WIRELESS HANDWRITING SCHEME

RELATED APPLICATION

This patent application is related to pending U.S. Patent Application Serial No. 09/507,078, entitled "Ultrasonic Wireless Pen Position Determination System and Method", by J. Xu, assigned to the assignee of the present invention, and herein incorporated by reference.

BACKGROUND

1. Field

The present disclosure relates to electronic handwriting schemes, and, more particularly, wireless electronic handwriting schemes.

2. Background Information

As computing devices become more mobile, such as with personal data assistants (PDAs), laptop computers, and handheld computers, for example, it may be desirable to input data into such devices in various ways. Traditional methods of inputting information into such computing devices include, as some examples, keyboards and pointing devices. Typically, such traditional data input methods are substantially accomplished by employing electrical signals to communicate information. In certain situations, it may be desirable to input handwritten information into such computing devices. Current methods for inputting such handwritten information include, for example, wireless pen systems. Current wireless pen systems, however, typically have certain disadvantages. These disadvantages may include, for example, skipping and rotation errors. Skipping, in this context, may occur if, for example, a unidirectional signal from a wireless pen is not properly oriented. This improper orientation may result in undesired discontinuities in handwritten information. Likewise, in this context, in systems employing such a unidirectional transmitter, rotation errors may result from the natural tendency of a writer to rotate a pen when writing. This rotation may result in extraneous information being captured. One example of such extraneous information may occur as a result of rotating the pen barrel with the pen's tip in a substantially stationary position with respect to the receivers in such a system. This rotation may, in turn, result in the system interpreting, for

example, an arc, which is undesirable. Additionally, state of the art approaches to communicate this information may employ a synchronization mechanism, which may add, for example, cost, complexity and power consumption to such wireless pen systems. Such synchronization mechanisms may also be disadvantageous for the mobility of such systems as such mechanisms may add additional components and, therefore, increase the size of such a system. Alternative wireless pen schemes that address at least some of the foregoing concerns may, therefore, be desirable.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, together with features and advantages thereof, may best be understood by reference to the following detailed description when read with the accompanying drawings in which:

FIG. 1 is a diagram that illustrates a prior embodiment of a wireless electronic handwriting system.

FIG. 2 is a diagram that illustrates another prior embodiment of a wireless electronic handwriting system.

FIG. 3 is a diagram that illustrates an embodiment of a wireless electronic handwriting system in accordance with the invention.

FIG. 4 is a diagram that illustrates an embodiment of an ultrasonic transmitter in accordance with the invention that may be employed, for example, by the embodiment illustrated in FIG. 3.

DETAILED DESCRIPTION

In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, components and circuits have not been described in detail so as not to obscure the present invention.

As was previously indicated, techniques for entering information into a computing device, other than traditional techniques, may be desirable. As was also previously

indicated, one such alternative technique may be accomplished by employing a wireless pen system. While embodiments of such wireless pen systems currently exist, these systems may have certain disadvantages. For example, as previously discussed, such systems may experience skipping or errors due to natural writing movements, such as rotation of a writing device employed in such an embodiment. Such systems may also experience various undesirable "dead zones", which will be discussed in more detail hereafter. Additionally, such systems typically employ multiple transmission/reception techniques such as, for example, one for synchronization and another for location determination. Employing such multiple techniques may reduce the mobility of such embodiments due to addition of, for example, components for synchronization in addition to adding cost, complexity and power consumption to such systems, which is undesirable.

In this regard, FIG. 1 is a diagram that illustrates a current embodiment, 100, of a wireless pen system. For this embodiment, a writing device, 150, comprises a transmitter, 160. Such a transmitter may contain multiple elements capable of transmitting, respectively, for example, infrared (IR) signals and unidirectional ultrasonic, or sonic, pulses. In alternative embodiments, a separate radio frequency (RF) transmitter may be employed in place of, for example, an IR transmitter. As is described in more detail hereinafter, these signals and pulses may then be employed, respectively, for synchronization and location determination. However, in this respect, a sensor/receiver apparatus, such as 110, may comprise sensors 170, which may be employed for receiving such IR signals, and separate sensors 140, which may be employed for receiving such sonic pulses. Such an apparatus may also contain an interface, such as cable 120, to couple such an apparatus with a computing device to, at least in part, capture handwritten information in electronic form. Such signals and pulses would typically be generated at some substantially predetermined frequency for both IR signals and ultrasonic pulses in order to facilitate the capture of handwritten information by employing techniques such as those discussed herein.

Since the proximity of sensors 170 and receivers 140 to one another is substantially fixed, the timing relationship of such received IR signals and sonic pulses may be employed in determining the location of such a writing device. In this regard, because IR signals travel at speeds approaching the speed of light, such IR signals will arrive at sensors 170 substantially simultaneously regardless of the location transmitter 160 relative

to such sensors. In this context, transmitter 160 would typically be in reasonable proximity to sensors 170 so as to allow such IR signals and ultrasonic pulses related to handwritten information to be received by, for example, sensors 170 and receivers 140, as is desirable. This distance would typically be on the order of no more than several feet away and typically confined to a writing surface, such as 130.

As opposed to such IR signals, because sonic pulses travel at a speed on the order of the speed of sound, some determinable delay between arrival at one of receivers 140 and the other receiver will typically exist. Such a delay may be based, at least in part, on the location of a transmitter employed to generate sonic pulses relative to such receivers. Based on the timing relationships of the received IR signal and the received sonic pulse at the respective sensors or receivers, a relative distance of transmitter 160 from each sensor may be determined by employing velocity equations. Such equations are well-known to those of skill in the art and the invention is not limited in scope to any particular technique for determining such distances.

Such relative distances may then be employed to determine a location for transmitter 160 with respect to receivers 140. Because the proximity of such receivers is substantially fixed, as was previously discussed, triangulation computations may be employed based, at least in part, on receiver proximity and the relative distances of the transmitter from the receivers. Such triangulation computations are well-known by those of skill in the art and the invention is not limited to any particular technique.

The embodiment illustrated in FIG. 1, however, has some disadvantages, which are related, at least, to the transmitter and receiver configurations. In this respect, because transmitter 160 comprises a unidirectional transmitter, the orientation of writing device 150 in such embodiments may determine whether or not IR signals and sonic pulses are received by, for example, sensors 170 and receivers 140. Therefore, a user of such a system may be restricted in writing motion by such a configuration. This may be disadvantageous, as it may not be compatible with natural movements associated with handwritten information, such as rotation and tilting of such a writing device. Such rotation or tilting may result in skipping, discontinuities or extraneous information in the captured handwritten information because of the altered orientation of sensor 160 relative to sensors 140.

Such embodiments may also experience multiple dead zones due to various factors. In this regard, for example, as is illustrated in FIG. 1, the typical configuration of receivers, such as 140, and sensors, such as 170, limits the angle at which they may be capable of receiving sonic pulses or IR signals. Outside this angle or scope, handwritten information may not be collected, even though it is within the bounds of writing surface 130. This is disadvantageous as it reduces the usable writing area a user may employ with such a system. Dead zones may also result, for example, from the configuration of a transmitter, such as 160. Though not illustrated in FIG. 1, such a dead zone may be due, at least in part, to the distance that transmitter 160 is from sensors 140 when it is desired to collect handwritten information. Because such transmitters typically have relatively large acoustic impedance as compare with air, large reflections of a sonic pulse may occur, resulting in significant attenuation of such a pulse. Such reflections due to impedance mismatches are well known to those skill in the art and are analogous to signal reflections in transmission lines due to electrical impedance mismatches. This attenuation due to such mismatches may, in turn, limit the radius from such receivers a user may employ in collecting handwritten information with such an embodiment. That is, a dead zone may exist outside such a radius.

Also, as was previously indicated, employing both sensors 140 and receivers 170 may be undesirable as it may result in added cost for such an embodiment. Such a configuration typically exists due, at least in part, to the capability of such sensor and receivers to receive, respectively, IR signals or sonic pulses. Such increases in cost are typically undesirable.

FIG. 2 illustrates another current embodiment of a wireless pen system that is typically employed in conjunction with a dry erase board. FIG. 2 contains two views of such an embodiment, a side view, 200, and a top view, 205. For this embodiment, writing device 250 comprises an infrared (IR) transmitter, 260, and an ultrasonic transmitter, 270. In this respect, IR transmitter 260 may be used in conjunction with IR sensors 230 to provide a substantially similar synchronization function as was previously described. For this embodiment, the sensor/receiver apparatus, 210, comprises IR sensors 230, receivers 240 and deflector 220. For this embodiment, ultrasonic pulses would be deflected by deflector 220 and then received by receivers 240. While this configuration may result in some improvement in the size of a dead zone due to the angles at which the signal may be

received, the size of such a dead zone may, however, still depend, at least in part, on the particular deflector configuration being used. Additionally, since IR sensors in such embodiments typically have similar reception angles as have been previously discussed, a dead zone may, therefore, also exist due to the limitation of these sensors and their ability to receive synchronization signals outside certain angles or outside a certain scope.

As was previously indicated, such an embodiment is typically used in conjunction with a dry erase board to electronically capture handwritten information. In this regard, a mounting apparatus, 290, which may comprise suction devices, may be employed. Additionally, cable 285 may be employed to couple such a receiver apparatus to a computing device to facilitate electronic collection of handwritten information on for example, writing surface 280. However, such a sensor apparatus has the previously discussed disadvantages associated with employing multiple sensors. For this embodiment, employing IR sensors 230 and receivers 240 may reduce the mobility of such a device as well as increase the cost of such an embodiment. Additionally, depending on the particular configuration of an ultrasonic transmitter, such as 270, such embodiments may also experience skipping, rotation errors and dead zones due to transmitter distance from sensors 240, as were all previously discussed. Therefore, alternative embodiments of wireless pen systems may be desirable.

FIG. 3 illustrates an embodiment of a wireless pen system in accordance with the invention that addresses at least some of the foregoing disadvantages. For this particular embodiment, though the invention is not limited in scope in this respect, writing device 350 comprises an omni-directional cylindrical ultrasonic transmitter. Also for this embodiment, receiver apparatus 310 comprises semi-cylindrical receivers 330. Though the invention is not limited in this respect, receivers 330 may comprise a capacitive piezo polymer film, such as polarized polyvinylidene fluoride (PVDF), for example. Such films are well known to those of skill in the art and may be obtained from, for example, Measurement Specialties, Inc., Sensor Products Division, 950 Forge Avenue – Bldg. B, Norristown, PA 19403. Such receivers may be advantageous in a number of respects.

For example, as is illustrated in FIG. 3, such a receiver configuration may reduce the size of a dead zone that may exist with state of the art approaches, as was previously described. In this respect, due, at least in part to their semi-cylindrical configuration, such receivers may be capable of receiving pulses or signals over a substantially 180 degree

range, or a substantially planar area. As is shown in FIG. 3, a dead zone for such an embodiment may be defined, at least in part, by the angle at which one sensor would be in the direct path from a transmitter to a second sensor. In this situation, the first sensor may interfere with the pulse from the transmitter, which may affect its ability to reach the second sensor. However, in comparison to FIG. 1, employing such an embodiment may nonetheless, reduce the size of the dead zone area.

Another potential advantage of such a configuration may result from employing such receivers in conjunction with both a synchronization signal and a location pulse, as has been previously described. In this regard, an RF signal may be generated by an electronic pulse used to excite ultrasonic transmitter 360. Such a pulse may be generated, for example, by a transducer located in the barrel of pen 350. Such excitation pulses are well known to those of skill in the art and are one way of initiating sonic pulses in ultrasonic transmitters, such as 360. Such a pulse may be generated, for example, by a transducer or by discharging a resistive capacitive (RC) circuit. Other techniques for generating such an excitation exist and the invention is, of course, not limited to the foregoing. Such an RF signal may then be received substantially simultaneously by receivers 330 and be employed in determining the relative distances of the transmitter from the receivers, in a similar manner as has been previously described. In such an embodiment, because a second set of sensors/receivers is not employed to receive a synchronization signal, the mobility of such embodiments may be improved due, at least in part, to reductions in size of such embodiments. Additionally, for example, the cost or such embodiments may be reduced.

As another example, due, at least in part, to the omni-directional configuration of transmitter 360, the previously discussed disadvantage of rotation errors may also be reduced since such rotation errors frequently occur due, at least in part, to the directional nature of transmitters employed in previous embodiments. For this embodiment, rotation of a writing device, such as 350, comprising such a transmitter would not substantially affect the ultrasonic pulse characteristics at receivers 330 generated by such a transmitter. Due, at least in part, to this aspect, rotation of a writing device, such as 350, may not substantially affect an accurate determination of the location of such a writing device. Additionally, because of the cylindrical configuration of such an omni-directional transmitter, it may be located relatively close to the tip of a writing device, such as 350.

This aspect may be advantageous as it may reduce adverse effects, such as, for example, extraneous information that may result from tilting such a writing device. In this respect, placing the transmitter closer to the tip of the pen reduces the radius of an arc along which the transmitter would travel during such tilting. This reduced radius may, therefore, reduce the total distance a transmitter would travel along such an arc and, in turn, reduce the amount of extraneous information.

For this particular embodiment, receiver apparatus 310 is coupled to computing device 370 via cable 320. This may allow computing device 370 to receive electronic information from receiver apparatus 310. The invention is, of course, not limited in scope in this respect and alternative embodiments exist. For example, sensors 330 may be included in computing device 370 as opposed to such a receiver apparatus 310 being coupled to such a computing device via cable 320. However, for this particular embodiment, electronic information communicated via cable 320 may be as is discussed in further detail hereinafter.

FIG. 4 illustrates an embodiment of an omni-directional transmitter, 400, in accordance with the invention that may reduce the dead-zone related to acoustic impedance mismatch, as was previously discussed. Such a transmitter may be employed as transmitter 360 in writing device 350, as was previously discussed. While the invention is not limited in scope to this, or any particular configuration, transmitter 400 may comprise a cylindrical epoxy resin base, 400, and a matrix comprising piezo electric rods, such as 420. Such a configuration may result in lower acoustic in comparison with state of the art apparatuses. In this respect, acoustic impedance of such a transmitter may be reduced by approximately one order of magnitude. Such a reduction in acoustic impedance of such a transmitter may, in turn, improve the impedance mismatch with air and increase the radius outside which the previous discussed dead zone occurs, which is desirable.

Method embodiments in accordance with the invention may employ the embodiment of a wireless pen system, as illustrated in FIG. 3. While such a method may be embodied as instructions on a storage medium, which may be executed by a computing device, such as 370, the invention is, of course, not so limited. Such a method embodiment may also employ techniques for determining writing device location as have been previously discussed. For example, an embodiment of such a method may comprise

generating a synchronization signal, such as may be generated as a result of an excitation pulse. Such a method embodiment may further comprise generating an ultrasonic pulse and then determining relative distance from a plurality of sensors based on the timing relationships of the synchronization signal and the ultrasonic pulse. Such a method may also further comprise determining the location of a writing device by employing triangulation calculations, the result of such calculations being based, at least in part, on the proximity of receivers, such as 330, and the relative distances determined by the timing relationships. Though the invention is not so limited, the synchronization signal and ultrasonic pulses, which are typically analog, may be converted to digital representations of those signals/pulses. These digital representations may then, in turn, be employed in determining relative distances and location of a writing device relative to receivers, such as 330.

While certain features of the invention have been illustrated and described herein, many modifications, substitutions, changes and equivalents will now occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

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1. An apparatus comprising:

a writing device including a substantially omni-directional wireless transmitter to produce a synchronization signal having a negligible delay over a writing surface and a location signal having an appreciable delay over the writing surface;

a plurality of integral wireless receivers disposed at known relative positions such that a location of the transmitter with respect to the writing surface is determinable, at least in part, from arrival times of location signal relative to the synchronization signal,

where each of the receivers is constructed to receive both the synchronization signal and the location signal at the same physical position.

2. The apparatus of claim 1 where the location signal is ultrasonic.

3. The apparatus of claim 2 where the receivers each include a semi-cylindrical element to detect the location signal simultaneously from any direction in a substantially 180-degree range of the writing surface

4. The apparatus of claim 2 where the semi-cylindrical element comprises a piezoelectric film.

5. The apparatus of claim 1 where the synchronization signal is a radio-frequency signal.

6. The apparatus of claim 5 where the receivers each include a piezoelectric film to receive the radio-frequency signal.

7. The apparatus of claim 1 where each of the receivers include a piezoelectric film to receive both an ultrasonic location signal and a radio-frequency synchronization signal.

8. The apparatus of claim 1 where the writing surface is substantially planar, and where the receivers are mounted on the writing surface.

9. An apparatus comprising:

a writing device to transmit wirelessly both a location signal and a synchronization signal;

a plurality of semi-cylindrical receivers capable of wirelessly receiving both the location signal and the synchronization signal from any direction over a substantially 180-degree range of a writing surface,

where the receivers are disposed at known relative positions such that a location of the transmitter with respect to the writing surface is determinable, at least in part, from arrival times of location signal relative to the synchronization signal.

10 The apparatus of claim 9 where the location signal is an ultrasonic signal.

11 The apparatus of claim 10 where the receivers include semi-cylindrical piezoelectric films.

12. The apparatus of claim 9 where the synchronization signal is a radio-frequency signal.

13. The apparatus of claim 9 where an electronic pulse serves as a radio-frequency synchronization signal and to excite an ultrasonic location signal.

14. The apparatus of claim 9 where the writing device comprises:

a barrel-shaped body having a tip to engage the writing surface;

a substantially omni-directional cylindrical ultrasonic transducer.

15. The apparatus of claim 14 where the transducer encircles the body near the tip of the body.

16. The apparatus of claim 14 where the cylindrical transmitter comprises a base material and a piezoelectric material.

17. The apparatus of claim 16 where the piezoelectric material comprises a plurality of rods distributed in the base material.

18. The apparatus of claim 14 where the location signal is ultrasonic.

19. The apparatus of claim 18 where the transmitter has a low impedance mismatch with air.

20. The apparatus of claim 14 where the synchronization signal is radio-frequency.

21. A system, comprising:

a writing device including a substantially omni-directional transmitter to produce a synchronization signal having a negligible delay over a writing surface and a location signal having an appreciable delay over the writing surface;

a plurality of integral wireless receivers disposed at known relative positions such that a location of the transmitter with respect to the writing surface is determinable, at least in part, from arrival times of location signal relative to the synchronization signal, where each of the receivers is constructed to receive both the synchronization signal and the location signal at the same physical location;

a processor coupled to the receivers to calculate the location of the writing device with respect to the receivers in response to the synchronization signal and the location signal.

22. The system of claim 21 further including an interface for coupling the receivers to the processor.

23. The system of claim 21 where the processor is included in a computing device.

24. The system of claim 23 where the computing device consists essentially of one or more of a personal computer, a personal data assistant, and an internet tablet.

25. The system of claim 21 where the synchronization signal is radio-frequency, and where the location signal is ultrasonic.

26. A method comprising:

omni-directionally generating in a writing device both a synchronization signal having a negligible delay over a writing surface and a location signal having an appreciable delay over the writing surface;

wirelessly transmitting the synchronization signal and the location signal;

receiving both the synchronization signal and the location signal in each of a plurality of receivers from any direction in substantially a 180-degree range of a writing surface;

determining a location of the writing device at least in part from the relative arrival times of the synchronization signal and the location signal at the receivers.

27. The method of claim 26 where the synchronization signal is a radio-frequency signal, and where the location signal is an ultrasonic signal.

28. The method of claim 27 where the synchronization signal is an electronic pulse.

29. The method of claim 28 where the pulse further excites the ultrasonic location signal.

30. The method of claim 26 where both the synchronization signal and the location signal are received by the same element.

31. The method of claim 26 where the transmitter has a reduced impedance mismatch with air.

32. A computer-readable medium bearing instructions and data for carrying out a method comprising:

omni-directionally generating both a synchronization signal and a location signal in a writing device;

wirelessly transmitting the synchronization signal and the location signal;

receiving both the synchronization signal and the location signal in each of a plurality of receivers from any direction in substantially a 180-degree range of a writing surface;

determining a location of the writing device at least in part from the relative arrival times of the synchronization signal and the location signal at the receivers.

33. The medium of claim 26 where determining the location of the writing device employs triangulation formulas responsive to the relative arrival times.