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ABSTRACT
A pedestrian navigation and spatial relation device including a position finder, a spatial relationship sensor, an input mechanism, and an output mechanism. The position finder can be configured to determine a geographic position of the device based upon received wireless signals. The spatial relationship sensor can provide data used to detect a position of at least one obstacle relative to the device. The input mechanism can specify a destination location. The output mechanism can present device output to a user. The device output can include sensory indicators for at least one of guiding a pedestrian to the destination location and warning a pedestrian about the detected obstacles.
FIG. 3

- Location Beacon 310
- Dynamic Beacon 315
- Communication System 320
- Environmental Controls 325
- Camera / Intercom 330
- Surveillance System 335
- Doors 350
- Adjustable Obstacle 355
- Actuator 340
- Actuator 345
- Smart Space Control Unit 305
- PSD 200
- Spatial Relation System 360
- Navigation System 370
- Service Provider 365
FIG. 4
Determine a destination location 505

Determine a present location of a mobile computing device 510

Determine a pedestrian travel path from the present location to the destination location 515

Emit sensory indicators to guide pedestrian 520

Search area proximate to the mobile computing device for obstacles 525

Detect obstacle? 530

YES

Emit sensory indicator to warn pedestrian of detected obstacle 535

NO

Move the mobile computing device 540

YES

Update the present location and the pedestrian travel path 545

NO

Receive new destination? 560

YES

Cancel current navigation operation 565

NO

FIG. 5
PEDESTRIAN NAVIGATION AND SPATIAL RELATION DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS


BACKGROUND

[0002] 1. Field of the Invention

[0003] The present invention relates to the field of portable computing devices and, more particularly, to a portable computing device for pedestrian navigation and for spatial relationship determinations between the device and obstacles proximate to the device.

[0004] 2. Description of the Related Art

[0005] Technological advances in areas of small-scale computing devices have resulted in the simplification of many previously challenging aspects of life. For example, the proliferation of mobile telephone and mobile e-mail devices have simplified interpersonal communication and have provided previously unobtainable freedoms for many business people. In another example, navigation devices, such as in-vehicle navigation systems, have dramatically improved the case with which people can travel. Further, personal navigation devices, such as hand-held location locators, allow excursionists to roam unfamiliar landscapes without fear of becoming lost.

[0006] At present, however, the abilities of personal navigation devices are largely limited to present location detection and rudimentary navigational features. That is, a destination can be entered into a personal navigation device and the device can indicate a bearing that a pedestrian can travel to reach that destination. Conventional pedestrian navigation devices do not typically take environmental constraints, such as available walkways and other such pedestrian paths, into consideration when guiding pedestrians to selected destinations. Further, no known conventional pedestrian navigation device possesses spatial awareness capabilities for detecting static and/or dynamic obstacles and for plotting pedestrian travel routes to avoid these obstacles.

SUMMARY OF THE INVENTION

[0007] The present invention provides a method, a system, and an apparatus for guiding pedestrians from their current location to a user-selectable destination. More specifically, the present invention can include a pedestrian spatial relation/navigation device (PSD) for aiding pedestrians traveling indoors and/or outdoors. The PSD can be spatially aware of the environment in which the pedestrian is to travel and can use this spatial awareness to aid the traveler. The PSD can contain obstacle sensing components for detecting the presence of obstacles in an environment relative to the PSD so that a pedestrian can avoid these obstacles. Further, the PSD can determine multiple potential pedestrian pathways for reaching a selected destination and can select a recommended travel pathway based upon static and dynamic factors, such as user preferences, temporal constraints, and known pathway obstacles and impediments. The PSD can also include training capabilities that a user can use to program misrecognized obstacles, to store points of interest, and provide other suitable feedback.

[0008] In one embodiment, the PSD can be specifically designed to assist visually impaired individuals. In such an embodiment, a visually impaired pedestrian can use the PSD to navigate to a selected destination and to avoid both static and dynamic obstacles in the pathway of or toward the destination. The PSD can provide audible and/or tactile cues to the visually impaired, via audible circuitry and/or a tactile presentation mechanism like a digital Braille pad.

[0009] One aspect of the present invention can include a pedestrian navigation method. The method can include the steps of determining a destination location and determining a present location of a mobile computing device based upon at least one wireless transmission received by the mobile computing device. In one embodiment, mobile telephone communications can be sent and received via the mobile computing device. A pedestrian travel path can be determined from the present location and the destination location. The present location and the pedestrian travel path can be intermittently updated as the mobile computing device is moved. At least one obstacle located near the path can be detected based upon at least one wireless transmission conveyed to the mobile computing device. At least a portion of the detected obstacles can be dynamic obstacles that change position over time. Further, at least a portion of the obstacles can contain a location beacon that the mobile computing device is configured to detect.

[0010] Sensory indicators can be emitted to guide a pedestrian to the destination location. The emitted sensory indicators can include a warning indicator for warning the pedestrian about detected obstacles for obstacle avoidance purposes. In one embodiment, the mobile computing device can be designed to assist visually impaired pedestrians. In such an embodiment, the sensory indicators can include at least one tactile indicator, such as a digital Braille pad. The sensory indicators can also include synthetically generated voice cues. In a particular embodiment, user feedback can be received through the mobile computing device. The user feedback can be used to improve guidance provided by the mobile computing device. Additionally, the mobile computing device can be communicatively linked to the Internet. Once linked to the Internet, navigation information can be accessed from a remote data source. This navigation information can be used to guide the pedestrian to the destination.

[0011] Another aspect of the present invention can include a PSD that can include a position finder, a spatial relationship sensor, an input mechanism, and an output mechanism. In one embodiment, the PSD can be designed for assisting visually impaired pedestrians. The position finder can be configured to determine a geographic position of the PSD based upon received wireless signals. In one embodiment, the position finder can include a Global Positioning System (GPS). The spatial relationship sensor can provide data used to detect a position of at least one obstacle relative to the PSD. In one embodiment, the spatial relationship sensor can include a short range wireless transceiver, a radio frequency identification system, and/or an ultrasonic transducer.
The input mechanism can specify a destination location. The output mechanism can include sensory indicators for guiding a pedestrian to the destination location and/or for warning a pedestrian about detected obstacles proximate to the PSD. For example, the output mechanism can include audio circuitry configured to provide audible sensory indicators. In another example, the output mechanism can include a tactile presentation mechanism configured to provide tactile sensory indicators.

In one embodiment, the PSD can determine multiple pathways for navigating to the destination location and can select one of the determined pathways based upon user preference, temporal constraints, and/or obstacles proximate to the pathway. In another embodiment, the PSD can include a cellular transceiver to send and receive mobile telephony communications. Further, the PSD can include a thin client configured to be communicatively linked to at least one remotely located server. The PSD can also include a training system configured to alter device operation based upon user feedback.

BRIEF DESCRIPTION OF THE DRAWINGS

There are shown in the drawings, embodiments that are presently preferred; it being understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown.

FIG. 1 is a schematic diagram illustrating an exemplary pedestrian spatial relation/navigation device (PSD) configured in accordance with the inventive arrangements disclosed herein.

FIG. 2 is a schematic diagram illustrating an exemplary PSD in accordance with the inventive arrangements disclosed herein.

FIG. 3 is a schematic diagram illustrating an exemplary environment in which a PSD can be utilized in accordance with the inventive arrangements disclosed herein.

FIG. 4 is a schematic diagram illustrating an exemplary system supporting a PSD in accordance with the inventive arrangements disclosed herein.

FIG. 5 is a flow chart illustrating an exemplary pedestrian navigation method in accordance with the inventive arrangements disclosed herein.

The input mechanism can specify a destination location. The output mechanism can include sensory indicators for guiding a pedestrian to the destination location and/or for warning a pedestrian about detected obstacles proximate to the PSD. For example, the output mechanism can include audio circuitry configured to provide audible sensory indicators. In another example, the output mechanism can include a tactile presentation mechanism configured to provide tactile sensory indicators.

In one embodiment, the PSD can determine multiple pathways for navigating to the destination location and can select one of the determined pathways based upon user preference, temporal constraints, and/or obstacles proximate to the pathway. In another embodiment, the PSD can include a cellular transceiver to send and receive mobile telephony communications. Further, the PSD can include a thin client configured to be communicatively linked to at least one remotely located server. The PSD can also include a training system configured to alter device operation based upon user feedback.

Detailed Description of the Invention

FIG. 1 is a schematic diagram illustrating an exemplary pedestrian spatial relation/navigation device (PSD) 100 configured in accordance with the inventive arrangements disclosed herein. As shown, the PSD 100 can include a processor 105, a mobile telephony transceiver 110, audio circuitry 115, a short range wireless transceiver 120, and a memory 125. Each of the aforementioned components can be communicatively linked via a suitable communications bus 130 or other circuitry.

The processor 105 can execute a suitable operating system and one or more applications for controlling the various functions of the PSD 100. For example, the processor 105 can execute an operating system which can support the execution of one or more applications intended to run on that platform and which support operation of the various functions and features disclosed herein. For example, as the PSD 100 can include one or more sensors to be described in greater detail herein, the operating system and computing architecture can be designed to support the operation of such sensors.

The memory 125 can be implemented as random access memory (RAM), read-only memory (ROM), Erasable Programmable Read-Only Memory (EPROM), or any other type of physical memory suitable for use within a portable computing device, such as the PSD 100. It should be appreciated that the memory 125, while illustrated as a separate unit, can be incorporated into the processor 105 or another device. In any case, the memory 125 can include programmatic instructions to be executed by the processor 105 as well as any operational data necessary for operation of the PSD 100.

Wireless signals can be received and sent via the antenna 155 which can be suited for longer-range communications such as conventional cellular or personal communication service (PCS) communications. Accordingly, the antenna 155 can be operatively connected to the mobile telephony transceiver 110. Signals detected by antenna 155 can be provided to the mobile telephony transceiver 110 for processing and decoding. For example, the mobile telephony transceiver 110 can include a codec for coding and decoding information received or to be sent via wireless transmission. The transceiver 110 can make the decoded signals and/or information available to other components of the PSD 100 for processing. Outbound information received by the mobile telephony transceiver 110 can be coded and/or formatted for wireless transmission by the codec and then provided to the antenna 155 for transmission.

Thus, it should be appreciated that the PSD 100 can communicate via conventional cellular telephone and/or PCS telephone calls and access wireless networks, for example using Wireless Access Protocol (WAP) or another suitable wireless communications protocol, such that the PSD 100 can access the Internet, the Web, a Local Area Network (LAN), and/or a wide area network (WAN), as well as any applications and/or services disposed on such networks via a wireless communications link.

The audio circuitry 115 can include a microphone or other transducing element (not shown) for receiving sound and one or more analog-to-digital converters (not shown) for digitizing the received sound. The audio circuitry 115 further can include one or more digital-to-analog converters (not shown) for converting digital information into an analog signal. The audio circuitry 115 can include a speaker or other transducing element (not shown) for generating sound from an analog signal as well as one or more amplifiers (not shown). Notably, although not shown, the PSD 100 can include one or more audio output jacks and/or other digital data interface ports.

It should be appreciated that the audio circuitry 115 can include additional processors, such as digital signal processors (DSP) as may be required for processing audio and performing functions such as audio encoding, audio decoding, noise reduction, and the like. According to one embodiment of the present invention, the audio circuitry can be implemented using one or more discrete components. In another arrangement, the audio circuitry 115 can be imple-
mented using one or more larger integrated circuits configured to perform the various functions disclosed herein. Thus, the PSD 100 can be configured to play various audio formats from streaming formats to MP3's, or other audio file formats such as .wav or .aiff files.

**0027** The audio circuitry 115 can also include and/or be communicatively linked to automatic speech recognition (ASR) and synthetic speech generation components that can be used to perform text-to-speech and speech-to-text conversions. When the audio circuitry 115 includes ASR and/or speech generation components, suitable software and/or firmware can be embedded within the audio circuitry 115. When the audio circuitry 115 is communicatively linked to remotely located ASR and/or speech generation components, communications between the audio circuitry 115 and the remotely located components can occur using the mobile telephony transceiver, the short range wireless transceiver 120, the interface port 145, or any other suitable elements.

**0028** The PSD 100 also can include a short range wireless transceiver 120 as well as an antenna 160 operatively connected thereto. The short range wireless transceiver 120 can both send and receive data. For example, according to one embodiment of the present invention, the short range wireless transceiver 120 can be implemented as a Bluetooth-enabled wireless transceiver, or as a transceiver configured to communicate with one of the 802.11 family of short range wireless communications specifications. The short range wireless transceiver 120 and accompanying antenna 160 can be configured to communicate using any of a variety of short range, wireless communications protocols and/or systems. Accordingly, the various examples disclosed herein have been provided for illustration only and should not be construed as a limitation of the present invention.

**0029** The PSD 100 can include a position finder 130 and one or more spatial relationship sensors, such as a radio frequency identification (RFID) mechanism 135, and an ultrasonic transducer 140. The spatial relationship sensors of the PSD 100 can provide data used to detect a position of at least one obstacle relative to the device. One of ordinary skill in the art should appreciate that the RFID 135 and the ultrasonic transducer 140 represent two illustrative spatial relationship sensors and that the PSD 100 is not limited in this regard. For example, the PSD 100 can include other spatial relationship sensors such as a radar sensor, a sonar sensor, an optically based sensor, a pressure sensor, a temperature sensor, and the like.

**0030** The position finder 130 can determine a geographic position of the device based upon received wireless signals. For example, the position finder 130 can include global positioning system (GPS) components for computing a position from signals conveyed by GPS satellites. In another example, the position finder 130 can receive wireless signals conveyed from signal broadcasting devices with known positions and can determine a geographical location through triangulation techniques. For instance, the position finder 130 can triangulate a position for the PSD 100 based upon cellular and PCS broadcasts conveyed from mobile telephony towers.

**0031** Alternatively, the position finder 130 can triangulate a position within a room or building based upon short range wireless broadcasts emitted from a multitude of emitting devices located at known geographical points. For example, a number of wireless access points adhering to the 802.11 family of standards can receive/broadcast RF signals, each access point can have a known broadcasting radius. The position finder 130 can determine which access points the device is within range of and from these points determine the relative location of the PSD 100. In another embodiment, the position finder 130 can triangulate a position for the PSD 100 based upon a multitude of previously established beacons within sensor detection range of the PSD 100.

**0032** One illustrative spatial relationship sensor, the RFID mechanism 135 incorporates the use of electromagnetic or electrostatic coupling in the radio frequency (RF) portion of the electromagnetic spectrum to uniquely identify an object, animal, or person. The RFID mechanism 135 does not require direct contact or line-of-sight scanning. An RFID mechanism 135 can include an antenna and transceiver (often combined into one reader) and a transponder (the tag). The antenna uses radio frequency waves to transmit a signal that activates the transponder. When activated, the tag transmits data back to the antenna. The data is used to notify a programmable logic controller, such as the processor 105, that an action should occur. For example, the action can include any programmatic response such as initiating communications to interface and exchange data with another computing system. The PSD 100 can include a low-frequency RFID mechanism 135 of approximately 30 kHz to 500 kHz having a short transmission range of approximately six feet, or a high-frequency RFID mechanism 135 of approximately 850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz and having a longer transmission range of approximately 90 feet or more.

**0033** Notably, the RFID mechanism 135 of the PSD 100 can include a tag, a transceiver, or both a tag and a transceiver. Additionally, RFID readable tags/transceivers can be attached to objects to permit the PSD 100 to determine the identity and/or location of the associated obstacle via the RFID mechanism 135. Further, an array of RFID mechanisms 140 both internal to the PSD 100 and external to the PSD 100 can be used to determine obstacle location based on triangulation.

**0034** The ultrasonic transducer 140 can include a transceiver capable of transmitting a beacon signal which can be received by one or more ultrasonic transceivers. The use of an ultrasonic transducer 140 enables high precision tracking technology to be used within one’s house, for example, in the case where one’s home is outfitted with one or more ultrasonic transceivers. Accordingly, a home or other “smart” environment, for example one equipped with a ultrasonic transceiver, can detect when a user having the PSD 100 is within a particular range of the transceiver. Thus, determinations can be made as to the position of the PSD 100 and the position of obstacles relative to the PSD 100.

**0035** The PSD 100 can also include one or more interface ports 145 used to physically connect devices and/or peripherals to the PSD 100. For example, the interface port 145 can be a standard wall jack to initiate telephone calls over the Public Switched Telephone Network (PSTN). The interface port 145 can also include a universal serial bus (USB) port, a firewire (IEEE 1394) port, a parallel port, a COM port like an RS-232 port, an ethernet port, an audio port, or the like. Use of the interface port 145 for communicatively linking the PSD 100 with external devices can be
advantageous in situations where wireless connectivity may not be available, is intermittent, or otherwise unsuitable for a particular purpose.

[0036] The PSD 100 also can include a variety of other components and sensors which have not been illustrated in FIG. 1. For example, the PSD 100 can include components such as a modem, a media port, and other components common to portable computing devices, which can include personal data assistants (PDAs), notebook computers, mobile telephones, computing tablets, and the like. The PSD 100 can also include sensors such as infrared transceivers, code readers, temperature sensors, chemical detectors, biological sensors, and the like. The listing of components and sensors is not intended as a limitation of the present invention, but rather as examples intended to broaden the scope of the inventive arrangements disclosed herein.

[0037] Each of the various components of the PSD 100 disclosed herein can be communicatively linked with one another using appropriate circuitry, whether through the memory 125, one or more additional memories (not shown), the processor 105, one or more additional interface processors or logic controllers (not shown), and/or the communications bus 150. For example, while each of the sensors described herein is depicted as being linked to the communications bus 150, it should be appreciated that each sensor can be configured to communicate with the processor 105 through a suitable interface, such as a digital input and/or output or through an intermediate interface processor, for example using an interrupt request of the processor.

[0038] Additionally, one skilled in the art will recognize that the various components disclosed herein can be embodied in various other forms and that the configuration disclosed and described with reference to FIG. 1 is provided for purposes of illustration only. For example, the various components can be implemented as one or more discrete components, as one or more processors, logic controllers, and/or DSP’s, or any combination thereof.

[0039] FIG. 2 is a schematic diagram illustrating an exemplary pedestrian spatial relation/navigation device (PSD) 200 in accordance with the inventive arrangements disclosed herein. As shown, the PSD 200 can include a presentation element 205, one or more control or operational keys 210, which can include special function command keys for operation of one or more of the functions disclosed herein, alphanumeric keys or buttons 215, and an antenna 220 (which may be configured to be fully located within the PSD 200). The PSD 200 further can include a battery or other power source (not shown). In one embodiment, the PSD 200 can be a mobile telephone.

[0040] The physical arrangement of the PSD 200 has been provided for purposes of illustration only. As such, it should be appreciated that the various components can be located in any of a variety of different configurations. For example, the PSD 200 can include additional keys or controls disposed on the frontal portion or the sides of the unit.

[0041] According to one embodiment of the present invention, the physical arrangement of the PSD 200 can be conducive for use by visually impaired individuals or those that may have difficulty accessing and/or operating the various keys and/or controls of conventional mobile computing devices, such as the elderly, persons with physical disabilities, or other infirmities. For example, the control keys 210 and the alphanumeric keys 215 of the PSD 200 can be larger in size than conventional cellular device keys and can be spaced a greater distance from one another with respect to both the width and length of the PSD 200. That is, the horizontal key spacing and the vertical key spacing can be greater than that found with conventional cellular devices. Further, the control keys 210 can include Braille markings for key identification purposes.

[0042] The presentation element 205 can include a tactile presentation mechanism, such as a Braille pad, a visual display, an audible presentation mechanism like a speaker, and the like. When the presentation element 205 includes a display screen, this display can be a liquid crystal display (LCD) implemented in either grayscale or color, a touch screen, or any other type of suitable display screen. The presentation element 205 can include a display screen that is larger than those found on conventional mobile computing devices and can have an increased contrast ratio if so desired.

[0043] The battery of the PSD 200 can be designed to operate for extended times. According to one arrangement, the battery can be comprised of electrical cells that release energy through chemical reactions. Alternatively, the “battery” powering the PSD 200 can utilize a fuel cell, such as a methane battery. Additionally, while the various enhancements disclosed herein may add size to the PSD 200, it is expected that the increased size would be an acceptable tradeoff for increased functionality and ease of use provided by the PSD 200. Alternatively, illustrated components such as the control keys 210 can be replaced by other, smaller components, such as a microphone in order to save space and decrease the size of the PSD 200.

[0044] As noted, the PSD 200 can include a variety of sensors. As shown in FIG. 2, the PSD 200 can be configured with one or more spatial relationship sensors 225. While the spatial relationship sensor 225 can be positioned on the PSD 200 in any of a variety of different locations, according to one embodiment, the spatial relationship sensor 225 can be positioned at the top portion of the PSD 200. Other sensors can be located throughout the exterior portion of the PSD 200. For example, an ultrasonic transducer can be located near the top or bottom of the PSD 200 such that when held, the sensor is not obstructed by the hand of a user. In contrast, a biometric sensor for identifying a user based upon biometrical data can be positioned to come in contact with a hand of a user when the PSD 200 is held.

[0045] FIG. 3 is a schematic diagram illustrating an exemplary environment in which the PSD 200 can be utilized. It should be appreciated that the PSD 200 can be designed to operate in a variety of environments, including indoor and outdoor environments. In one embodiment, the PSD 200 can operate within a standard environment that has not been specifically modified for the needs of a visually challenged person or other PSD 200 user. In another embodiment, the PSD 200 can interact with customized environment, such as a smart space, where a smart space can be an environment equipped with suitable transceivers, communications equipment, and other controller units. For example, a home can be so configured. Alternatively, a workspace, caretaking facility, building, park, mall, and/or other space that can be occupied and/or inhabited by persons can be configured as a smart space.
As shown in FIG. 3, the PSD 200 can communicate with a smart space control unit 305. The PSD 200 can also communicate directly with components shown as being linked to the smart space control unit 305, such as beacon 310, communication system 320, obstacle 355, and the like, and a smart space need not include a smart space control unit 305 for the PSD 200 to function within the smart space.

The PSD 200 can include one or more application programs which allow the user to access the functionality of the various systems and/or devices connected to the smart space control unit 305. In one embodiment, the PSD 200 can be a thin client and the smart space control unit 305 can function as an application server. The smart space control unit 305 can also be configured with a multitude of PSD 200 and/or user specific settings so that information exchanged between the PSD 200 and the smart space control unit 305 can be tailored for the needs, capabilities, and privileges of different users and/or PSDs.

Through the smart space control unit 305, the user of PSD 200 can access information pertaining to the smart space, including space layout, space pedestrian pathways, and space obstacles. For example, the smart space control unit 305 can include a server that broadcasts the layout of the smart space to the PSD 200 through a wireless communication means, such as through a wireless network communication like the 802.11 family of wireless networking protocols, a Bluetooth transmission, and the like.

It should be appreciated that the PSD 200 can communicate with the smart space control unit 305 using any of a variety of different communications mechanisms and that the PSD 200 is not limited to any specific communication mechanism. For example, the PSD 200 can initiate cellular telephone and/or conventional telephone calls to the smart space control unit 305 when the PSD 200 is not located within or proximate to the home within which the smart space control unit 305 is disposed. In another example, the PSD 200 can communicate with the home control unit using short range wireless communications when in range. In still another example, the PSD 200 can be linked to the smart space control unit 305 via one or more interface ports.

Further, the smart space control unit 305 can be communicatively linked to a communication system 320, where the communication system 320 can include a home intercom system, a line based computer network, a message service, a telephony system, an Internet connection, and the like. The capabilities of the communication systems 320 can be utilized by a user of the PSD 200 through access granted via the smart space control unit 305. For example, the communication system 320 can communicatively link the smart space control unit 305 to a multitude of remotely located computing systems, such as a spatial relation system 360, a service provider 365, a navigation system 370, and the like. Web services, databases, and other remotely located computing and/or data resources can be provided by the service provider 365. In one embodiment, the PSD 200 can utilize included communication capabilities to directly communicate with the spatial relation system 360, the service provider 365, and the navigation system 370 without using the smart space control unit 305 as an intermediary.

The smart space control unit 305 and/or the PSD 200 can be communicatively linked to a multitude of inter-active subsystems that can include at least one location beacon 310 and at least one dynamic beacon 315. The beacons 310 and 315 can be detected by the smart space control unit 305 and/or the PSD 200 and used for navigational and spatial relation purposes.

The location beacon 310 and the dynamic beacon 315 can consist of a transceiver or other mechanism that permits the PSD 200 to determine a location of the beacon 310 and/or beacon 315 relative to the PSD 200 using sensors of the PSD 200. The PSD 200 can also determine the identity, size, weight, and other object identification characteristics from information conveyed by the beacon 310 and the beacon 315. For example, the beacon 310 and the beacon 315 can include tags containing digitally embedded information that can be sensed and/or read by the RFID 135 and/or the ultrasonic transducer 140. These tags can be affixed to obstacles and/or objects within the smart space.

When location beacons 310 are attached to fixed points with known locations, the PSD 200 can triangulate the position of the PSD 200 using the location beacons 310 as reference points. When the location beacons 310 are affixed to static objects, such as a wall, a doorway, a staircase, a desk, a pedestrian walkway, and the like, the PSD 200 can use the location beacons 310 as obstacle identification points in order to guide a user so that the user is not impeded by the obstacles within the smart space.

Dynamic beacons 315 can be affixed to mobile objects, such as chairs, pets, people, portable appliances, and the like. The dynamic beacons 315 can be used to track the current position of the associated dynamic object so that the PSD 200 can locate the object and/or avoid the object as desired. For example, the dynamic beacon 315 can be affixed to a remote control unit, a set of keys, and/or a telephone so that the user of the PSD 200 can locate these commonly misplaced objects. In another example, the dynamic beacon 315 can be affixed to a vacuum cleaner, an ironing board, or a footrest so that a visually challenged person using the PSD 200 can be made aware of the presence of the associated object for obstacle avoidance purposes.

Obstacle positioning information can also be gathered through sensors contained within the smart space and conveyed to the PSD 200 via the smart space control unit 305. For example, a camera 330 or video system can intermittently video the smart space. Determinations can be performed by the smart space control unit 305 based upon video feeds to determine the location of the PSD 200 user as well as obstacles near the PSD 200 user. Results can be fed from the smart space control unit 305 to the PSD 200.

Additionally, surveillance system 335 data can be gathered by the smart space control unit 305 and used to determine the location of a PSD 200 user and obstacles near the PSD 200 user. Typical surveillance systems 335 can include motion sensors, pressure sensors, sound detectors, and the like. It should be noted that the PSD 200 is not limited to any particular object detection source and that data provided by multiple sources, including spatial relationship sensors of the PSD 200 and data gathered via smart space sensors, can be combined to improve the accuracy of the PSD 200.

It should be appreciated that while smart spaces have been described with reference to a single, centralized
computer system, one or more computer systems can be included. For example, lighting can be controlled with one computer system while temperature is controlled by another, and appliances can be controlled by yet another computer system. The various computer systems may or may not communicate with one another so long as each is able to communicate with the PSD 200. Still, each system can be configured to communicate with the PSD 200 independently and operate on its own. For instance, each appliance can be a "smart" appliance having built-in communications and control mechanisms for being accessed remotely. In that case, each appliance need not communicate with other appliances or a centralized computing system so long as the appliance and/or system can communicate directly with the PSD 200.

[0058] FIG. 4 is a schematic diagram illustrating an exemplary system 400 supporting the PSD 200 in accordance with the inventive arrangements disclosed herein. The system 400 can include the PSD 200, a proxy server 415, and an external server 410, each communicatively linked via a communications network 405. Notably, the PSD 200 can be communicatively linked to the communications network 405 via any suitable connection, whether wireless or wired. The external server 410 can provide the PSD 200 with navigational information, mapping information, object avoidance information, and the like. The external server 410 can also perform one or more tasks for the PSD 200 such as a speech synthesis task, a speech recognition task, a route planning task, a communication task, an triangulation task, an obstacle location task, and the like. In one arrangement, the PSD 200 can be a thin client that is communicatively linked to a remotely located application server, such as an external server 410. The proxy server 415 can be an intermediary between the PSD 200 and the external server 410 that can provide security, administrative control, and traffic management for the PSD 200.

[0059] FIG. 5 is a flow chart illustrating an exemplary pedestrian navigation method 500 in accordance with the inventive arrangements disclosed herein. The method 500 can be performed in the context pedestrian navigation. In one embodiment, the method 500 can be used to aid a visually impaired individual to navigate to a selected destination while avoiding obstacles. The method can begin in step 505 by determining a destination location. This determination can be performed by a mobile computing device, such as a PSD, responsive to a user input. The PSD can be embodied in a mobile telephone, a wearable computing device, or other such mobile computing device.

[0060] The user input can be provided directly to the mobile computing device or can be provided to a remote system, such as a networked computer, and can be subsequently conveyed to the mobile computing device. Further, the user input can be processed by a remote computing device and/or the mobile computing device into a form readable by the mobile computing device. For example, the user can input an address and/or room number verbally, this input can be conveyed to a remote server, speech-to-text converted, and translated into coordinate values that are conveyed back to the mobile computing device in a format comprehensible by the mobile computing device.

[0061] In step 510, the present location of the mobile computing device can be automatically determined using position finding capabilities of the mobile computing device. In step 515, a pedestrian travel path can be determined from the present location to the destination location. It should be noted that multiple travel paths can be computed initially, each of which can be used by the pedestrian to travel from the present location to the destination location. One of these potential travel paths can be selected as a preferred travel path based upon user preference, temporal constraints, static and dynamic obstacles, and the like.

[0062] In step 520, the mobile computing device can emit sensory indicators to guide pedestrians to the destination location. A sensory indicator can include audible indicators, visual indicators, tactile indicators, and the like. An audible indicator can include tonal warnings, speech cues, and the like. Visual indicators can include graphically displayed images, textual directions, and the like. Tactile indicators can include device vibrations, Braille pad presentations, heat sensations, low powered electric stimulations, and the like.

[0063] In step 525, the area proximate to the mobile computing device can be searched for obstacles. In one scenario, these obstacles can be determined by surveillance systems, environmental sensors, and the like that are connected to computer systems remote from the mobile computing device. Then, the remote computer system can wirelessly communicate with the mobile computing device. In another scenario, the mobile computing device can include environmental sensors that can detect nearby obstacles. When obstacles are detected in step 530, one or more sensory indicators can be emitted from the mobile computing device in step 535 to warn a pedestrian about the detected obstacle. When no obstacles are detected in step 530, step 535 can be skipped and the method can proceed to step 540.

[0064] In step 540, a determination can be made as to whether the mobile computing device has been moved. When the mobile computing device has been moved, the method can proceed to step 545, where the present location and the pedestrian travel path can be updated. After the update, the method can loop to step 520, where sensory indicators can be emitted to guide the pedestrian to the destination location. If the mobile computing device has not been moved, the method can proceed to step 550.

[0065] In step 550, a determination can be made as to whether the pedestrian has arrived at the destination or not. If so, the method can end in step 555 or the method can be repeated for a new destination by looping to step 510. If the pedestrian has not arrived at the destination, as determined by the location of the mobile computing device, the method can progress from step 550 to step 560. In step 560, a determination can be made as to whether a new, different destination has been entered. If not, the method can loop back to step 540, where a new determination as to whether the mobile computing device has been moved can be performed. If a new destination has been entered as determined by step 560, the method can progress from step 560 to step 565, where the current navigation operation being performed by the mobile computing device can be canceled. Once canceled, the method can loop to step 510, where the present location of the mobile computing device. The new destination location and the present location of the mobile computing device can be used to determine a pedestrian travel path.
The present invention can be realized in hardware, software, or a combination of hardware and software. The present invention can be realized in a centralized fashion in one computer system or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software can be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

The present invention also can be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

This invention can be embodied in other forms without departing from the spirit or essential attributes thereof. Accordingly, reference should be made to the following claims, rather than to the foregoing specification, as indicating the scope of the invention.

What is claimed is:

1. A pedestrian navigation method comprising the steps of:
   determining a present location of a mobile computing device based upon at least one wireless transmission received by said mobile computing device;
   detecting at least one obstacle located near a pedestrian travel path based upon at least one wireless transmission conveyed to said mobile computing device;
   determining at least one available pedestrian travel path; and
   emitting sensory indicators to guide a pedestrian along said determined travel path.

2. The method of claim 1, further comprising the steps of:
   determining a destination location, wherein said determined travel path guides said pedestrian from said present location to said destination location.

3. The method of claim 2, further comprising the steps of:
   intermittently updating said present location and said determined travel path as said mobile computing device is moved.

4. The method of claim 1, wherein said emitted sensory indicators include a warning indicator for warning said pedestrian about detected obstacles.

5. The method of claim 1, wherein at least a portion of said obstacles are dynamic obstacles that change position over time.

6. The method of claim 1, wherein said at least one available pedestrian travel path comprises a plurality of available pedestrian travel paths, said method further comprising:
   determining a navigation route based upon said plurality of pedestrian travel paths, wherein the navigation route dynamically adjusts over time responsive to input received via the mobile computing device.

7. The method of claim 1, further comprising the steps of:
   detecting at least one object near the mobile computing device; and
   interacting with the at least one detected object using the mobile computing device, wherein actuators coupled to the detected object are utilized during the interacting step.

8. The method of claim 1, said detecting step further comprising:
   determining a location beacon affixed to one of said obstacles.

9. The method of claim 1, wherein said sensory indicators comprise at least one tactile indicator.

10. The method of claim 1, further comprising the steps of:
   receiving user feedback through said mobile computing device; and
   using said user feedback to improve guidance provided by said mobile computing device over time.

11. The method of claim 2, further comprising the steps of:
   accessing navigation information from a remote data source; and
   utilizing said navigation information to guide said pedestrian to said destination location.

12. The method of claim 1, further comprising the steps of:
   accessing environmental information from a remote data source to determine at least one environmental condition, wherein said environmental condition is considered to be one of said detected obstacles.

13. A machine-readable storage having stored thereon, a computer program having a plurality of code sections, said code sections executable by a machine for causing the machine to perform the steps of:
   determining a present location of a mobile computing device based upon at least one wireless transmission received by said mobile computing device;
   detecting at least one obstacle located near a pedestrian travel path based upon at least one wireless transmission conveyed to said mobile computing device;
   determining at least one available pedestrian travel path; and
   emitting sensory indicators to guide a pedestrian along said determined travel path.

14. The machine-readable storage of claim 13, further comprising the steps of:
   determining a destination location, wherein said determined travel path guides said pedestrian from said present location to said destination location.

15. The machine-readable storage of claim 14, further comprising the steps of:
intermittently updating said present location and said determined travel path as said mobile computing device is moved.

16. The machine-readable storage of claim 13, wherein said emitted sensory indicators include a warning indicator for warning said pedestrian about detected obstacles.

17. The method of claim 13, wherein at least a portion of said obstacles are dynamic obstacles that change position over time.

18. The machine-readable storage of claim 13, said detecting step further comprising:

   detecting a location beacon affixed to one of said obstacles.

19. The machine-readable storage of claim 13, wherein said sensory indicators comprise at least one tactile indicator.

20. The machine-readable storage of claim 13, further comprising the steps of:

   receiving user feedback through said mobile computing device; and

   using said user feedback to improve guidance provided by said mobile computing device.

21. The machine-readable storage of claim 14, further comprising the steps of:

   accessing navigation information from a remote data source; and

   utilizing said navigation information to guide said pedestrian to said destination location.

22. The machine-readable storage of claim 13, further comprising the steps of:

   accessing environmental information from a remote data source to determine at least one environmental condition, wherein said environmental condition is considered to be one of said detected obstacles.

23. A pedestrian navigation system comprising:

   means for determining a present location of a mobile computing device based upon at least one wireless transmission received by said mobile computing device;

   means for detecting at least one obstacle located near a pedestrian travel path based upon at least one wireless transmission conveyed to said mobile computing device;

   means for determining at least one available pedestrian travel path; and

   means for emitting sensory indicators to guide a pedestrian along said determined travel path.

24. A pedestrian navigation and spatial relation device comprising:

   a position finder configured to determine a geographic position of said device based upon received wireless signals;

   a spatial relationship sensor configured to provide data used to detect a position of at least one obstacle relative to the device;

   an input mechanism for specifying a destination location; and

   an output mechanism for presenting device output to a user, wherein device output includes sensory indicators for at least one of guiding a pedestrian to said destination location and warning a pedestrian about said detected obstacles.

25. The device of claim 24, wherein said device is configured to determine multiple pathways for navigating to said destination location and configured to select one of the determined pathways based upon at least one of user preference, a temporal constraint, and obstacles proximate to said pathway.

26. The device of claim 24, wherein said position finder comprises a Global Positioning System.

27. The device of claim 24, wherein said spatial relationship sensor comprises at least one of a short range wireless transceiver, a radio frequency identification system, and an ultrasonic transducer.

28. The device of claim 24, further comprising:

   a mobile telephony transceiver configured to send and receive mobile telephony communications.

29. The device of claim 24, wherein said output mechanism comprises a tactile presentation pad configured to provide tactile sensory indicators.

30. The device of claim 24, wherein said device is a thin client configured to be communicatively linked to at least one remotely located server.

31. The device of claim 24, further comprising a training system configured to alter device operation based upon user feedback.

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