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(54) Title: ATTACHING ELECTRONIC COMPONENTS TO INTERACTIVE TEXTILES

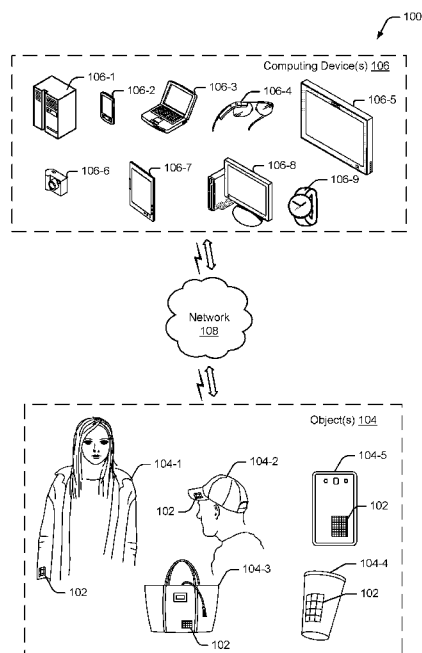


Fig. 1

(57) Abstract: This document describes techniques and apparatuses for attaching electronic components to interactive textiles. In various implementations, an interactive textile that includes conductive thread woven into the interactive textile is received. The conductive thread includes a conductive wire (e.g., a copper wire) that is twisted, braided, or wrapped with one or more flexible threads (e.g., polyester or cotton threads). A fabric stripping process is applied to the interactive textile to strip away fabric of the interactive textile and the flexible threads to expose the conductive wire in a window of the interactive textile. After exposing the conductive wires in the window of the interactive textile, an electronic component (e.g., a flexible circuit board) is attached to the exposed conductive wire of the conductive thread in the window of the interactive textile.



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ATTACHING ELECTRONIC COMPONENTS TO INTERACTIVE TEXTILES

PRIORITY APPLICATION

[0001] This international application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Patent Application Serial No. 62/167,168, titled “Attaching Electronic Components to Interactive Textiles,” filed on May 27, 2015, and U.S. Patent Application No. 14/930,220, titled “Attaching Electronic Components to Interactive Textiles,” filed on November 2, 2015, the disclosures of which are incorporated by reference herein in their entirety.

BACKGROUND

[0002] Currently, producing touch sensors can be complicated and expensive, especially if the touch sensor is intended to be light, flexible, or adaptive to various different kinds of use. Conventional touch pads, for example, are generally non-flexible and relatively costly to produce and to integrate into objects.

SUMMARY

[0003] This document describes techniques and apparatuses for attaching electronic components to interactive textiles. An interactive textile includes conductive thread woven into the interactive textile to form a capacitive touch sensor that is

configured to detect touch-input. The interactive textile can process the touch-input to generate touch data that is useable to initiate functionality at various remote devices that are wirelessly coupled to the interactive textile. For example, the interactive textile may aid users in controlling volume on a stereo, pausing a movie playing on a television, or selecting a webpage on a desktop computer. Due to the flexibility of textiles, the interactive textile may be easily integrated within flexible objects, such as clothing, handbags, fabric casings, hats, and so forth.

[0004] In various implementations, an interactive textile that includes conductive thread woven into the interactive textile is received. The conductive thread includes a conductive wire (e.g., a copper wire) that is twisted, braided, or wrapped with one or more flexible threads (e.g., polyester or cotton threads). A fabric stripping process is applied to the interactive textile to strip away fabric of the interactive textile and the flexible threads to open up a window in the interactive textile in which the conductive wire is exposed.

[0005] In some implementations, the fabric stripping process applies a laser beam to the interactive textile to ablate the fabric of the interactive textile and the flexible threads in the window of the interactive textile. An absorption of the laser is low to cause the laser beam to ablate the fabric of the interactive textile and the flexible threads without ablating the conductive wire. Alternately, the fabric stripping process may apply a heating element to the interactive textile to burn or melt the fabric of the interactive textile and the flexible threads in the window of the interactive textile. In this case, a temperature of the heating element is configured to melt or burn the fabric of the interactive textile and the flexible thread without melting or burning the

conductive wire.

[0006] After exposing the conductive wires in the window of the interactive textile, an electronic component (e.g., a flexible circuit board) is attached to the exposed conductive wire of the conductive thread in the window of the interactive textile. To do so, electronic plates of the electronic component are aligned with the exposed conductive wire, and heat is applied to cause the electronic plates of the electronic component to connect to the exposed conductive wire.

[0007] This summary is provided to introduce simplified concepts concerning attaching electronic components to interactive textiles, which is further described below in the Detailed Description. This summary is not intended to identify essential features of the claimed subject matter, nor is it intended for use in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Embodiments of techniques and devices for gest attaching electronic components to interactive textiles are described with reference to the following drawings. The same numbers are used throughout the drawings to reference like features and components:

Fig. 1 is an illustration of an example environment in which techniques using, and an objects including, an interactive textile may be embodied.

Fig. 2 illustrates an example system that includes an interactive textile and a gesture manager.

Fig. 3 illustrates an example of an interactive textile in accordance with

one or more implementations.

Fig. 4 illustrates an example environment in which a fabric stripping process to expose conductive wires of an interactive textile may be implemented.

Fig. 5 which illustrates an example environment in which an attachment process to attach an electronic component to exposed conductive wires of an interactive textile may be implemented

Fig. 6 illustrates an example system in which a textile machine can be implemented to attach an electronic component to an interactive textile.

Fig. 7 illustrates an example method of attaching an electronic component to an interactive textile.

Fig. 8 illustrates various components of an example computing system that can be implemented as any type of client, server, and/or computing device as described with reference to the previous Figs. 1-7 to implement attaching electronic components to interactive textiles.

DETAILED DESCRIPTION

Overview

[0009] An interactive textile includes conductive thread woven into the interactive textile to form a capacitive touch sensor that is configured to detect touch-input. The interactive textile can process the touch-input to generate touch data that is useable to initiate functionality at various remote devices that are wirelessly coupled to the interactive textile. For example, the interactive textile may aid users in controlling volume on a stereo, pausing a movie playing on a television, or selecting a webpage on

a desktop computer. Due to the flexibility of textiles, the interactive textile may be easily integrated within flexible objects, such as clothing, handbags, fabric casings, hats, and so forth.

[0010] In order to sense multi-touch input the conductive thread must be connected to electronic components, such as flexible circuit boards. One possible approach is to specially make the interactive textiles with loose conductive threads, known as “floats”, extending from the fabric. At the end of the textile manufacturing process, the electronic components can then be connected to the floats. However, this method of connecting the electronic components requires the manufacturer to design products precisely, keeping in mind where the floats will connect to the electronics. Designers and manufacturers would like to be able to design and manufacture interactive textiles without concern as to where the electronic components are to be connected to the textiles.

[0011] In various implementations, a fabric stripping process is applied to an interactive textile to enable electronic components to be attached to conductive threads that are fully woven into interactive textile 102. An interactive textile that includes conductive thread woven into the interactive textile is received. The conductive thread includes a conductive wire (e.g., a copper wire) that that is twisted, braided, or wrapped with one or more flexible threads (e.g., polyester or cotton threads). A fabric stripping process is applied to the interactive textile to strip away fabric of the interactive textile and the flexible threads to open up a window in the interactive textile in which the conductive wire is exposed.

[0012] In some implementations, the fabric stripping process applies a laser

beam to the interactive textile to ablate the fabric of the interactive textile and the flexible threads in the window of the interactive textile. An absorption of the laser is low to cause the laser beam to ablate the fabric of the interactive textile and the flexible threads without ablating the conductive wire. Alternately, the fabric stripping process may apply a heating element to the interactive textile to burn or melt the fabric of the interactive textile and the flexible threads in the window of the interactive textile. In this case, a temperature of the heating element is configured to melt or burn the fabric of the interactive textile and the flexible thread without melting or burning the conductive wire.

[0013] After exposing the conductive wires in the window of the interactive textile, an electronic component (e.g., a flexible circuit board) is attached to the exposed conductive wire of the conductive thread in the window of the interactive textile. To do so, electronic plates of the electronic component are aligned with the exposed conductive wire, and heat is applied to cause the electronic plates of the electronic component to connect to the exposed conductive wire.

[0014] Notably, the described techniques enable interactive textiles to be made in a more standard way without concern for designing different sizes or products so that the electronic components can be connected in a certain area of the textile. Doing so frees designers of interactive textiles to create the interactive textiles and then to go in and attach electronic components wherever they need them, instead of designing the textile layout with a specific connection point in mind.

Example Environment

[0015] Fig. 1 is an illustration of an example environment 100 in which techniques using, and objects including, an interactive textile may be embodied. Environment 100 includes an interactive textile 102, which is shown as being integrated within various objects 104. Interactive textile 102 is a textile that is configured to sense multi-touch input. As described herein, a textile corresponds to any type of flexible woven material consisting of a network of natural or artificial fibers, often referred to as thread or yarn. Textiles may be formed by weaving, knitting, crocheting, knotting, or pressing threads together.

[0016] In environment 100, objects 104 include “flexible” objects, such as a shirt 104-1, a hat 104-2, and a handbag 104-3. It is to be noted, however, that interactive textile 102 may be integrated within any type of flexible object made from fabric or a similar flexible material, such as articles of clothing, blankets, shower curtains, towels, sheets, bed spreads, or fabric casings of furniture, to name just a few. Interactive textile 102 may be integrated within flexible objects 104 in a variety of different ways, including weaving, sewing, gluing, and so forth.

[0017] In this example, objects 104 further include “hard” objects, such as a plastic cup 104-4 and a hard smart phone casing 104-5. It is to be noted, however, that hard objects 104 may include any type of “hard” or “rigid” object made from non-flexible or semi-flexible materials, such as plastic, metal, aluminum, and so on. For example, hard objects 104 may also include plastic chairs, water bottles, plastic balls, or car parts, to name just a few. Interactive textile 102 may be integrated within hard objects 104 using a variety of different manufacturing processes. In one or more

implementations, injection molding is used to integrate interactive textiles 102 into hard objects 104.

[0018] Interactive textile 102 enables a user to control object 104 that the interactive textile 102 is integrated with, or to control a variety of other computing devices 106 via a network 108. Computing devices 106 are illustrated with various non-limiting example devices: server 106-1, smart phone 106-2, laptop 106-3, computing spectacles 106-4, television 106-5, camera 106-6, tablet 106-7, desktop 106-8, and smart watch 106-9, though other devices may also be used, such as home automation and control systems, sound or entertainment systems, home appliances, security systems, netbooks, and e-readers. Note that computing device 106 can be wearable (*e.g.*, computing spectacles and smart watches), non-wearable but mobile (*e.g.*, laptops and tablets), or relatively immobile (*e.g.*, desktops and servers).

[0019] Network 108 includes one or more of many types of wireless or partly wireless communication networks, such as a local-area-network (LAN), a wireless local-area-network (WLAN), a personal-area-network (PAN), a wide-area-network (WAN), an intranet, the Internet, a peer-to-peer network, point-to-point network, a mesh network, and so forth.

[0020] Interactive textile 102 can interact with computing devices 106 by transmitting touch data through network 108. Computing device 106 uses the touch data to control computing device 106 or applications at computing device 106. As an example, consider that interactive textile 102 integrated at shirt 104-1 may be configured to control the user's smart phone 106-2 in the user's pocket, television 106-5 in the user's home, smart watch 106-9 on the user's wrist, or various other appliances

in the user's house, such as thermostats, lights, music, and so forth. For example, the user may be able to swipe up or down on interactive textile 102 integrated within the user's shirt 104-1 to cause the volume on television 106-5 to go up or down, to cause the temperature controlled by a thermostat in the user's house to increase or decrease, or to turn on and off lights in the user's house. Note that any type of touch, tap, swipe, hold, or stroke gesture may be recognized by interactive textile 102.

[0021] In more detail, consider Fig. 2 which illustrates an example system 200 that includes an interactive textile and a gesture manager. In system 200, interactive textile 102 is integrated in an object 104, which may be implemented as a flexible object (*e.g.*, shirt 104-1, hat 104-2, or handbag 104-3) or a hard object (*e.g.*, plastic cup 104-4 or smart phone casing 104-5).

[0022] Interactive textile 102 is configured to sense multi-touch-input from a user when one or more fingers of the user's hand touch interactive textile 102. Interactive textile 102 may also be configured to sense full-hand touch input from a user, such as when an entire hand of the user touches or swipes interactive textile 102. To enable this, interactive textile 102 includes a capacitive touch sensor 202 that is coupled to one or more electronic components 203, such as flexible circuit boards, sensors, heating elements, and so forth. In some cases, electronic component 203 may include a textile controller 204 and a power source 206.

[0023] Capacitive touch sensor 202 is configured to sense touch-input when an object, such as a user's finger, hand, or a conductive stylus, approaches or makes contact with capacitive touch sensor 202. Unlike conventional hard touch pads, capacitive touch sensor 202 uses a conductive thread 208 woven into interactive textile

102 to sense touch-input. Thus, capacitive touch sensor 202 does not alter the flexibility of interactive textile 102, which enables interactive textile 102 to be easily integrated within objects 104.

[0024] Power source 206 is coupled to textile controller 204 to provide power to textile controller 204, and may be implemented as a small battery. Textile controller 204 is coupled to capacitive touch sensor 202. For example, wires from the conductive threads 208 may be connected to textile controller 204 using flexible PCB, creping, gluing with conductive glue, soldering, and so forth.

[0025] In one or more implementations, electronic components 203 may also include one or more output devices, such as light sources (e.g., LED's), displays, or speakers. In this case, the output devices may also be connected to textile controller 204 to enable textile controller 204 to control their output.

[0026] Textile controller 204 is implemented with circuitry that is configured to detect the location of the touch-input on conductive thread 208, as well as motion of the touch-input. When an object, such as a user's finger, touches capacitive touch sensor 202, the position of the touch can be determined by controller 204 by detecting a change in capacitance on the grid of conductive thread 208. Textile controller 204 uses the touch-input to generate touch data usable to control computing device 102. For example, the touch-input can be used to determine various gestures, such as single-finger touches (e.g., touches, taps, and holds), multi-finger touches (e.g., two-finger touches, two-finger taps, two-finger holds, and pinches), single-finger and multi-finger swipes (e.g., swipe up, swipe down, swipe left, swipe right), and full-hand interactions (e.g., touching the textile with a user's entire hand, covering textile with the user's entire

hand, pressing the textile with the user's entire hand, palm touches, and rolling, twisting, or rotating the user's hand while touching the textile). Capacitive touch sensor 202 may be implemented as a self-capacitance sensor, or a projective capacitance sensor, which is discussed in more detail below.

[0027] Object 104 may also include network interfaces 210 for communicating data, such as touch data, over wired, wireless, or optical networks to computing devices 106. By way of example and not limitation, network interfaces 210 may communicate data over a local-area-network (LAN), a wireless local-area-network (WLAN), a personal-area-network (PAN) (*e.g.*, Bluetooth™), a wide-area-network (WAN), an intranet, the Internet, a peer-to-peer network, point-to-point network, a mesh network, and the like (*e.g.*, through network 108 of Fig. 1).

[0028] In this example, computing device 106 includes one or more computer processors 212 and computer-readable storage media (storage media) 214. Storage media 214 includes applications 216 and/or an operating system (not shown) embodied as computer-readable instructions executable by computer processors 212 to provide, in some cases, functionalities described herein. Storage media 214 also includes a gesture manager 218 (described below).

[0029] Computing device 106 may also include a display 220 and network interfaces 222 for communicating data over wired, wireless, or optical networks. For example, network interfaces 222 can receive touch data sensed by interactive textile 102 from network interfaces 210 of object 104. By way of example and not limitation, network interface 222 may communicate data over a local-area-network (LAN), a wireless local-area-network (WLAN), a personal-area-network (PAN) (*e.g.*,

Bluetooth™), a wide-area-network (WAN), an intranet, the Internet, a peer-to-peer network, point-to-point network, a mesh network, and the like.

[0030] Gesture manager 218 is capable of interacting with applications 216 and interactive textile 102 effective to activate various functionalities associated with computing device 106 and/or applications 216 through touch-input (e.g., gestures) received by interactive textile 102. Gesture manager 218 may be implemented at a computing device 106 that is local to object 104, or remote from object 104.

[0031] Having discussed a system in which interactive textile 102 can be implemented, now consider a more-detailed discussion of interactive textile 102.

[0032] Fig. 3 illustrates an example 300 of interactive textile 102 in accordance with one or more implementations. In this example, interactive textile 102 includes non-conductive threads 302 woven with conductive threads 208 to form interactive textile 102. Non-conductive threads 302 may correspond to any type of non-conductive thread, fiber, or fabric, such as cotton, wool, silk, nylon, polyester, and so forth.

[0033] At 304, a zoomed-in view of conductive thread 208 is illustrated. Conductive thread 208 includes a conductive wire 306 that is twisted, braided, or wrapped with a flexible thread 308. Twisting conductive wire 306 with flexible thread 308 causes conductive thread 208 to be flexible and stretchy, which enables conductive thread 208 to be easily woven with non-conductive threads 302 to form interactive textile 102.

[0034] In one or more implementations, conductive wire 306 is a thin copper wire. It is to be noted, however, that conductive wire 306 may also be implemented

using other materials, such as silver, gold, or other materials coated with a conductive polymer. Flexible thread 308 may be implemented as any type of flexible thread or fiber, such as cotton, wool, silk, nylon, polyester, and so forth.

[0035] In one or more implementations, conductive thread 208 includes a conductive core that includes at least one conductive wire 306 (e.g., one or more copper wires) and a cover layer, configured to cover the conductive core, that is constructed from flexible threads 308. In some cases, conductive wire 306 of the conductive core is insulated. Alternately, conductive wire 306 of the conductive core is not insulated.

[0036] In one or more implementations, the conductive core may be implemented using a single, straight, conductive wire 306. Alternately, the conductive core may be implemented using a conductive wire 306 and one or more flexible threads 308. For example, the conductive core may be formed by twisting one or more flexible threads 308 (e.g., silk threads, polyester threads, or cotton threads) with conductive wire 306 (e.g., as shown at 304 of Fig. 3), or by wrapping flexible threads 308 around conductive wire 306.

[0037] In one or more implementations, the conductive core includes flexible threads 308 braided with conductive wire 306. A variety of different types of flexible threads 308 may be utilized to braid with conductive wire 306, such as polyester or cotton, in order to form the conductive core. In one or more implementations, however, silk threads are used for the braided construction of the conductive core. Silk threads are slightly twisted which enables the silk threads to “grip” or hold on to conductive wire 306. Thus, using silk threads may increase the speed at which the braided conductive core can be manufactured. In contrast, a flexible thread like polyester is

slippery, and thus does not “grip” the conductive wire as well as silk. Thus, a slippery thread is more difficult to braid with the conductive wire, which may slow down the manufacturing process.

[0038] An additional benefit of using silk threads to create the braided conductive core is that silk is both thin and strong, which enables the manufacture of a thin conductive core that will not break during the interaction textile weaving process. A thin conductive core is beneficial because it enables the manufacturer to create whatever thickness they want for conductive thread 208 (e.g., thick or thin) when covering the conductive core with the second layer.

[0039] After forming the conductive core, a cover layer is constructed to cover the conductive core. In one or more implementations, the cover layer is constructed by wrapping flexible threads (e.g., polyester threads, cotton threads, wool threads, or silk threads) around the conductive core. For example, the cover layer may be formed by wrapping polyester threads around the conductive core at approximately 1900 turns per yard.

[0040] In one or more implementations, the cover layer includes flexible threads braided around the conductive core. The braided cover layer may be formed using the same type of braiding as described above. Any type of flexible thread 308 may be used for the braided cover layer. The thickness of the flexible thread and the number of flexible threads that are braided around the conductive core can be selected based on the desired thickness of conductive thread 208. For example, if conductive thread 208 is intended to be used for denim, a thicker flexible thread (e.g., cotton) and/or a greater number of flexible threads may be used to form the cover layer.

[0041] In one or more implementations, conductive thread 208 is constructed with a “double-braided” structure. In this case, the conductive core is formed by braiding flexible threads, such as silk, with a conductive wire (e.g., copper), as described above. Then, the cover layer is formed by braiding flexible threads (e.g., silk, cotton, or polyester) around the braided conductive core. The double-braided structure is strong, and thus is unlikely to break when being pulled during the weaving process. For example, when the double-braided conductive thread is pulled, the braided structure contracts and forces the braided core of copper to contract also with makes the whole structure stronger. Further, the double-braided structure is soft and looks like normal yarn, as opposed to a cable, which is important for aesthetics and feel.

[0042] Interactive textile 102 can be formed cheaply and efficiently, using any conventional weaving process (e.g., jacquard weaving or 3D-weaving), which involves interlacing a set of longer threads (called the warp) with a set of crossing threads (called the weft). Weaving may be implemented on a frame or machine known as a loom, of which there are a number of types. Thus, a loom can weave non-conductive threads 302 with conductive threads 208 to create interactive textile 102.

[0043] In example 300, conductive thread 208 is woven into interactive textile 102 to form a grid that includes a set of substantially parallel conductive threads 208 and a second set of substantially parallel conductive threads 208 that crosses the first set of conductive threads to form the grid. In this example, the first set of conductive threads 208 are oriented horizontally and the second set of conductive threads 208 are oriented vertically, such that the first set of conductive threads 208 are positioned substantially orthogonal to the second set of conductive threads 208. It is to

be appreciated, however, that conductive threads 208 may be oriented such that crossing conductive threads 208 are not orthogonal to each other. For example, in some cases crossing conductive threads 208 may form a diamond-shaped grid. While conductive threads 208 are illustrated as being spaced out from each other in Fig. 3, it is to be noted that conductive threads 208 may be weaved very closely together. For example, in some cases two or three conductive threads may be weaved closely together in each direction. Further, in some cases the conductive threads may be oriented as parallel sensing lines that do not cross or intersect with each other.

[0044] Conductive wire 306 may be insulated to prevent direct contact between crossing conductive threads 208. To do so, conductive wire 306 may be coated with a material such as enamel or nylon. Alternately, rather than insulating conductive wire 306, interactive textile may be generated with three separate textile layers to ensure that crossing conductive threads 208 do not make direct contact with each other. The three textile layers may be combined (*e.g.*, by sewing or gluing the layers together) to form interactive textile 102. In this example, a first textile layer may include horizontal conductive threads 208 and a second textile layer may include vertical conductive threads 208. A third textile layer, that does not include any conductive threads, may be positioned between the first and second textile layers to prevent vertical conductive threads from making direct contact with horizontal conductive threads 208.

[0045] In one or more implementations, interactive textile 102 includes a top textile layer and a bottom textile layer. The top textile layer includes conductive threads 208 woven into the top textile layer, and the bottom textile layer also includes conductive threads woven into the bottom textile layer. When the top textile layer is

combined with the bottom textile layer, the conductive threads from each layer form capacitive touch sensor 202. The top textile layer and the bottom textile layer may be combined in a variety of different ways, such as by weaving, sewing, or gluing the layers together to form interactive textile 102. In one or more implementations, the top and bottom textile layers are combined using a jacquard weaving process or any type of 3D-weaving process. When the top and bottom textile layers are combined, the conductive threads of the top layer couple to the conductive threads of the bottom layer to form capacitive touch sensor 202, as described above.

[0046] During operation, capacitive touch sensor 202 may be configured to determine positions of touch-input on the grid of conductive thread 208 using self-capacitance sensing or projective capacitive sensing.

[0047] When configured as a self-capacitance sensor, textile controller 204 charges crossing conductive threads 208 (e.g., horizontal and vertical conductive threads) by applying a control signal (e.g., a sine signal) to each conductive thread 208. When an object, such as the user's finger, touches the grid of conductive thread 208, the conductive threads 208 that are touched are grounded, which changes the capacitance (e.g., increases or decreases the capacitance) on the touched conductive threads 208.

[0048] Textile controller 204 uses the change in capacitance to identify the presence of the object. To do so, textile controller 204 detects a position of the touch-input by detecting which horizontal conductive thread 208 is touched, and which vertical conductive thread 208 is touched by detecting changes in capacitance of each respective conductive thread 208. Textile controller 204 uses the intersection of the

crossing conductive threads 208 that are touched to determine the position of the touch-input on capacitive touch sensor 202. For example, textile controller 204 can determine touch data by determining the position of each touch as X,Y coordinates on the grid of conductive thread 208.

[0049] When implemented as a self-capacitance sensor, “ghosting” may occur when multi-touch input is received. Consider, for example, that a user touches the grid of conductive thread 208 with two fingers. When this occurs, textile controller 204 determines X and Y coordinates for each of the two touches. However, textile controller 204 may be unable to determine how to match each X coordinate to its corresponding Y coordinate. For example, if a first touch has the coordinates X1, Y1 and a second touch has the coordinates X4,Y4, textile controller 204 may also detect “ghost” coordinates X1, Y4 and X4,Y1.

[0050] In one or more implementations, textile controller 204 is configured to detect “areas” of touch-input corresponding to two or more touch-input points on the grid of conductive thread 208. Conductive threads 208 may be weaved closely together such that when an object touches the grid of conductive thread 208, the capacitance will be changed for multiple horizontal conductive threads 208 and/or multiple vertical conductive threads 208. For example, a single touch with a single finger may generate the coordinates X1,Y1 and X2,Y1. Thus, textile controller 204 may be configured to detect touch-input if the capacitance is changed for multiple horizontal conductive threads 208 and/or multiple vertical conductive threads 208. Note that this removes the effect of ghosting because textile controller 204 will not detect touch-input if two single-point touches are detected which are spaced apart.

[0051] Alternately, when implemented as a projective capacitance sensor, textile controller 204 charges a single set of conductive threads 208 (e.g., horizontal conductive threads 208) by applying a control signal (e.g., a sine signal) to the single set of conductive threads 208. Then, textile controller 204 senses changes in capacitance in the other set of conductive threads 208 (e.g., vertical conductive threads 208).

[0052] In this implementation, vertical conductive threads 208 are not charged and thus act as a virtual ground. However, when horizontal conductive threads 208 are charged, the horizontal conductive threads capacitively couple to vertical conductive threads 208. Thus, when an object, such as the user's finger, touches the grid of conductive thread 208, the capacitance changes on the vertical conductive threads (e.g., increases or decreases). Textile controller 204 uses the change in capacitance on vertical conductive threads 208 to identify the presence of the object. To do so, textile controller 204 detects a position of the touch-input by scanning vertical conductive threads 208 to detect changes in capacitance. Textile controller 204 determines the position of the touch-input as the intersection point between the vertical conductive thread 208 with the changed capacitance, and the horizontal conductive thread 208 on which the control signal was transmitted. For example, textile controller 204 can determine touch data by determining the position of each touch as X,Y coordinates on the grid of conductive thread 208.

[0053] Whether implemented as a self-capacitance sensor or a projective capacitance sensor, capacitive sensor 208 is configured to communicate the touch data to gesture manager 218 to enable gesture manager 218 to determine gestures based on

the touch data, which can be used to control object 104, computing device 106, or applications 216 at computing device 106.

[0054] Gesture manager 218 can be implemented to recognize a variety of different types of gestures, such as touches, taps, swipes, holds, and covers made to interactive textile 102. To recognize the various different types of gestures, gesture manager 218 is configured to determine a duration of the touch, swipe, or hold (e.g., one second or two seconds), a number of the touches, swipes, or holds (e.g., a single tap, a double tap, or a triple tap), a number of fingers of the touch, swipe, or hold (e.g., a one finger-touch or swipe, a two-finger touch or swipe, or a three-finger touch or swipe), a frequency of the touch, and a dynamic direction of a touch or swipe (e.g., up, down, left, right). With regards to holds, gesture manager 218 can also determine an area of capacitive touch sensor 202 of interactive textile 102 that is being held (e.g., top, bottom, left, right, or top and bottom). Thus, gesture manager 218 can recognize a variety of different types of holds, such as a cover, a cover and hold, a five finger hold, a five finger cover and hold, a three finger pinch and hold, and so forth.

Attaching Electronic Components to Interactive Textiles

[0055] In order to sense multi-touch input, conductive threads 208 must be connected to electronic components 203, such as flexible circuit boards. When conductive thread 208 is woven into interactive textile 102, however, the conductive wire 306 may not be visible and cannot be accessed because they are wrapped with flexible threads 308 and woven into the fabric of the textile. In the past, therefore, the

interactive textiles were specially made to have loose conductive threads, known as “floats”, extending from the fabric. At the end of the textile manufacturing process, the electronic components could then be connected to the floats. However, this method of connecting the electronic components required the manufacturer to design products precisely, keeping in mind where the floats would connect to the electronics. Designers and manufacturers would like to be able to design and manufacture interactive textiles without concern as to where the electronic components are to be connected to the textiles.

[0056] In various implementations, a fabric stripping process is applied to interactive textile 102 to enable electronic components 203 to be attached to conductive threads 208 that are fully woven into interactive textile 102. Consider, for example, Fig. 4 which illustrates an example environment 400 in which a fabric stripping process to expose conductive wires of an interactive textile may be implemented.

[0057] Environment 400 includes a fabric stripping component 402, which may include a laser 404 and/or a heating element 406. Fabric stripping component 402 is configured to strip away the fabric of interactive textile 102 around conductive threads 208, and to strip away flexible threads 308 of conductive threads 208 without removing the conductive wires 306. Thus, at the end of the fabric stripping process, a window 408 is opened in the interactive textile in which conductive wires 306 are exposed. Note that in window 408, the fabric of interactive textile 102 and flexible thread 308 of conductive thread 208 is removed, and all that remains is exposed conductive wire 306. In this example, the exposed conductive wires 306 are shown as

parallel lines, however, the exposed wires could also be a grid, or another type of pattern such as a diamond.

[0058] In one or more implementations, fabric stripping component 402 uses a laser ablation process to expose conductive wires 306 in window 408 of interactive textile 102. Laser ablation is the process of removing material by irradiating it with a laser beam. At low laser flux, the material is heated by the absorbed laser energy and evaporates or sublimates. At high laser flux, the material is typically converted to a plasma. Laser ablation may include techniques that remove material with a pulsed laser, as well as techniques in which the material is ablated with a continuous wave laser beam if the laser intensity is high enough.

[0059] Fabric stripping component 402 can apply a focused laser beam of laser 404 to window 408 to ablate flexible threads 308 and the fabric of textile 102 in window 408 without ablating the conductive wire 306. The absorption of laser 404 is low which enables the focused laser beam to ablate the fabric of interactive textile 102 and flexible thread 308 without ablating the conductive wire 306. For example, the absorption of the laser may be configured to ablate materials such as cotton or polyester without ablating metals such as copper or silver.

[0060] Alternately, fabric stripping component 402 may use a heating process to melt or burn away the fabric of interactive textile 102 and flexible thread 308 to expose conductive wires 306 in window 408. For example, fabric stripping component 402 can apply heating element 406 to interactive textile 102 to melt or burn away the fabric of textile 102 and flexible thread 308 in window 408. A temperature of heating element 406 is configured to melt or burn the fabric of interactive textile 102

and flexible thread 308 without melting or burning conductive wire 306. In one or more implementations, heating element 406 comprises a hot bar, although other types of heating elements could also be utilized.

[0061] After exposing conductive wires 306 in window 408, an attachment process is applied to attach an electronic component 203 to the exposed conductive wires. As an example, consider Fig. 5 which illustrates an example environment 500 in which an attachment process to attach an electronic component to exposed conductive wires of an interactive textile may be implemented.

[0062] Environment 500 includes an attachment component 502, which includes a hot plate 504. Attachment component 502 is configured to attach an electronic component 203 (e.g., a flexible circuit board) to the exposed conductive wires 306 of interactive textile 102 in window 408.

[0063] Attachment component 502 receives interactive textile 102 from fabric stripping component 402 after one or more windows 408 have been opened up in the textile, and places electronic component 203 on top of the opened window 408 of interactive textile 102 so that electronic plates of electronic component 203 are aligned with the exposed conductive wires 306. In one or more implementations, the electronic plates of electronic component 203 may be prepped with solder.

[0064] In one or more implementations, attachment component 502 connects a specially prepared connection tape 506 to the exposed conductive wires 306 in window 408 of interactive textile 102. Connection tape 506 may be prepared with both electrical pads pre-tinned with solder and with heat-activated adhesive.

[0065] After electronic component 203 is placed on top of opened window 408, attachment component 502 applies heat via hot plate 504 by pressing hot plate 504 against the connection so that the solder of the connection tape, or the solder applied to the electronic plates of electronic component 203, melts and connects to the exposed conductive wires 306 of interactive textile 102. At the same time, the application of the hot plate causes a mechanical connection to be formed between the exposed conductive wire 306 and electronic component 203 via the heat-activated adhesive of connection tape 506.

[0066] While Figs. 4 and 5 illustrate a single window 408, it is to be appreciated that any number of windows 408 may be opened up in interactive textile 102 to enable any number of electronic components 203 to be attached to interactive textile 102 at a variety of different positions.

[0067] In one or more implementations, the fabric stripping process and the attachment process is implemented by a machine. Consider, for example, Fig. 6 which illustrates an example system 600 in which a textile machine 602 can be implemented to attach an electronic component to interactive textile 102.

[0068] Textile machine 602 includes a controller 604 which may be implemented in computer-executable instructions, and configured to control textile machine 602 to attach electronic component 203 to interactive textile 102. Textile machine 602 further includes fabric stripping component 402 and attachment component 502.

[0069] Controller 604 is configured to control machinery of textile machine 602 to position interactive textiles 102 proximate fabric stripping component 402. Then, controller 604 controls the fabric stripping component to strip away the fabric of

interactive textile 102 around conductive threads 208, and to strip away the flexible threads 308 to open up a window 408 in which the conductive wires 306 are exposed, as described with regards to Fig. 4 above. After window 408 is opened up in interactive textile 102, controller 604 controls attachment component 502 to attach electronic component 203 to the exposed wires 306 in the opened window of interactive textile 102, as described above with regards to Fig. 5.

Example Methods

[0070] Fig. 7 illustrates an example method 700 of attaching an electronic component to an interactive textile. This method is shown as sets of blocks that specify operations performed but are not necessarily limited to the order or combinations shown for performing the operations by the respective blocks. The techniques are not limited to performance by one entity or multiple entities operating on one device.

[0071] At 702, an interactive textile that includes conductive threads woven into the interactive textile is received. For example, fabric stripping component 402 receives interactive textile 102. Interactive textile 102 includes conductive threads 208 woven into the interactive textile, where each conductive thread 208 includes a conductive wire 306 that is twisted, braided, or wrapped with one or more flexible threads 308.

[0072] At 704, fabric of the interactive textile and flexible threads of the conductive threads are stripped away to open up a window in the interactive textile in which conductive wires of the conductive threads are exposed. For example, fabric stripping component 402 strips away fabric of interactive textile 102 and flexible

threads 308 of conductive threads 208 to open up window 408 in interactive textile 102 in which conductive wires 306 are exposed.

[0073] At 706, an electronic component is attached to the exposed conductive wires in the window of the interactive textile. For example, attachment component 502 attaches electronic component 203 to exposed conductive wires 306 in window 408 of interactive textile 102.

Example Computing System

[0074] Fig. 8 illustrates various components of an example computing system 800 that can be implemented as any type of client, server, and/or computing device as described with reference to the previous Figs. 1-7 to implement attaching electronic components to interactive textiles. In embodiments, computing system 800 can be implemented as one or a combination of a wired and/or wireless wearable device, System-on-Chip (SoC), and/or as another type of device or portion thereof. Computing system 800 may also be associated with a user (*e.g.*, a person) and/or an entity that operates the device such that a device describes logical devices that include users, software, firmware, and/or a combination of devices.

[0075] Computing system 800 includes communication devices 802 that enable wired and/or wireless communication of device data 804 (*e.g.*, received data, data that is being received, data scheduled for broadcast, data packets of the data, etc.). Device data 804 or other device content can include configuration settings of the device, media content stored on the device, and/or information associated with a user of the device. Media content stored on computing system 800 can include any type of audio,

video, and/or image data. Computing system 800 includes one or more data inputs 806 via which any type of data, media content, and/or inputs can be received, such as human utterances, touch data generated by interactive textile 102, user-selectable inputs (explicit or implicit), messages, music, television media content, recorded video content, and any other type of audio, video, and/or image data received from any content and/or data source.

[0076] Computing system 800 also includes communication interfaces 808, which can be implemented as any one or more of a serial and/or parallel interface, a wireless interface, any type of network interface, a modem, and as any other type of communication interface. Communication interfaces 808 provide a connection and/or communication links between computing system 800 and a communication network by which other electronic, computing, and communication devices communicate data with computing system 800.

[0077] Computing system 800 includes one or more processors 810 (*e.g.*, any of microprocessors, controllers, and the like), which process various computer-executable instructions to control the operation of computing system 800 and to enable techniques for, or in which can be embodied, interactive textiles. Alternatively or in addition, computing system 800 can be implemented with any one or combination of hardware, firmware, or fixed logic circuitry that is implemented in connection with processing and control circuits which are generally identified at 812. Although not shown, computing system 800 can include a system bus or data transfer system that couples the various components within the device. A system bus can include any one or combination of different bus structures, such as a memory bus or memory controller,

a peripheral bus, a universal serial bus, and/or a processor or local bus that utilizes any of a variety of bus architectures.

[0078] Computing system 800 also includes computer-readable media 814, such as one or more memory devices that enable persistent and/or non-transitory data storage (*i.e.*, in contrast to mere signal transmission), examples of which include random access memory (RAM), non-volatile memory (*e.g.*, any one or more of a read-only memory (ROM), flash memory, EPROM, EEPROM, etc.), and a disk storage device. A disk storage device may be implemented as any type of magnetic or optical storage device, such as a hard disk drive, a recordable and/or rewriteable compact disc (CD), any type of a digital versatile disc (DVD), and the like. Computing system 800 can also include a mass storage media device 816.

[0079] Computer-readable media 814 provides data storage mechanisms to store device data 804, as well as various device applications 818 and any other types of information and/or data related to operational aspects of computing system 800. For example, an operating system 820 can be maintained as a computer application with computer-readable media 814 and executed on processors 810. Device applications 818 may include a device manager, such as any form of a control application, software application, signal-processing and control module, code that is native to a particular device, a hardware abstraction layer for a particular device, and so on.

[0080] Device applications 818 also include any system components, engines, or managers to implement attaching electronic components to interactive textiles. In this example, device applications 818 include gesture manager 218 and controller 604.

Conclusion

[0081] Although embodiments of techniques using, and objects including, attaching electronic components to interactive textiles have been described in language specific to features and/or methods, it is to be understood that the subject of the appended claims is not necessarily limited to the specific features or methods described. Rather, the specific features and methods are disclosed as example implementations of attaching electronic components to interactive textiles.

CLAIMS

What is claimed is:

1. A method for attaching an electronic component to an interactive textile, the method comprising:

receiving an interactive textile that includes conductive threads woven into the interactive textile, each conductive thread comprising one or more flexible threads and a conductive wire;

stripping away fabric of the interactive textile and the flexible threads of the conductive threads to open up a window in the interactive textile in which the conductive wires are exposed; and

attaching an electronic component to the exposed conductive wires of the conductive thread in the window of the interactive textile.

2. The method of claim 1, wherein the stripping away the fabric of the interactive textile and the flexible threads of the conductive threads comprises applying a laser beam to the interactive textile to ablate the fabric of the interactive textile and the flexible threads to open up the window in the interactive textile.

3. The method of claim 2, wherein an absorption of the laser is low to cause the laser beam to ablate the fabric of the interactive textile and the flexible threads without ablating the conductive wires.

4. The method of claim 1, wherein the stripping away the fabric of the interactive textile and the flexible threads of the conductive threads comprises applying a heating element to the interactive textile to burn or melt the fabric of the interactive textile and the flexible threads to open up the window in the interactive textile.

5. The method of claim 4, wherein a temperature of the heating element is configured to melt or burn the fabric of the interactive textile and the flexible thread without melting or burning the conductive wire.

6. The method of claim 4, wherein the heating element comprises a hot bar.

7. The method of claim 1, wherein the attaching the electronic component further comprises:

aligning electronic plates of the electronic component with the exposed conductive wire; and

applying heat to cause the electronic plates of the electronic component to connect to the exposed conductive wire.

8. The method of claim 7, wherein the electronic plates of the electronic component are prepped with solder, and wherein the applying heat causes the solder to melt and connect to the exposed conductive wires.

9. The method of claim 7, further comprising:

connecting connection tape to the exposed conductive wires in the window of the interactive textile, the connection tape configured with electrical pads pre-tinned with solder and with a heat-activated adhesive; and

wherein the applying heat causes the solder to melt and connect to the exposed conductive wire and causes the heat-activated adhesive to form a mechanical connection between the exposed conductive wires and the electronic component.

10. The method of claim 1, wherein the electronic component comprises a flexible circuit board.

11. The method of claim 1, wherein the conductive wire comprises a copper wire.

12. The method of claim 1, wherein the flexible thread comprises polyester thread, cotton thread, or silk thread.

13. A system comprising:

a laser;

a hot plate;

at least a memory and a processor to implement a controller, the controller configured to:

position an interactive textile proximate the laser, the interactive textile comprising conductive threads woven into the interactive textile, each conductive thread comprising one or more flexible threads and a conductive wire;

control the laser to apply a laser beam to the interactive textile to ablate fabric of the interactive textile and the flexible threads of the conductive threads to open up a window in the interactive textile in which the conductive wires are exposed;

position an electronic component over the exposed conductive wires in the window of the interactive textile such that electronic plates of the electronic component are aligned with the exposed conductive wire; and

control the hot plate to apply heat to the electronic component to cause the electronic plates of the electronic component to connect to the exposed conductive wires.

14. The system of claim 13, wherein an absorption of the laser is low to cause the laser beam to ablate the fabric of the interactive textile and the flexible threads without ablating the conductive wires.

15. The system of claim 13, wherein the electronic plates of the electronic component are prepped with solder, and wherein the controller is configured to control the hot plate to apply heat to the electronic component to cause the solder to melt and connect to the exposed conductive wires.

16. The system of claim 13, wherein the controller is further configured to: position connection tape over the exposed conductive wires in the window of the interactive textile, the connection tape configured with electrical pads pre-tinned with solder and with a heat-activated adhesive; and

wherein the controller is configured to control the hot plate to apply heat to the electronic component to cause the solder to melt and connect to the exposed conductive wire and to cause the heat-activated adhesive to form a mechanical connection between the exposed conductive wires and the electronic component.

17. The system of claim 13, wherein the electronic component comprises a flexible circuit board.

18. The system of claim 13, wherein the conductive wire comprises a copper wire, and wherein the flexible thread comprises polyester thread, cotton thread, or silk thread.

19. A system comprising:

a heating element;

a hot plate;

at least a memory and a processor to implement a controller, the controller configured to:

position an interactive textile proximate the hot bar, the interactive textile comprising conductive threads woven into the interactive textile, each conductive thread comprising one or more flexible threads and a conductive wire;

control the heating element to burn or melt fabric of the interactive textile and the flexible threads of the conductive threads to open up the window in the interactive textile in which the conductive wires are exposed;

position an electronic component over the exposed conductive wires in the window of the interactive textile such that electronic plates of the electronic component are aligned with the exposed conductive wire; and

control the hot plate to apply heat to the electronic component to cause the electronic plates of the electronic component to connect to the exposed conductive wires.

20. The system of claim 19, wherein a temperature of the heating element is configured to melt or burn the fabric of the interactive textile and the flexible thread without melting or burning the conductive wire.

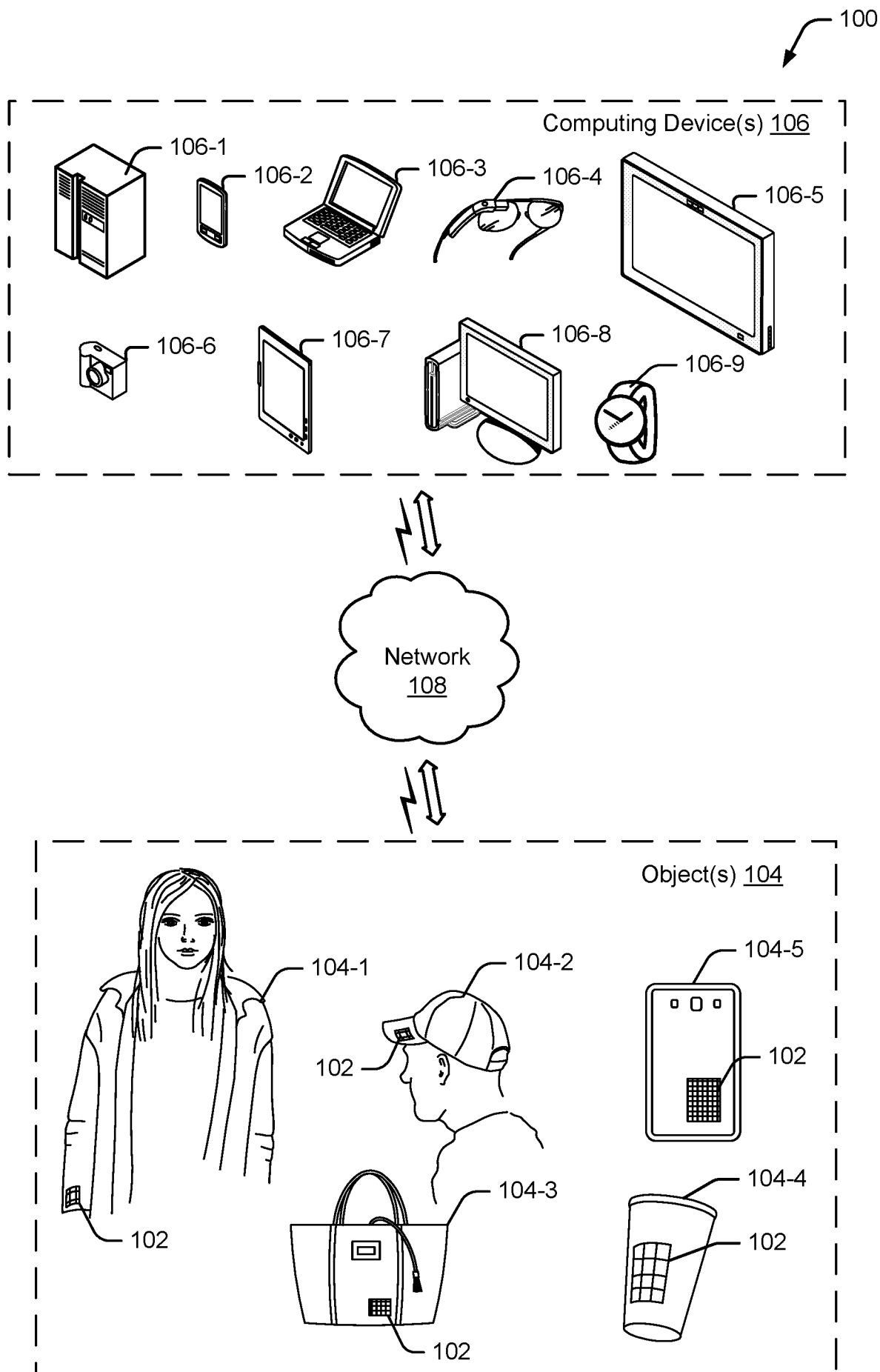
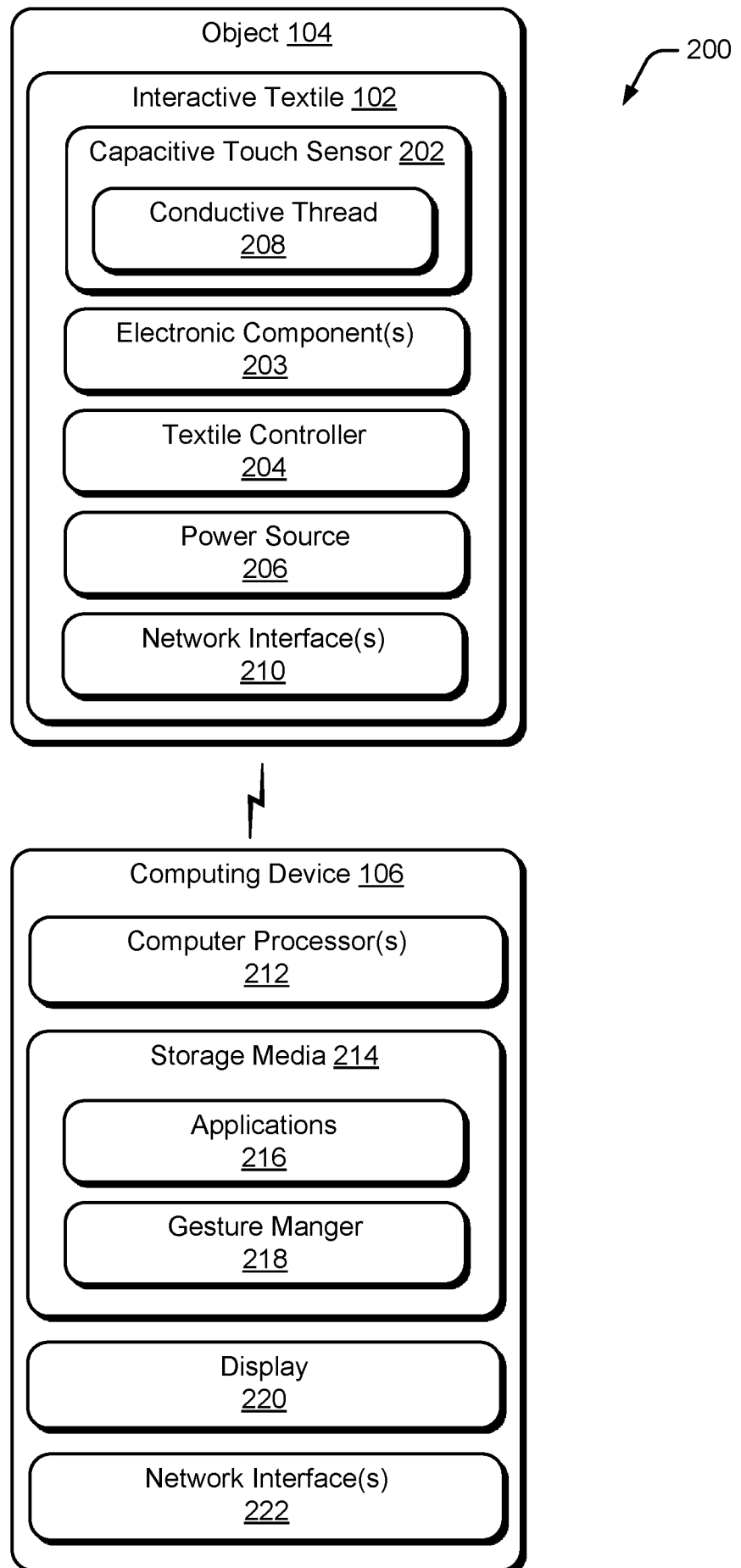


Fig. 1

**Fig. 2**

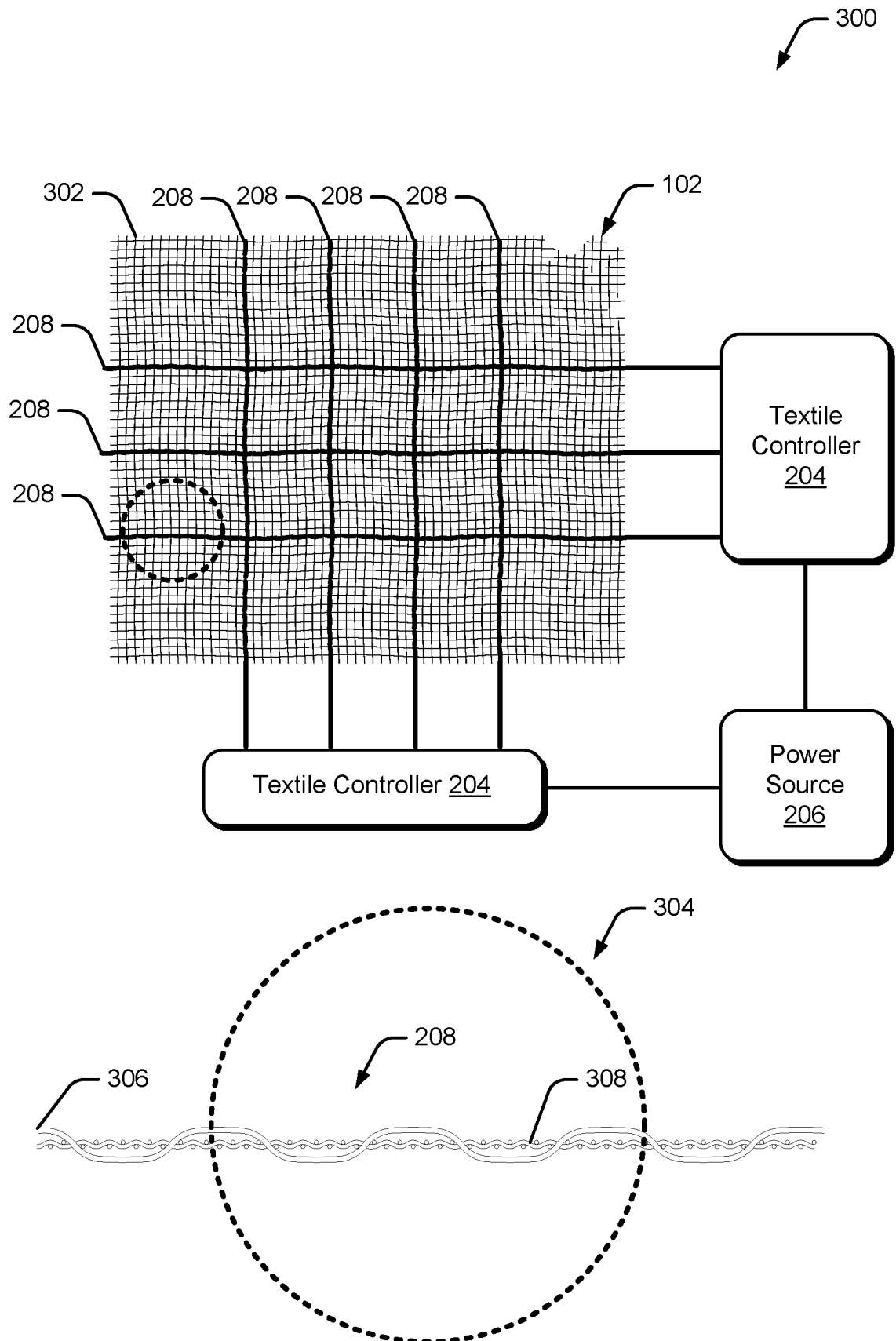


Fig. 3

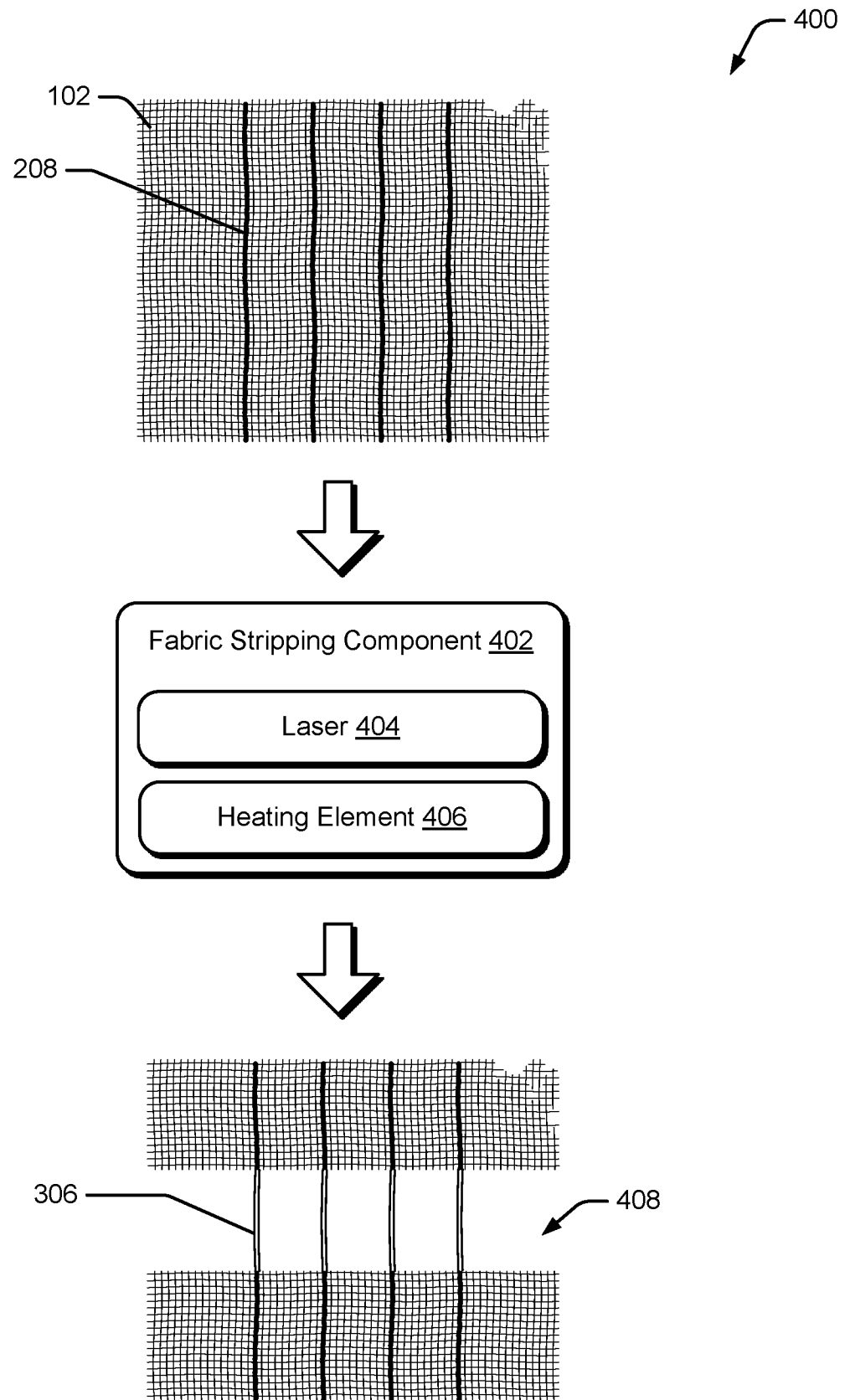


Fig. 4

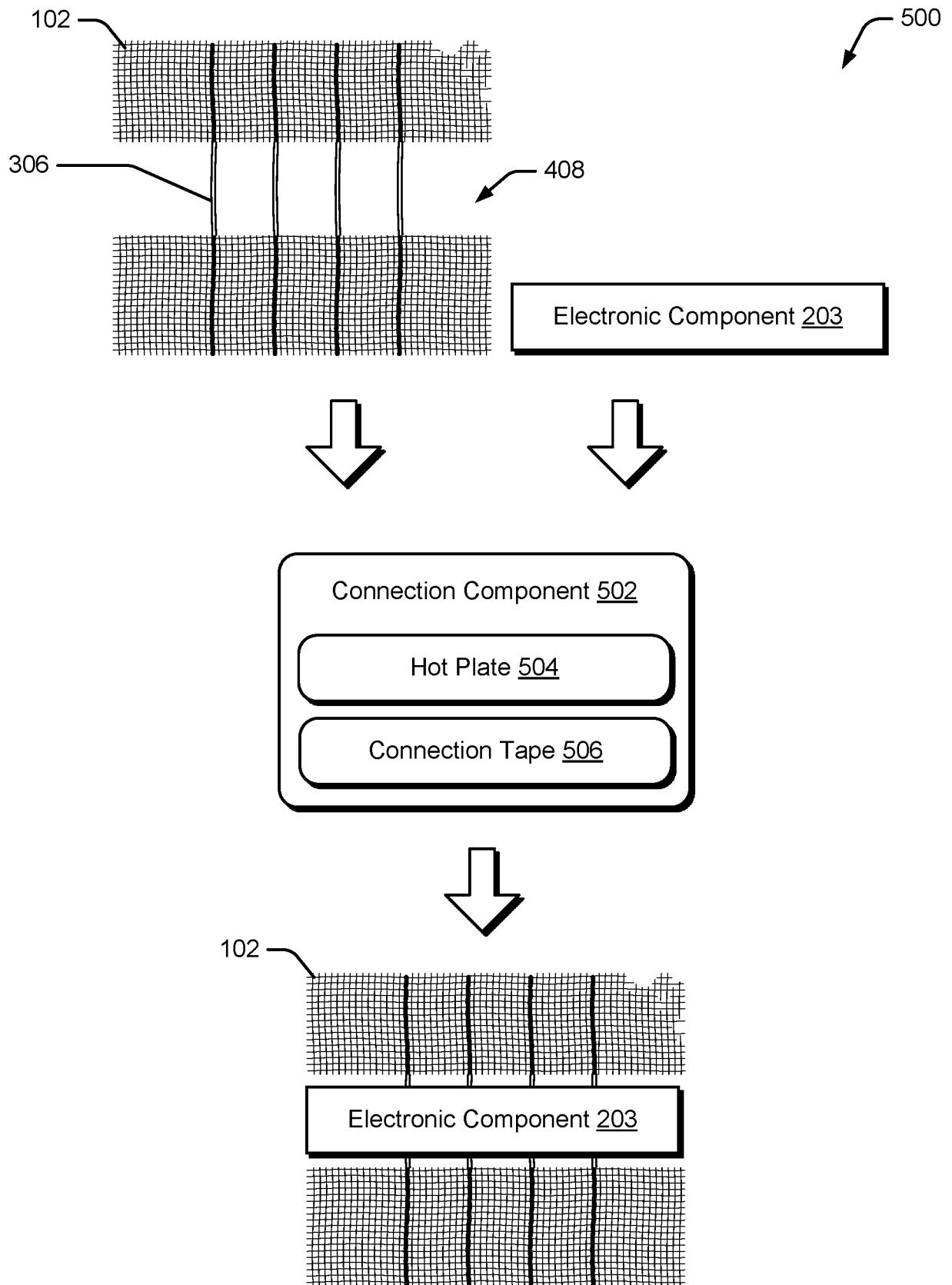


Fig. 5

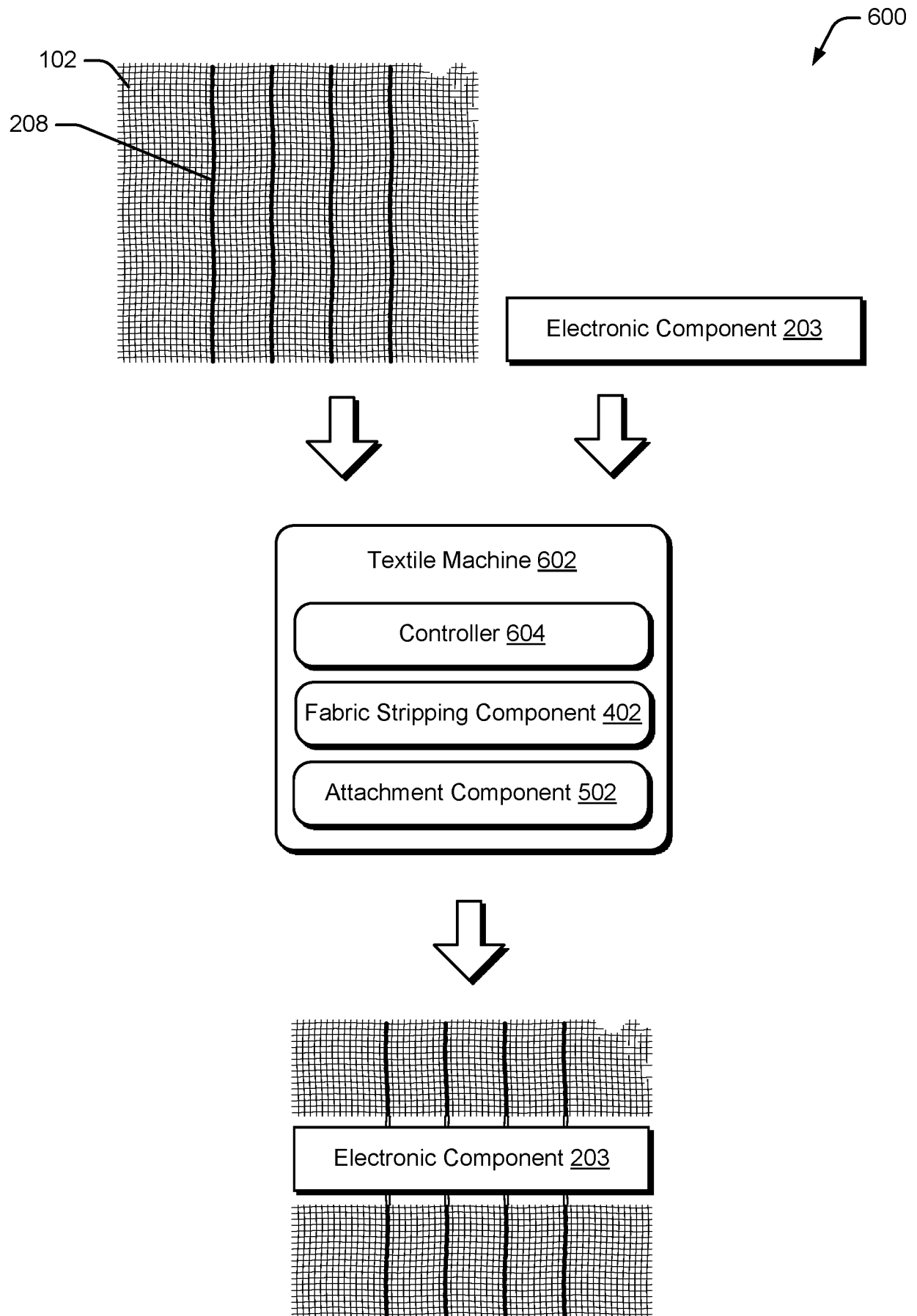


Fig. 6

700

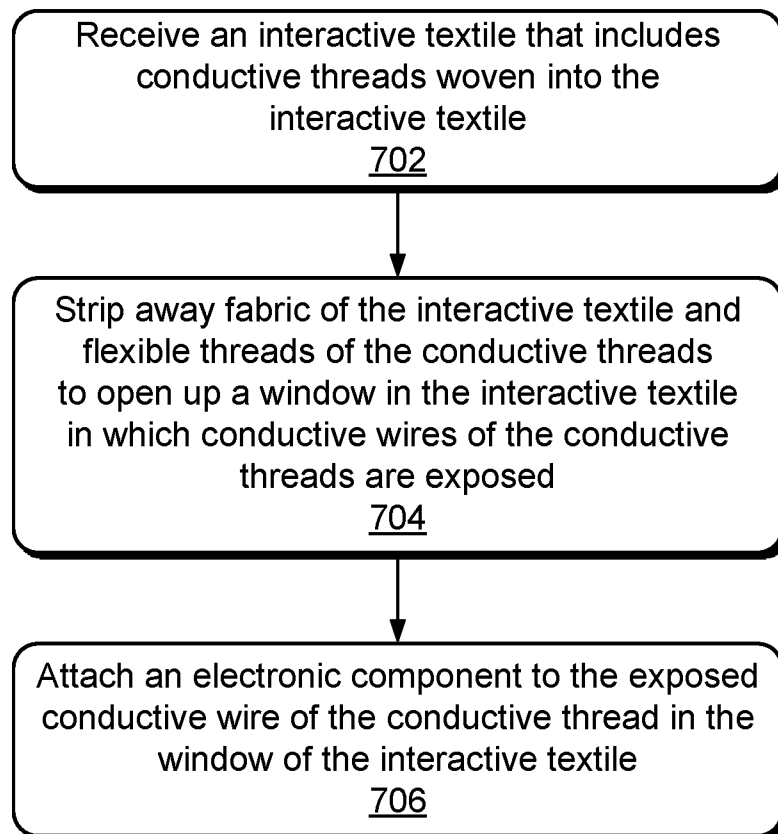
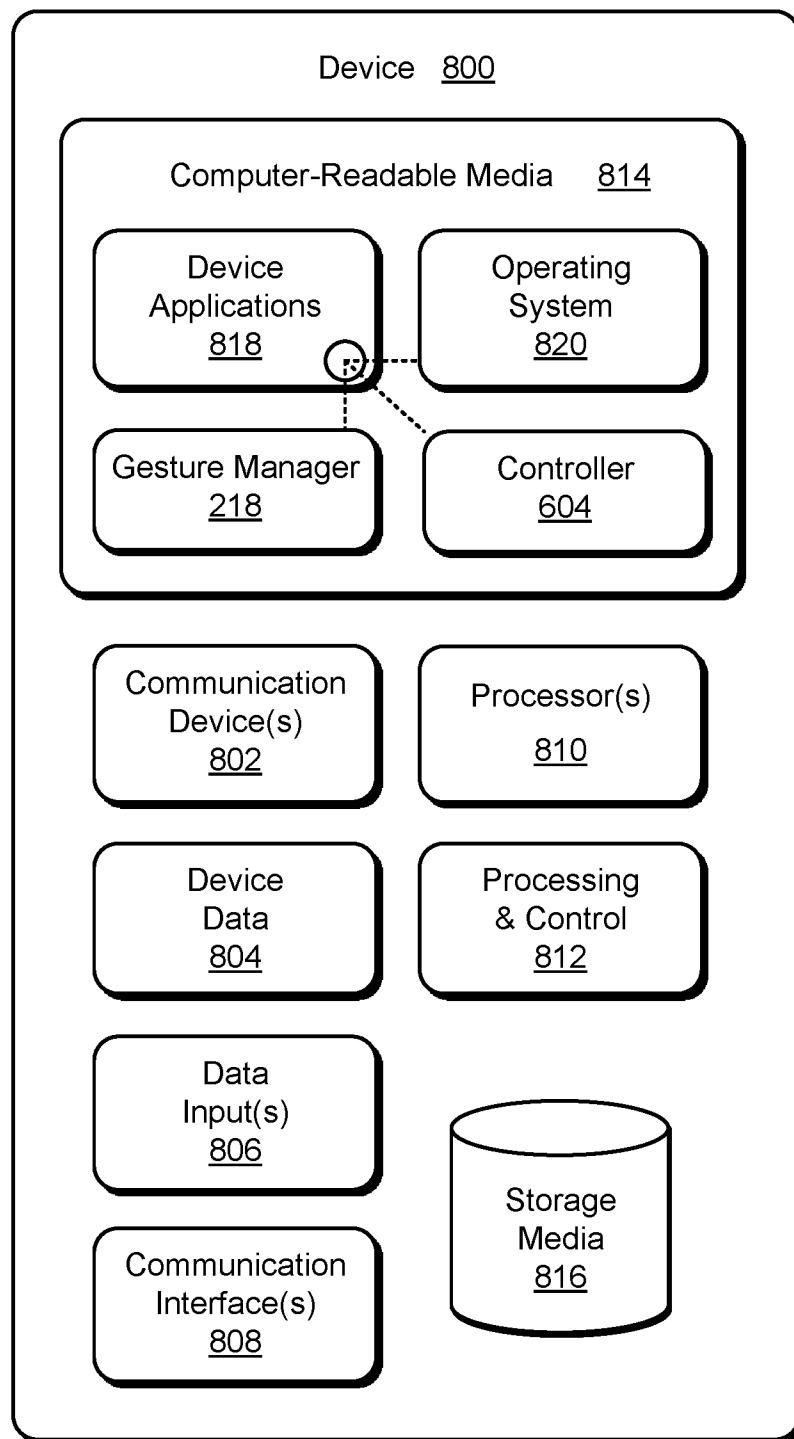


Fig. 7

**Fig. 8**

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/034366

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F3/044
ADD.

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

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 practicable, search terms used)

EPO-Internal, WPI Data, INSPEC, COMPENDEX, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/069695 A1 (JUNG STEFAN [DE] ET AL) 31 March 2005 (2005-03-31)	1-6
Y	paragraphs [0007] - [0015], [0029] - [0033], [0040] - [0042] -----	7-20
Y	US 2004/259391 A1 (JUNG STEFAN [DE] ET AL) 23 December 2004 (2004-12-23)	7-20
A	paragraphs [0005] - [0029], [0037] - [0042], [0051] - [0059], [0064] - [0066] claims 1-13 -----	1-6



Further documents are listed in the continuation of Box C.



See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

8 August 2016

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/034366

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