with the at least one tag for receiving a tag signal from the at least one tag for enabling the reader to determine the position of the at least one tag relative to the reader;

the at least one tag comprising an input system for input of communication data to be sent to the reader.

2. Apparatus as claimed in claim 1, wherein the reader is a single reader.

3. Apparatus as claimed in claim 1 or claim 2, wherein the at least one tag further comprises a radio frequency system, an antenna, and a baseband system.

4. Apparatus as claimed in claim 3, wherein the antenna is an omni-directional antenna.

5. Apparatus as claimed in any one of claims 1 to 4, wherein the reader comprises an antenna array.

6. Apparatus as claimed in claim 5, wherein the antenna array comprises a plurality of directional antennas.

7. Apparatus as claimed in claim 5 or claim 6, wherein the antenna array is locatable in a location selected from the group consisting of: with a

projector for projecting a display on the surface, on the surface, and adjacent the surface.

8. Apparatus as claimed in any one of claims 5 to 7, wherein the antenna array is for producing at least one beam over the surface, the at least one beam being a relatively wide angle beam on the surface and a relatively narrow angle beam in a direction perpendicular to the surface.

9. Apparatus as claimed in claim 8, wherein the surface forms a boundary for the at least one beam.

10. Apparatus as claimed in any one of claims 1 to 9, wherein the input system comprises at least one selected from the group consisting of: a mechanical input, an electrical input, and a mechanical/electrical input.

11. Apparatus as claimed in any one of claims 1 to 10, wherein the input system is also for receiving and outputting output data from the receiver.

12. Apparatus as claimed in any one of claims 1 to 11, wherein the wireless communication is by ultra-wide-band pulses.

13. Apparatus as claimed in any one of claims 1 to 12, wherein the reader is for operative connection to the interacting mechanism, the interacting mechanism being selected from the group consisting of: a microprocessor, a computer, a personal computer, a portable computer, and a projector.

14. Apparatus as claimed in any one of claims 1 to 13, wherein the reader is also for estimation of direction of arrival, and time of flight for estimating a range of the at least one tag.

15. Apparatus as claimed in any one of claims 1 to 14, wherein there are a plurality of tags, each tag having a unique identifier that forms part of the communications data.

16. Apparatus as claimed in any one of claims 1 to 15, wherein the surface is substantially flat.

17. Apparatus as claimed in any one of claims 1 to 17, wherein the tag signal comprises coded UWB pulses.

18. A method for pseudo interaction with a surface by interaction with an interacting mechanism using wireless positioning, the method comprising:

placing at least one tag relative to the surface for enabling interaction with the interacting mechanism;

sending a tag signal from the at least one tag to a reader by wireless communication;

the reader using the tag signal to determine the position of the at least one tag relative to the reader;

using an input system of the at least one tag for input of communication data; and

sending the communication data to the reader with the tag signal.

19. A method as claimed in claim 18, wherein the reader is a single reader.

20. A method as claimed in claim 18 or claim 19, wherein the tag signal comprises coded UWB pulses.

21. A method as claimed in any one of claims 18 to 20, wherein the at least one tag further comprises a radio frequency system, an antenna, and a baseband system.

22. A method as claimed in claim 21, wherein the antenna is an omni-directional antenna.

23. A method as claimed in any one of claims 18 to 22, wherein the reader comprises an antenna array.

24. A method as claimed in claim 23, wherein the antenna array comprises a plurality of directional antennas.

25. A method as claimed in claim 23 or claim 24, wherein the antenna array is located in a location selected from the group consisting of: with a projector projecting a display on the surface, on the surface, and adjacent the surface.

26. A method as claimed in any one of claims 23 to 25, wherein the antenna array produces at least one beam over the surface, the at least one beam being a relatively wide angle beam on the surface and a relatively narrow angle beam in a direction perpendicular to the surface.

27. A method as claimed in claim 26, wherein the surface forms a boundary for the at least one beam.

28. A method as claimed in any one of claims 18 to 27, wherein the input system comprises at least one selected from the group consisting of:

a mechanical input, an electrical input, and a mechanical/electrical input.

29. A method as claimed in any one of claims 18 to 28, wherein the input system also receives and outputs output data from the receiver.

30. A method as claimed in any one of claims 18 to 29, wherein the wireless communication is by ultra-wide-band pulses.

31. A method as claimed in any one of claims 18 to 30, wherein the reader is operatively connected to the interacting mechanism, the interacting mechanism being selected from the group consisting of: a microprocessor, a computer, a personal computer, a portable computer, and a projector.

32. A method as claimed in any one of claims 18 to 31, wherein the reader also estimates direction of arrival, and time of flight to estimate a range of the at least one tag.

33. A method as claimed in any one of claims 18 to 32, wherein there are a plurality of tags, each tag having a unique identifier that forms part of the communication data.

34. A method as claimed in any one of claims 18 to 33, wherein the surface is substantially flat.

35. A method as claimed in any one of claims 18 to 34, wherein the tag signal is sent in response to a range request sent by the reader.

36. A method as claimed in any one of claims 18 to 35, wherein the communications data is sent from the at least one tag to the reader whenever required.