Title: AN INTERACTIVE SYSTEM AND A METHOD OF ENCODING

Abstract: The present invention relates to an interactive system and a method for encoding, e.g. position encoding, a touch by an object. The system comprises a display, a waveguide for guiding light, which waveguide is displaceable in relation to the display, a first light source for emitting light into the waveguide, and a detector for detecting light from the waveguide. The waveguide may be in a first position next to the display, and in a second position displaced in relation to the display. When the waveguide is in the first position, a first surface of the waveguide is a touch-sensitive surface, such that the object touching the first surface disturbs at least a part of the light from the first light source, the disturbance of the light being detectable at the detector. Thus, encoding of the touch is enabled.
AN INTERACTIVE SYSTEM AND A METHOD OF ENCODING

The present invention relates to an interactive system for encoding, e.g. position encoding, a touch by an object and a method of encoding, e.g. position encoding, an object touching an interactive system.

Touch screens are seen in many portable devices today, such as mobile phones, personal digital assistants (PDA's) and various remote controls.

Figs. 1A, 1B, and 1C show a top view and two side views of an optical touch screen. An optical touch screen is disclosed in US 2006/01 14237 A1. Furthermore, international patent application publication number WO 2009/086836 A1 discloses an optical device for detection of touch. In Figs. 1A, 1B, and 1C, a plane, transparent waveguide plate is being illuminated by two arrays of light emitters along two sides of the waveguide. Along two opposite sides, two arrays of photo receivers are positioned. The individual detector elements (i.e. photo receivers) detect light transmitted through the waveguide from a corresponding light emitter. In case no object, e.g. a finger, is touching the waveguide, all light beams originating from the light emitters are passed through the waveguide without experiencing significant damping. This is due to total internal reflection, as illustrated in Fig. 1B. However, in case an object touches the surface of the waveguide, as illustrated in Fig. 1C, light may be coupled out of the waveguide leading to a damping of the electromagnetic signal received by the two corresponding detector elements, as illustrated by the dashed lines in Fig. 1A. Hence, two coordinates of the position of the object can be deduced by observing which of the detector elements experience a damping of the electromagnetic signal. In Fig. 1A the positions of the dark detector elements in the two detector arrays reveal the position of the object. By positioning the waveguide system on top of a display, a complete touch screen may be realised, as illustrated in Fig. 1B and 1C.

It is an object of the present invention to provide an interactive system for encoding touch by an object. It is an object of the present invention to provide a method of encoding an object touching an interactive system.

According to the present invention, the above-mentioned and other aspects are fulfilled by a system comprising a display, and a touch-sensitive device. The touch-sensitive device may comprise a waveguide for guiding light, a first light source for emitting light into the waveguide, and a detector for detecting light from the waveguide. The waveguide may be displaceable in relation to the display. The waveguide may comprise a first planar waveguide and may have a first surface and a second surface. The waveguide may in a first position be positioned next to the display, such that the
second surface may face the display, e.g. be in front of the display, whereby the second surface may be substantially prevented from being touched by the object, and the first surface may be accessible for touch by the object. The waveguide may in a second position be displaced in relation to the display, such that the first surface may be accessible for touch by the object, and the second surface may be accessible for touch by the object. The first surface of the waveguide may in the first position be a touch-sensitive surface, such that the object touching the first surface may disturb at least a part of the light from the first light source. The disturbance of the light may be detected at the detector. The waveguide may be transparent such that the display is viewable when the waveguide is in the first position.

Provision of a system comprising a waveguide or a touch-sensitive device, which is displaceable in relation to the display as described above, may enable more functionalities than a system, wherein a waveguide or a touch-sensitive device is not displaceable in relation to a display.

According to the present invention, the above-mentioned and other aspects are fulfilled by a method of encoding an object touching an interactive system. The system may comprise a display and a touch-sensitive device. The touch-sensitive device may comprise a waveguide for guiding light, a first light source for emitting light into the waveguide, and a detector for detecting light from the waveguide. The waveguide may be displaceable in relation to the display. The waveguide may comprise a first planar waveguide, a first surface, and a second surface. The method may comprise emitting light from the first light source into the waveguide when the waveguide is in a first position next to the display, such that the second surface may face the display, whereby the second surface may substantially be prevented from being touched by the object, and the first surface may be accessible for touch by the object. The method may comprise emitting light from the first light source or a second light source into the waveguide when the waveguide is in a second position, such that the waveguide may be displaced in relation to the display, such that the first surface may be accessible for touch by the object, and the second surface may be accessible for touch by the object.

The method may comprise detecting light at the detector. The first surface of the waveguide may, in the first position, be a touch-sensitive surface, such that the object touching the first surface may disturb at least a part of the light from the first light source, the disturbance of the light may be detected at the detector.
BRIEF DESCRIPTION OF THE DRAWINGS

Features and advantages of the present invention will become readily apparent to those skilled in the art by the following detailed description of exemplary embodiments thereof with reference to the attached drawings, in which:

Fig. 1A schematically illustrates a top view of an embodiment of a touch-sensitive device,
Fig. 1B schematically illustrates a side view of an embodiment of a touch-sensitive device in front of a display,
Fig. 1C schematically illustrates a side view of an embodiment of a touch-sensitive device in front of a display,
Fig. 2A schematically illustrates a top view of a first embodiment of a system according to the present invention, where the waveguide is in the second position,
Fig. 2B schematically illustrates a side view of the first embodiment illustrated in Fig. 2A,
Fig. 3A schematically illustrates a top view of a second embodiment of a system according to the present invention, where the waveguide is in the first position,
Fig. 3B schematically illustrates a side view of the second embodiment illustrated in Fig. 3A,
Fig. 4A schematically illustrates a top view of the second embodiment illustrated in Fig. 3A, where the waveguide is in the second position,
Fig. 4B schematically illustrates a side view of the second embodiment illustrated in Fig. 4A,
Fig. 5A schematically illustrates a side view of a third embodiment of a system according to the present invention, where the waveguide is in the first position,
Fig. 5B schematically illustrates a side view of the third embodiment illustrated in Fig. 5A, where the waveguide is in the second position,
Fig. 6A schematically illustrates a side view of a fourth embodiment of a system according to the present invention, where the waveguide is in the first position, and
Fig. 6B schematically illustrates a side view of the fourth embodiment illustrated in Fig. 6A, where the waveguide is in the second position.
The figures are schematic and simplified for clarity, and they may merely show details which are essential to the understanding of the invention, while other details may have been left out. Throughout, the same reference numerals are used for identical or corresponding parts.

It should be noted that in addition to the exemplary embodiments of the invention shown in the accompanying drawings, the invention may be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the invention to those skilled in the art.

DETAILED DESCRIPTION

Figs. 2A and 2B schematically illustrate a first embodiment of a system according to the present invention. The system comprises a display and a touch-sensitive device. The touch-sensitive device comprises a light source, a waveguide and a detector. The waveguide comprises a first surface and a second surface.

The waveguide and/or the touch-sensitive device are displaceable in relation to the display. For instance, the device and/or the waveguide may be slidably connected to the display. Alternative, the touch-sensitive device and/or the waveguide may be moved freely in relation to the display. In Figs. 2A and 2B, the waveguide is in the second position. The waveguide and/or the touch-sensitive device may be electrically connected to the display, e.g. wired or wireless. The connection may be via a terminal.

In the second position, illustrated in Fig. 2B, the second surface is exposed for touch by the object. An object, illustrated by a finger in Fig. 2B, touching the second surface at position "B" may disturb the guided light and may lead to unintended activation of the device and/or system. The intended activation may for instance be on surface.

Figs. 3A and 3B illustrate top views and side views, respectively, of a second embodiment of a system according to the present invention. The waveguide is in the first position. A touch screen is illustrated comprising a touch-sensitive, first planar waveguide, such as a thin acrylic plate, two arrays of light emitters arranged along two adjacent sides of the waveguide, two arrays of photo receivers arranged along the two opposite sides of the waveguide, and a display. Light from the light emitters is coupled into the waveguide and is guided towards the corresponding photo receivers arranged at the opposite sides of the waveguide. Light is coupled into the waveguide at a desired angle, giving rise to a desired angle of...
propagation $\theta$ in the waveguide allowing an object 18 touching the first side 114 of the
waveguide to couple light out from the waveguide, as illustrated in Fig. 3B. In the
illustrated situation, the corresponding photo receiver 112 experiences a drop in the
detected signal. Hence, due to the two-dimensional arrangement, as illustrated in Fig.
3A, two signal drops detected in the two orthogonal arrays of photo receivers, will
readily indicate the position of the touching object.

The waveguide 110 is transparent to visible light. Thus, the touch-sensitive waveguide
may be placed directly on top of the display 104. An interconnecting electrical control
unit (not illustrated) connecting the touch-sensitive waveguide with the display provides
a touch screen.

In some situations of use, it may be desirable to have the touch-sensitive waveguide
displaced, e.g. temporary placed next to the display. This may for example be desirable
if a separate touch pad for controlling a cursor on the display is desired.

In embodiments, e.g. 102, the touch-sensitive waveguide 110 and/or the touch-
sensitive device 106 may be temporary moved away from the display or displaced in
relation to the display. This is illustrated in Figs. 4A and 4B. Figs. 4A and 4B illustrate
top views and side views, respectively, of the second embodiment of the system 102
according to the present invention. The waveguide 110 is in the second position. In
order to avoid undesired activations of the waveguide from below, i.e. from the second
surface 116, an isolation layer 122 is applied to the waveguide at the second surface
116, implying that touch "B" shown on Figs. 4A and 4B does not influence the light 120
and, hence, does not get registered as a touch, whereas touch "A" may be detectable
because the object 18 illustrated at touch "A" may disturb light 120 guided by the
waveguide.

The isolation layer, e.g. 122, of a system, e.g. 102, according to the present invention
may comprise a dielectric layer with a refractive index lower than the refractive index of
a desired object, such as a finger. The refractive index of the isolation layer may be
smaller than the refractive index of the waveguide. The angle of propagation $\theta$ of the
light in the waveguide may fulfill the relation

$$n_i < n_w \sin(\theta) < n_o,$$

where $n_i$ is the refractive index of the isolation layer, $n_w$ is the refractive index of the
waveguide, and $n_o$ is the refractive index of the object. For the above relation, the
waveguide is sensitive to touch "A" and insensitive to touch "B" as illustrated in Figs. 4A
and 4B as solid lines and broken lines. Solid lines indicate that light has been disturbed, such as being coupled out, scattered etc.

Figs. 5A and 5B illustrate a third embodiment of a system 202 according to the present invention, in which the touch-sensitive waveguide 210 is hingely connected to the display 204. The hinged connection is illustrated by the black dot 224. A hinged connection may provide that the waveguide may be flipped away from the display, a feature that for instance may be relevant to a mobile phone. The system includes a second light source 226. In the situation illustrated in Fig. 5A the device is closed, i.e. in the first position, in which case the first light source 208 is switched on and the second light source 226 is switched off. Light from the first light source 208 is coupled into the waveguide at a slightly steeper angle, compared to the second light source. Hence the angle of propagation $\theta$ of the light 220 from the first light source should fulfil the relation:

$$\sin(\theta) < n_w, n_o,$$

where $n_w, \sin(\theta)$ must be smaller than both $n_i$ and $n_o$, whichever is smallest, to fulfil the relation. In this case the light will penetrate through the isolation layer, making the device touch-sensitive, as is illustrated by the dashed line in Fig. 5A.

In case the device, e.g. 202, is flipped open, i.e. in the second position, it may be desirable to have the second surface 216 of the waveguide to be touch-sensitive and the isolation layer 222 at the first surface 214 to be touch-insensitive. This may for instance be achieved by switching on the second light source 226 providing light having a larger propagation angle $\theta$, i.e.:

$$n_i < n_w, \sin(\theta) < n_o.$$

In this case the light will experience total internal reflection at the waveguide-isolation layer interface, and, hence, the light will not get access to an object 18 touching the isolation layer. As a consequence, the isolation layer and the first surface will be insensitive to a touching object.

In embodiments according to the present invention, the isolation layer, which needs only be a few hundred nanometers thick, may be protected against wear by a wear protection layer. There may not be restrictions on the refractive index of the protection layer, since the isolation layer may make a firm optical isolation between the waveguide and the protection layer.
Fig. 6A schematically illustrates a side view of a fourth embodiment of a system 302 according to the present invention, where the waveguide 310 is in the first position. Fig. 6B schematically illustrates a side view of the fourth embodiment illustrated in Fig. 6A, where the waveguide is in the second position. The system comprises a display 304, a first light source 308, a second light source 326, a waveguide 310 and a detector 312. The waveguide comprises a first planar waveguide 328 and a second planar waveguide 330 and an isolation or separation layer 322 between the first planar waveguide and the second planar waveguide. The waveguide has a first side 314 and a second side 316. The waveguide is hingely connected to the display illustrated by the black dot 324.

In the first position, the first light source 308 emits light into the first planar waveguide 328, such that the first surface 314 is touch-sensitive. In the second position, the second light source 326 emits light into the second planar waveguide 330, such that the second surface 316 is touch-sensitive. Furthermore, in the second position, the first light source may not emit light into the first planar waveguide, such that the first surface is touch-insensitive.

The light guided by the waveguide 10, 110, 210, 310 may comprise a number of first light rays being parallel seen from above, and a number of second light rays being parallel seen from above. This is illustrated in Figs. 2A, 3A, and 3B. As an alternative to or in addition to the number light detectors illustrated in Figs. 2A, 3A, and 3B, the system, e.g. 2, 102, 202, or 302, according to the present invention may comprise redirecting members as explained in WO/2009/086836 (international patent application publication), which redirecting members redirects the light towards a detector array. Similarly, as an alternative to or in addition to the number of light emitters illustrated in Figs. 2A, 3A, and 3B, the system, e.g. 2, 102, 202, or 302, according to the present invention may comprise redirecting members as explained in WO/2009/086836, which redirecting members redirects light from an emitter. Any other way of emitting light in the waveguide of the present invention and detecting the light can be imagined, e.g. diffractive structures may be used. The detector may be a detector array. The light source may be a point source.

When a surface of the waveguide according to the present invention is denoted a touch-sensitive surface, the object touching that surface may disturb light guided by the waveguide. In such a case, the surface may also be denoted an active surface.

When a surface of the waveguide according to the present invention is denoted a touch-insensitive surface, the object touching that surface is prevented from disturbing
light guided by the waveguide. In such a case, the surface may also be denoted an inactive surface.

The waveguide and/or the touch-sensitive device of the system according to the present invention may be displaceable in relation to the display, such as being movably attached to the display, such as being slidably attached to the display or being hingely attached to the display. The waveguide and/or the touch-sensitive device may be fixed or partly locked to the display in the first position and/or the second position. The waveguide and/or the touch-sensitive device may be slidably or hingely attached to the display by means of any method known in the art.

The first surface of the waveguide in the second position may be a touch-sensitive surface, such that the object touching the first surface disturbs at least a part of the light from the first light source, the disturbance of the light being detected at the detector.

The second surface of the waveguide in the second position may not be a touch-sensitive surface, i.e. a touch-insensitive surface, such that the object touching the second surface does not disturb the light from the first light source.

The waveguide may comprise an isolation layer at the second surface preventing the object from disturbing light guided by the waveguide if the object touches the second surface of the waveguide.

The first surface of the waveguide in the second position may be a touch-insensitive surface. This has the advantage that unintended activation of the system according to the present invention may be prevented.

The second surface of the waveguide in the second position may be a touch-sensitive surface.

The waveguide may comprise an isolation layer situated at the first surface, such that the first surface of the waveguide in the first position is a touch-sensitive surface, the first surface of the waveguide in the second position is not a touch-sensitive surface, and the second surface of the waveguide in the second position is a touch-sensitive surface. This has the advantage that unintended activation of the system according to the present invention may be prevented.

The waveguide may comprise a second planar waveguide situated between the first planar waveguide and the second surface, such that the first surface of the waveguide in the first position is a touch-sensitive surface, and the second surface of the waveguide in the second position is a touch-sensitive surface.
Light may be prevented from being guided by the first planar waveguide when the waveguide is in the second position and light may be guided by the second planar waveguide when the waveguide is in the second position.

The system may comprise a second light source. Light from the second light source may be coupled into the waveguide when the waveguide is in the second position. Alternatively or additionally, to a second light source a change of angle of propagation of the light guided with the waveguide may be provided.

The detector may be a detector array such that position encoding using the detector array is provided. Thus, position encoding of one and/or two dimensions may be provided.

The system may comprise a processor configured for encoding touch by the object touching a touch-sensitive surface of the waveguide.

The method according to the present invention may comprise the system according to the present invention.

In embodiments according to the present invention, a liquid crystal display may be incorporated between the isolation and the protection layer.

In embodiments according to the present invention, the touch-sensitive device is configured in such a way that when flipped open, an object touching the touch-sensitive surface in a sliding movement, causes characters on the display to scroll through different sets of letters, numbers, or symbols in such a way that the user may accept the highlighted character by shortly lifting the object. The object may be a finger.

In embodiments according to the present invention, the touch-sensitive device is configured in such a way that when flipped open, an object touching the touch-sensitive surface in a sliding movement, causes a cursor to move correspondingly on the display in such a way that the user may accept the appointed function by shortly lifting the object.

It may be desirable to be able to slide away or otherwise move the touch-sensitive device away from the display. For instance, if a cursor is to be controlled on the display, it may be desirable to use the touch-sensitive device as a touch pad separated from the display. In such cases, however, the waveguide may get exposed from the second surface and, hence, a touch from an object, e.g. a finger, at the second surface may disturb the guided light and may lead to unintended activations of the device. The present invention may overcome this problem as explained in the present disclosure.
It may be desirable to be able to flip away the touch-sensitive part of the screen and for instance use it as a touch pad, for example to control a cursor. However, this feature may require that the touch-sensitive device is sensitive on different surfaces when the touch-sensitive device is in different positions.

The isolation layer, e.g. the one illustrated in Fig. 6, may comprise polytetrafluoroethylene. The isolation layer may be transparent, e.g. such that the display is viewable through the waveguide. The wear protection layer may be transparent, e.g. such that the display is viewable through the waveguide.

Light from the second light source may be coupled into the waveguide in such a way that the light can penetrate the isolation layer.

The waveguide may be transparent, e.g. such that the display is viewable through the waveguide.

The system according to the present invention may comprise a transparent key pad.

The waveguide and/or the touch-sensitive device, may be electrically connected to the display, e.g. by a wired or a wireless connection.

When the waveguide is in the second position, at least one of the first surface and the second surface may be touch-insensitive.

Light may be coupled into the waveguide and guided via total internal reflection in the plane of the waveguide towards the detector.

The object touching at least one of the first surface and the second surface may prevent at least part of the light guided by the waveguide from reaching the detector.

The system may include a wear protective layer that covers the isolation layer.

The wear protective layer may have a refractive index that allows light to be transmitted through the wear protective layer.
CLAIMS

1. An interactive system for encoding touch by an object, the system comprising:
   - a display,
   - a waveguide for guiding light, the waveguide being displaceable in relation to the display,
   - a first light source for emitting light into the waveguide, and
   - a detector for detecting light from the waveguide,
   the waveguide comprising a first planar waveguide and having a first surface and a second surface,
   wherein the waveguide in a first position being positioned next to the display, such that the second surface faces the display, whereby the second surface is substantially prevented from being touched by the object, and the first surface being accessible for touch by the object, and
   the waveguide in a second position being displaced in relation to the display, such that the first surface being accessible for touch by the object, and the second surface being accessible for touch by the object, and
   wherein the first surface of the waveguide in the first position is a touch-sensitive surface, such that the object touching the first surface disturbs at least a part of the light from the first light source, the disturbance of the light being detected at the detector.

2. A system according to claim 1, wherein the displaceable waveguide is movably attached to the display.

3. A system according to claim 2, wherein the movably attached waveguide is slidably attached to the display.

4. A system according to claim 2, wherein the movably attached waveguide is hingely attached to the display.

5. A system according to any of the preceding claims, wherein the first surface of the waveguide in the second position is a touch-sensitive surface, such that the object touching the first surface disturbs at least a part of the light from the first light source, the disturbance of the light being detected at the detector, and the second surface of the waveguide in the second position is not a touch-sensitive surface,
such that the object touching the second surface does not disturb the light from the first light source.

6. A system according to claim 5, wherein the waveguide comprises an isolation layer at the second surface preventing the object from disturbing light guided by the waveguide if the object touches the second surface of the waveguide.

7. A system according to any of the claims 1-4, wherein the first surface of the waveguide in the second position is not a touch-sensitive surface and the second surface of the waveguide in the second position is a touch-sensitive surface.

8. A system according to any of the preceding claims, wherein the waveguide comprises an isolation layer situated at the first surface, wherein the first surface of the waveguide in the first position is a touch-sensitive surface, and wherein the first surface of the waveguide in the second position is not a touch-sensitive surface and the second surface of the waveguide in the second position is a touch-sensitive surface.

9. A system according to any of the preceding claims, wherein the waveguide comprises a second planar waveguide situated between the first planar waveguide and the second surface, wherein the first surface of the waveguide in the first position is a touch-sensitive surface, and wherein the second surface of the waveguide in the second position is a touch-sensitive surface.

10. A system according to claim 9, wherein light is prevented from being guided by the first planer waveguide when the waveguide is in the second position and light is guided by the second planar waveguide when the waveguide is in the second position.

11. A system according to any of the preceding claims, wherein the system comprises a second light source, wherein light from the second light source is coupled into the waveguide when the waveguide is in the second position.

12. A system according to any of the preceding claims, wherein the detector is a detector array.

13. A system according to any of the preceding claims, wherein the system comprises a processor configured for encoding touch by the object touching a touch-sensitive surface of the waveguide.

14. A method of encoding an object touching an interactive system comprising:

- a waveguide for guiding light,
- a display,
- a first light source for emitting light into the waveguide, and
- a detector for detecting light from the waveguide, the waveguide being displaceable in relation to the display, and the waveguide comprising a first planar waveguide, a first surface, and a second surface, the method comprising emitting light from the first light source into the waveguide when the waveguide is in a first position next to the display, such that the second surface faces the display, whereby the second surface is substantially prevented from being touched by the object, and the first surface being accessible for touch by the object, and emitting light from the first light source or a second light source into the waveguide when the waveguide is in a second position displaced in relation to the display, such that the first surface being accessible for touch by the object, and the second surface being accessible for touch by the object, and detecting light at the detector,

wherein the first surface of the waveguide in the first position is a touch-sensitive surface, such that the object touching the first surface disturbs at least a part of the light from the first light source, the disturbance of the light being detected at the detector.

15. A method according to claim 14, wherein the system is a system according to any of the claims 1-13.
# INTERNATIONAL SEARCH REPORT

**PCT/DK2010/000108**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. G06F3/042
ADD. H04M1/02

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

G06F G02F H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<th>Relevant to claim No</th>
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<td>US 6 038 313 A (COLLINS HUGH MARK A [CA]) 14 March 2000 (2000-03-14) column 1, line 5 - column 2, line 34</td>
<td>1-15</td>
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Date of the actual completion of the international search: 7 October 2010
Date of mailing of the international search report: 19/10/2010

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NL - 2280 HV Rijswijk
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Anticol i, Claud

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