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Shuster et al.

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(54) **DEVICE FOR PHYSICAL INTERACTION BETWEEN REMOTELY LOCATED USERS**

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G06F 3/01 (2006.01)
G06F 3/041 (2006.01)
H04L 29/08 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 3/0414*** (2013.01); ***G06F 3/016*** (2013.01); ***H04L 67/10*** (2013.01); *G06F 2203/04102* (2013.01); *G06F 2203/04103* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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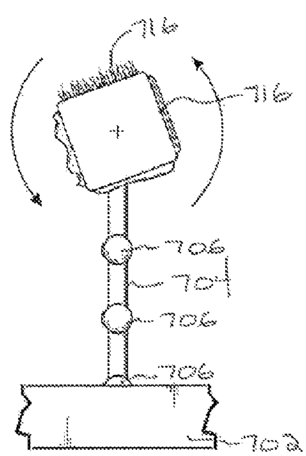
(74) *Attorney, Agent, or Firm* — Sherrie Flynn; Coleman & Horowitt LLP

(57) **ABSTRACT**

An electronic device for touch translation includes a body and pins extending therefrom and including couplings to facilitate movement of a first portion relative to a second portion. The pins are controllable to move the first portion relative to the second portion and to control force applied by the pins on an external object. Heads are disposed on the pins, which heads are greater in width than the pins and are movable relative to the pins about respective couplings. Sensors cooperating with the pins detect forces applied to the pins and a communication subsystem communicates over a network, with a remote electronic device. A controller, based on detected forces, transmits signals to the remote electronic device to control the remote electronic device, and actuates pins to control the relative movement of the portions based on signals received from the remote electronic device.

50 Claims, 14 Drawing Sheets



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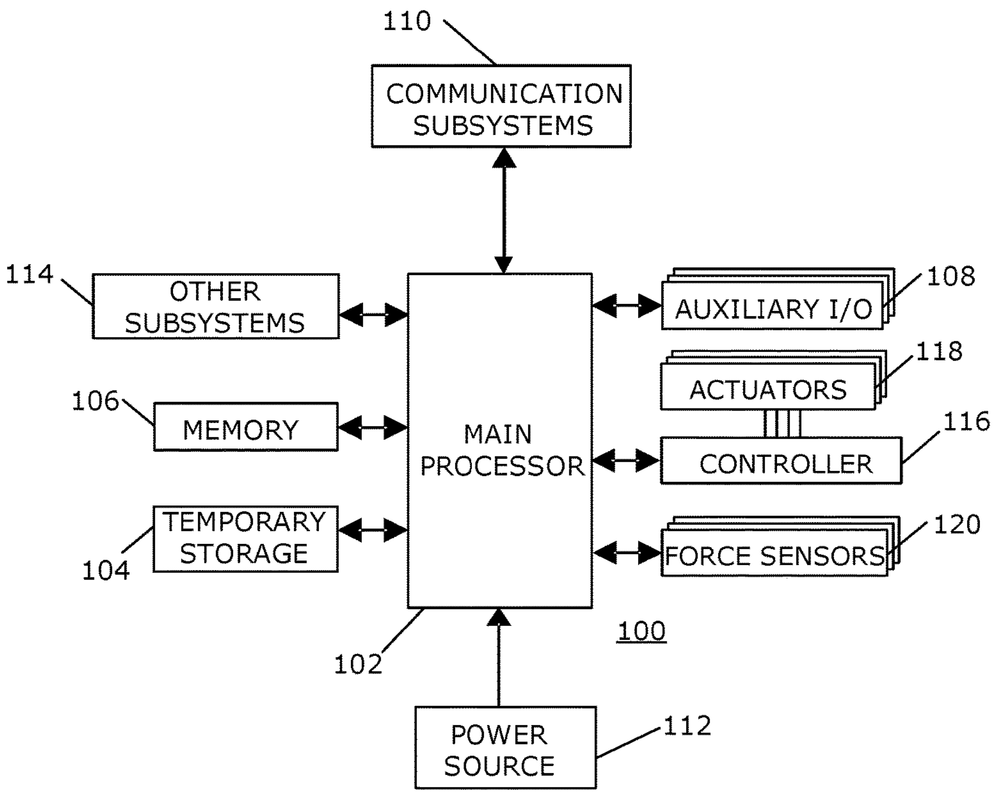
110
COMMUNICATION SUBSYSTEMS
114
OTHER SUBSYSTEMS
106
MEMORY
TEMPORARY STORAGE
104
MAIN PROCESSOR
102
AUXILIARY I/O
108
ACTUATORS
118
CONTROLLER
116
FORCE SENSORS
120
100
POWER SOURCE
112

FIG. 1

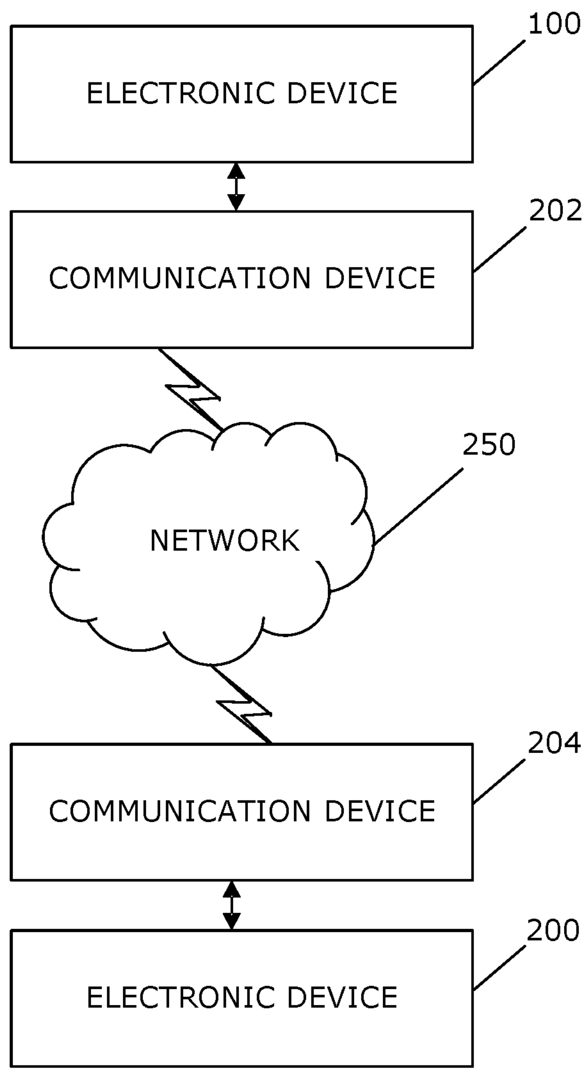
ELECTRONIC DEVICE
100
COMMUNICATION DEVICE
202
NETWORK
250
COMMUNICATION DEVICE
204
ELECTRONIC DEVICE
200

FIG. 2

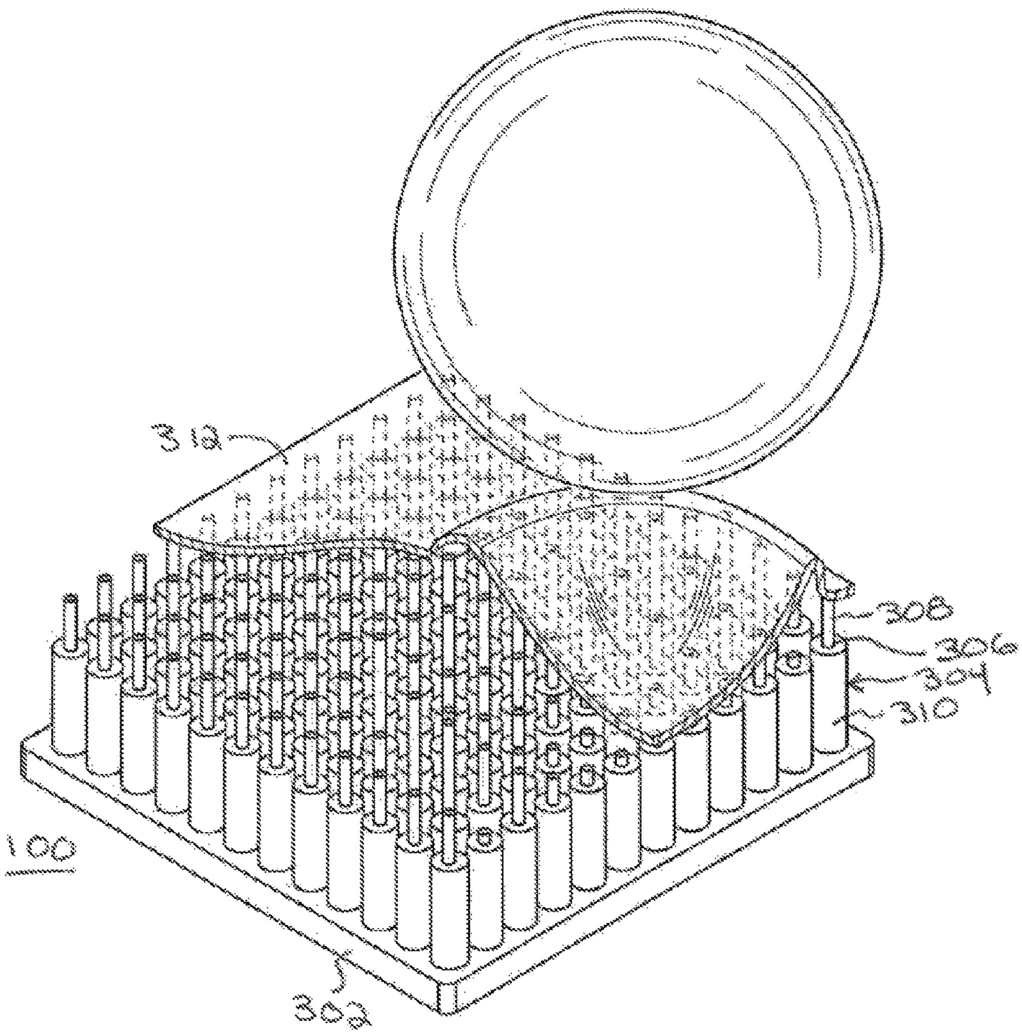

FIG. 3A

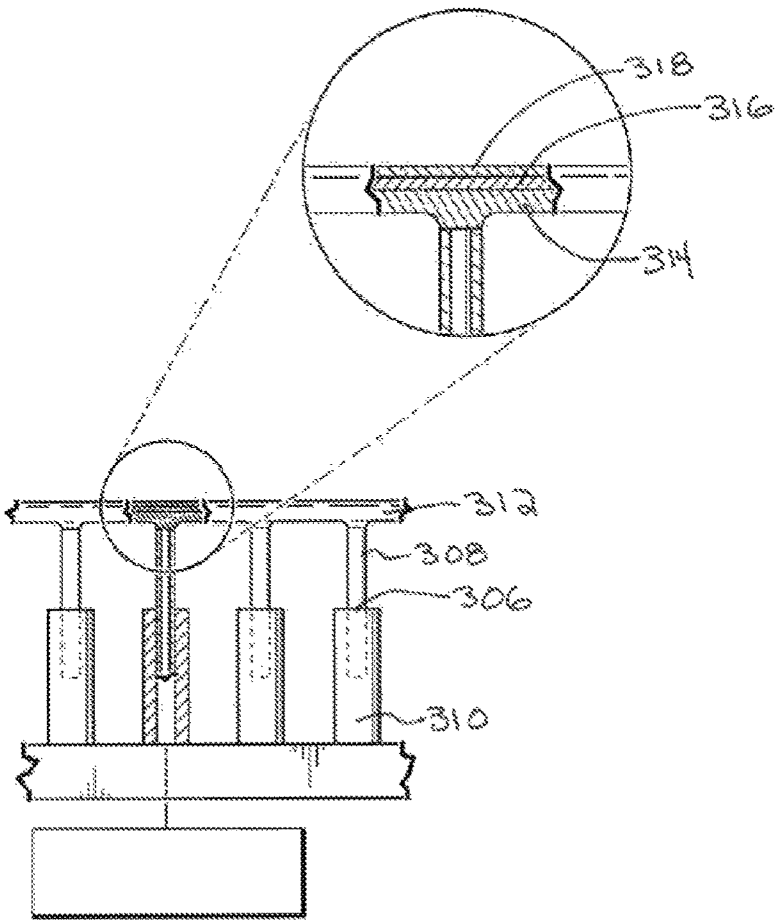

FIG. 3B

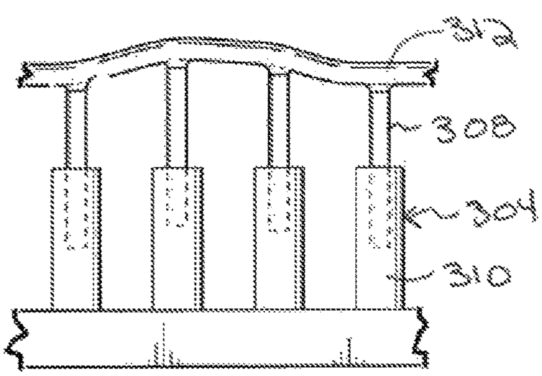

FIG. 3C

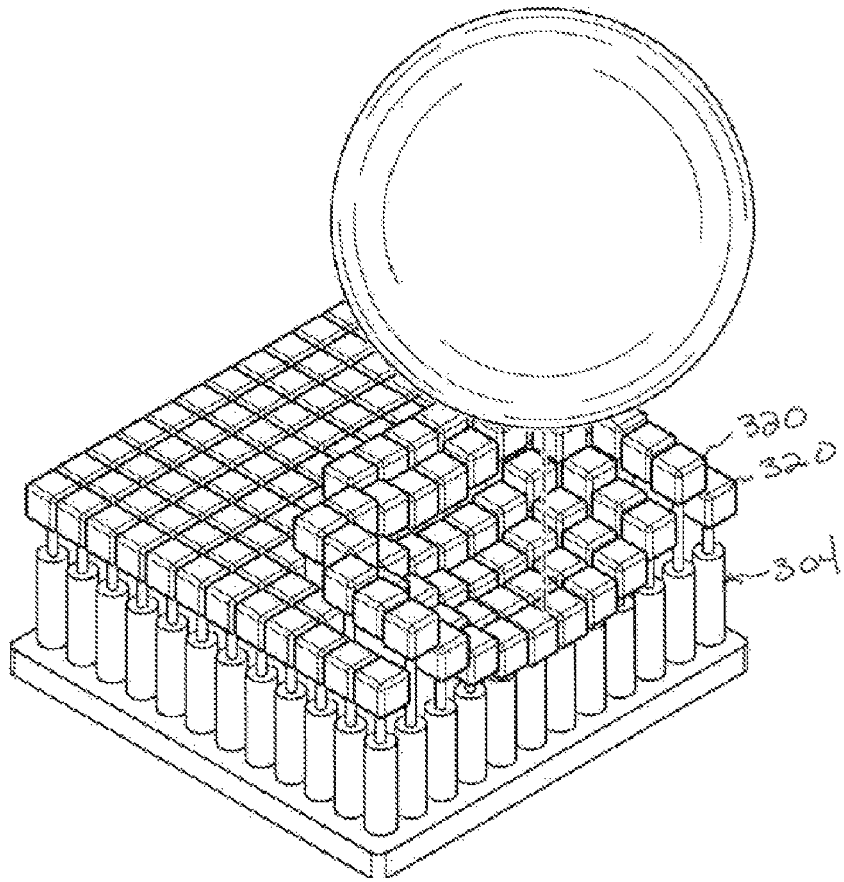

FIG. 3D

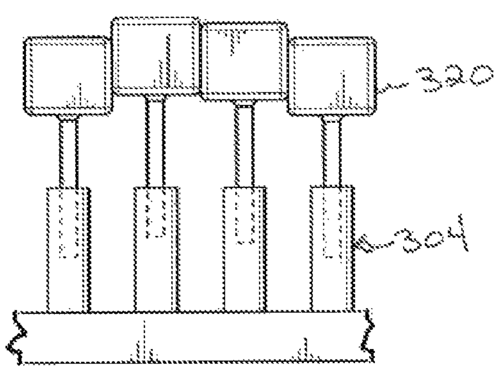

FIG. 3E

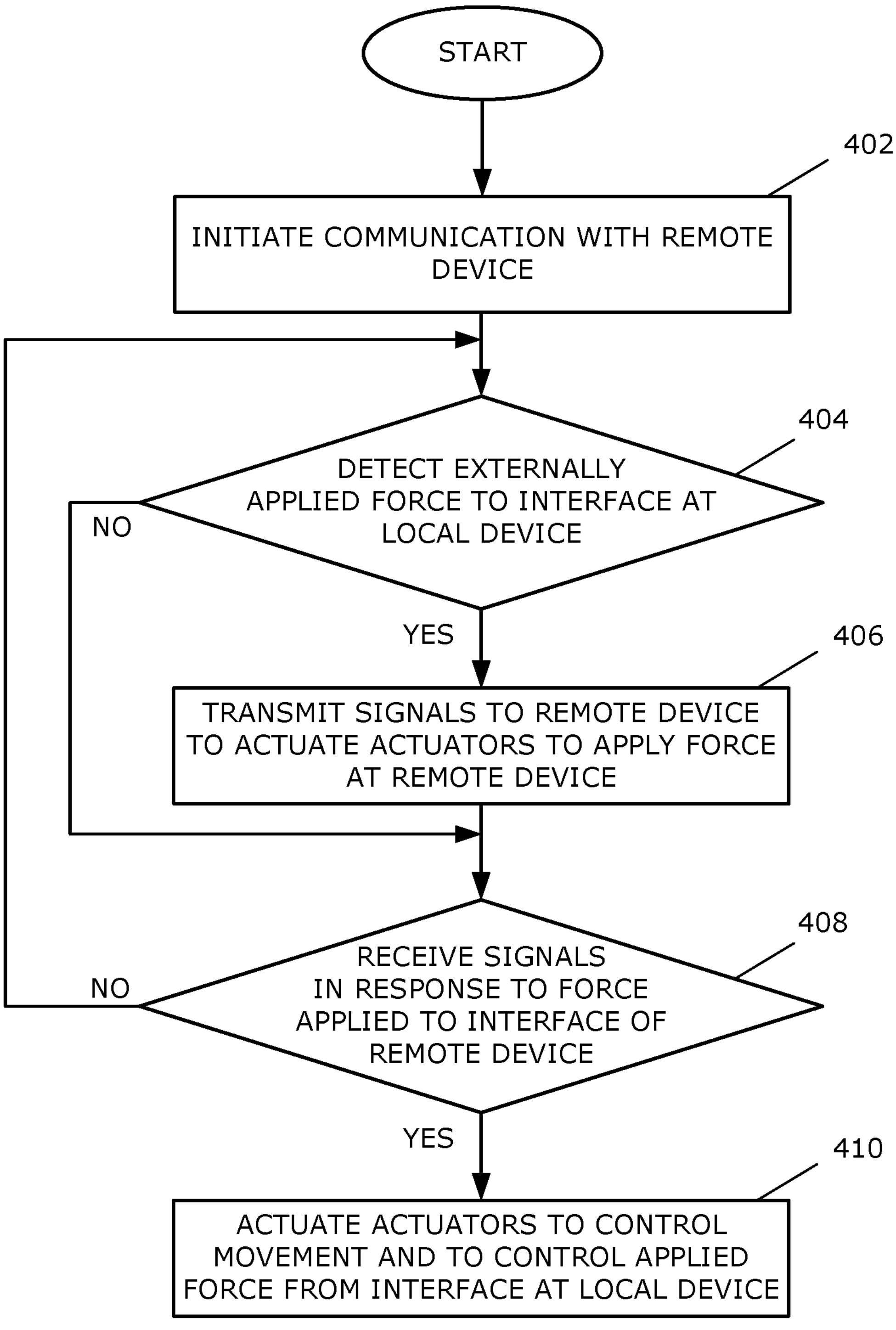
START
402
INITIATE COMMUNICATION WITH REMOTE DEVICE
404
DETECT EXTERNALLY APPLIED FORCE TO INTERFACE AT LOCAL DEVICE
NO
YES
406
TRANSMIT SIGNALS TO REMOTE DEVICE TO ACTUATE ACTUATORS TO APPLY FORCE AT REMOTE DEVICE
408
RECEIVE SIGNALS IN RESPONSE TO FORCE APPLIED TO INTERFACE OF REMOTE DEVICE
NO
YES
410
ACTUATE ACTUATORS TO CONTROL MOVEMENT AND TO CONTROL APPLIED FORCE FROM INTERFACE AT LOCAL DEVICE

FIG. 4

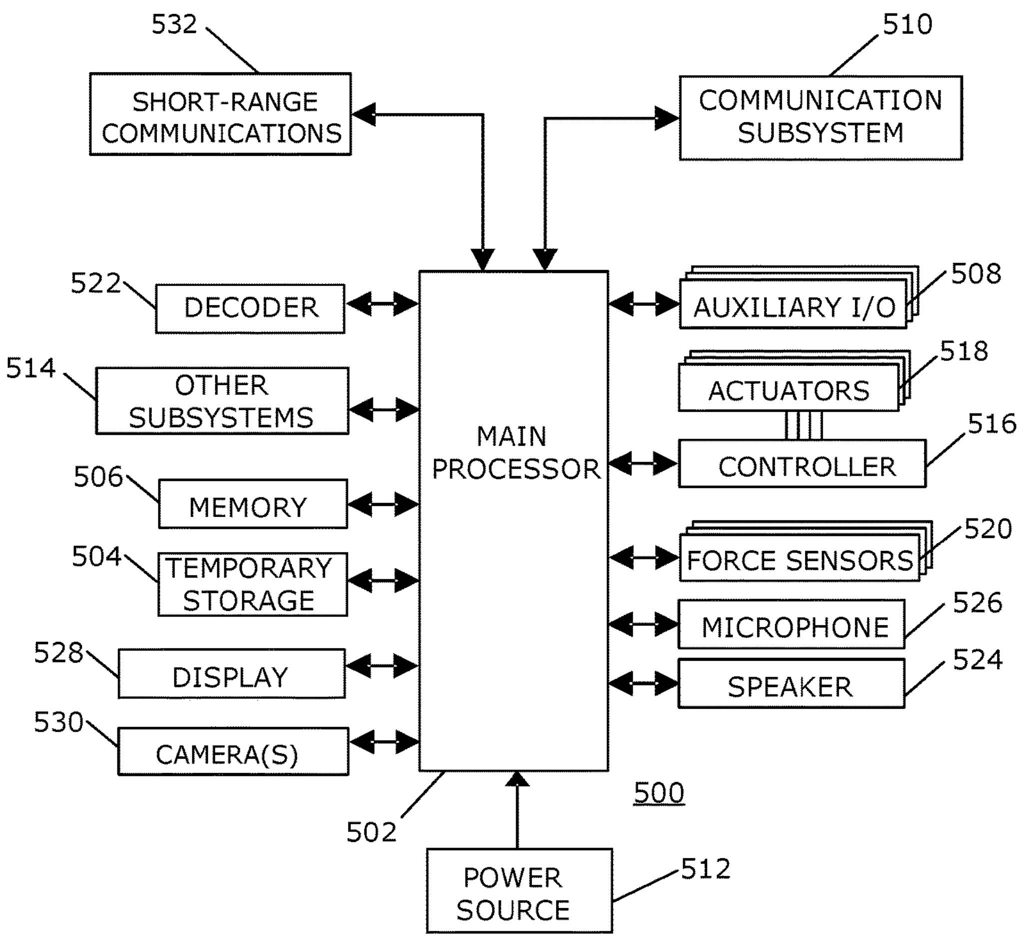
532
SHORT-RANGE COMMUNICATIONS
510
COMMUNICATION SUBSYSTEM
522
DECODER
514
OTHER SUBSYSTEMS
506
MEMORY
504
TEMPORARY STORAGE
528
DISPLAY
530
CAMERA(S)
MAIN PROCESSOR
502
508
AUXILIARY I/O
518
ACTUATORS
516
CONTROLLER
520
FORCE SENSORS
526
MICROPHONE
524
SPEAKER
500
POWER SOURCE
512

FIG. 5

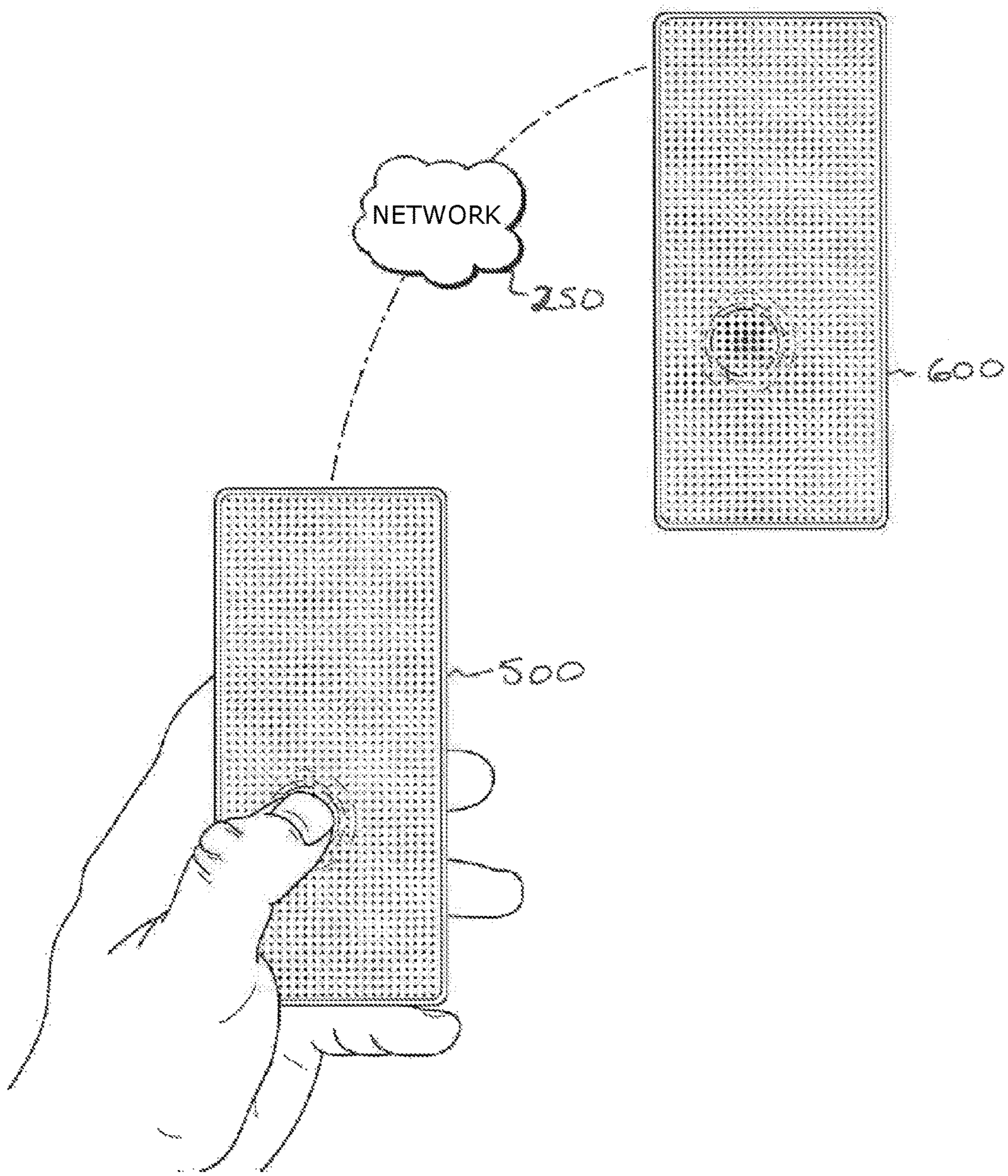

FIG. 6

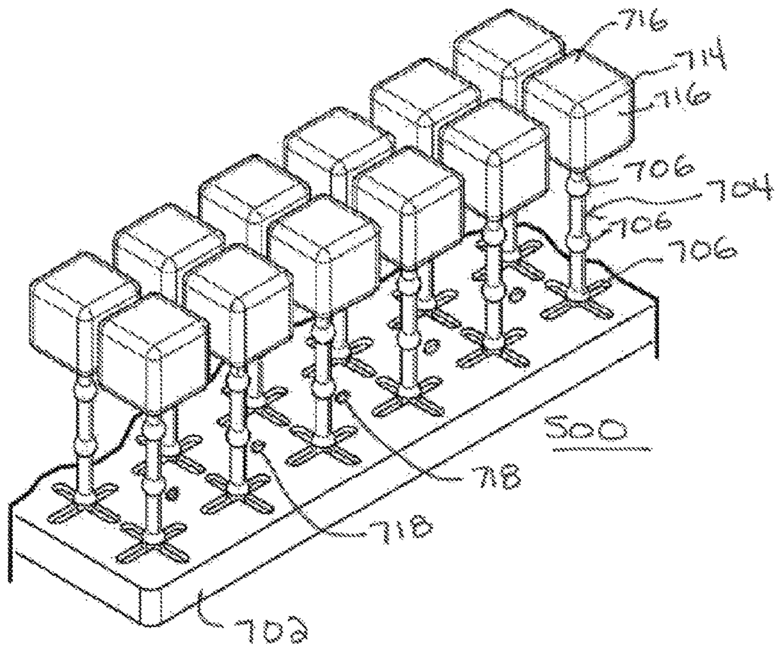

FIG. 7A

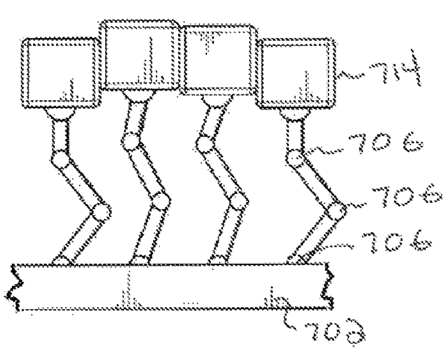

FIG. 7B

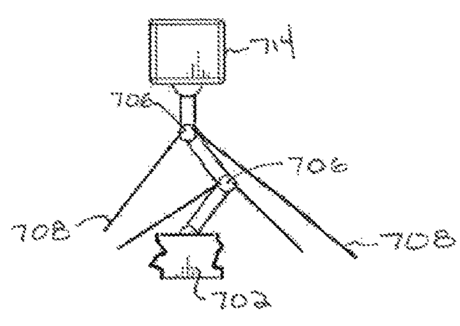

FIG. 7C

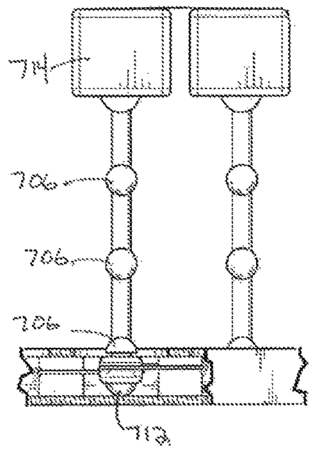

FIG. 7D

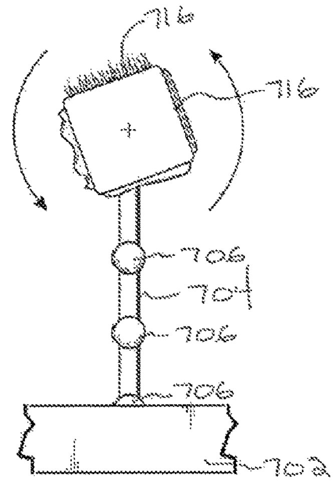

FIG. 7E

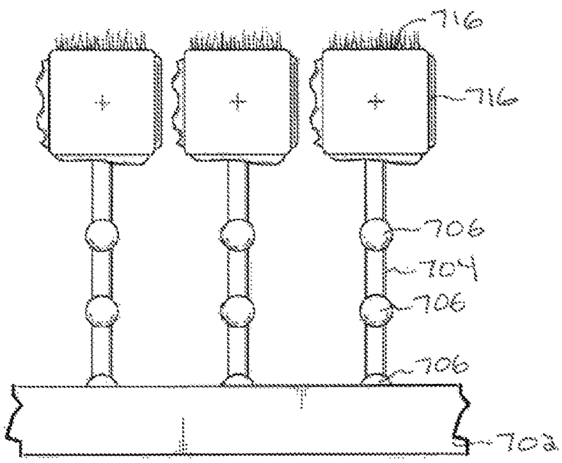

FIG. 7F

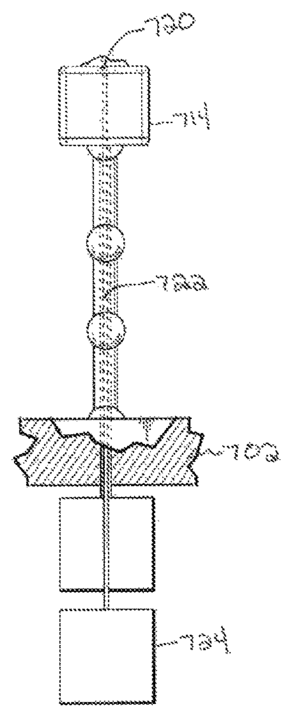

FIG. 7G

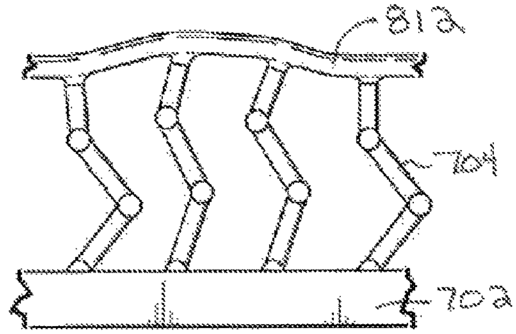

FIG. 8A

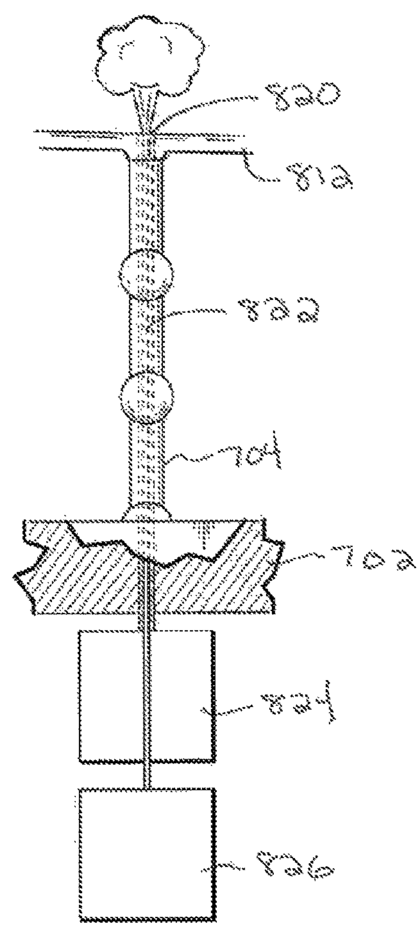

FIG. 8B

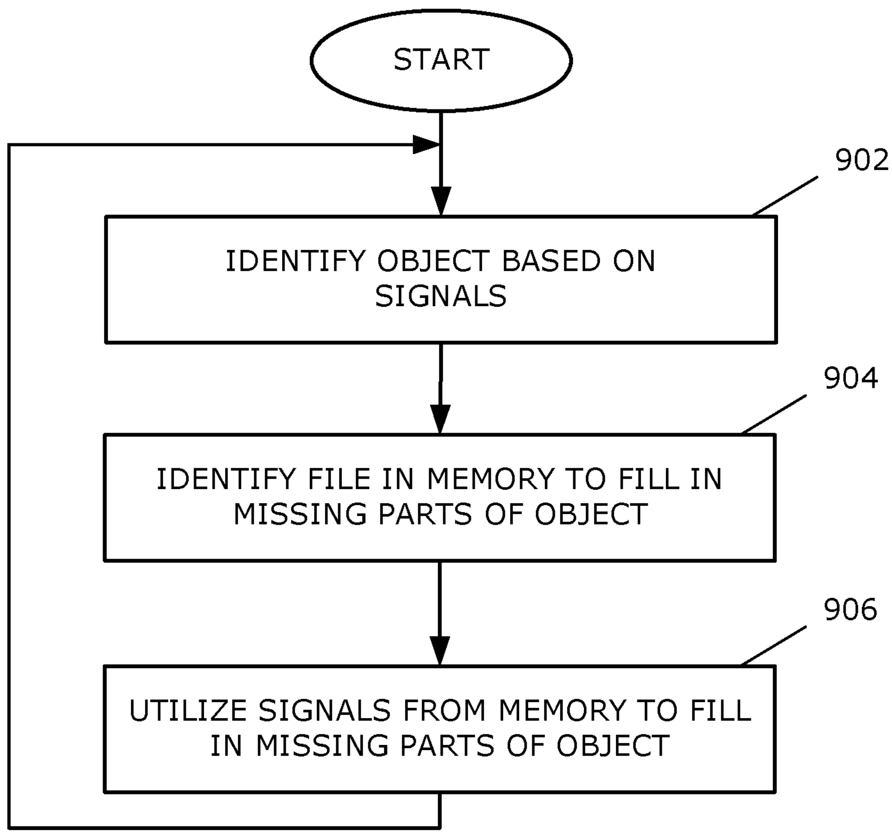
START
902
IDENTIFY OBJECT BASED ON SIGNALS
904
IDENTIFY FILE IN MEMORY TO FILL IN MISSING PARTS OF OBJECT
906
UTILIZE SIGNALS FROM MEMORY TO FILL IN MISSING PARTS OF OBJECT

FIG. 9

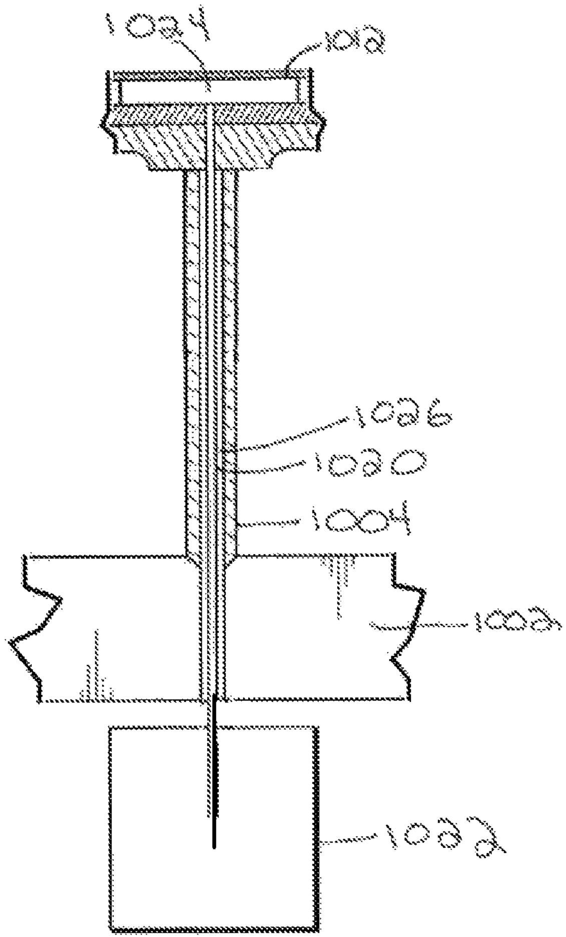
1024
1012
1026
1020
1004
1002
1022

FIG. 10

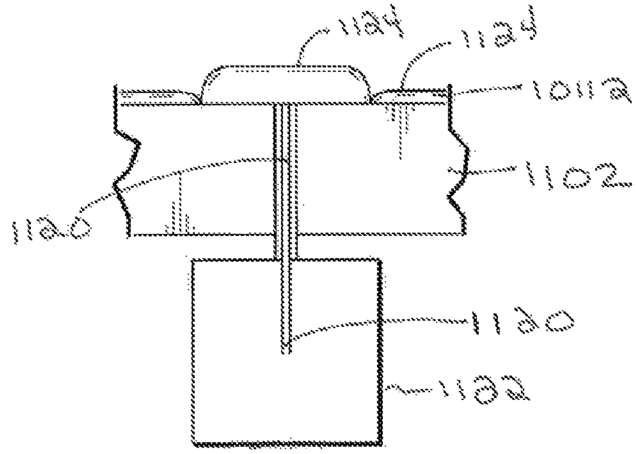
1124
1124
10112
1102
1120
1120
1122

FIG. 11

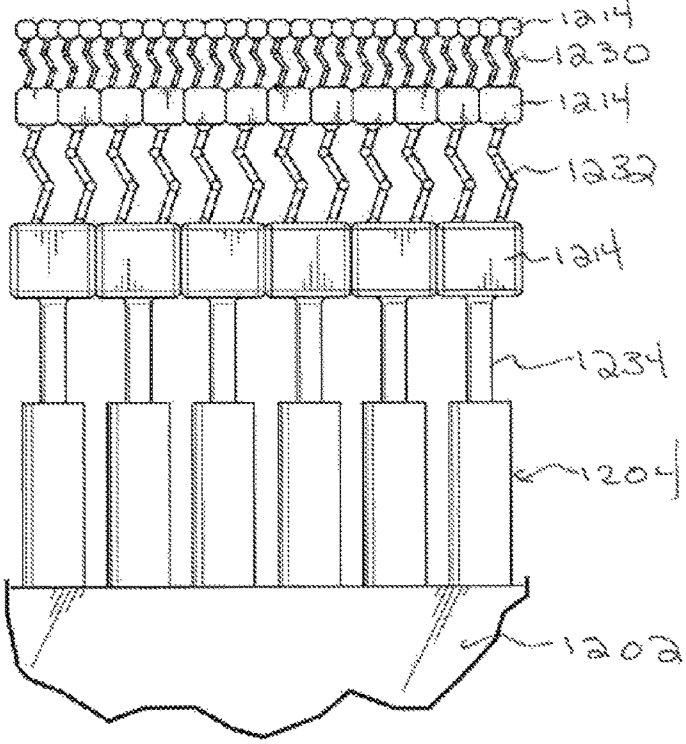

FIG. 12

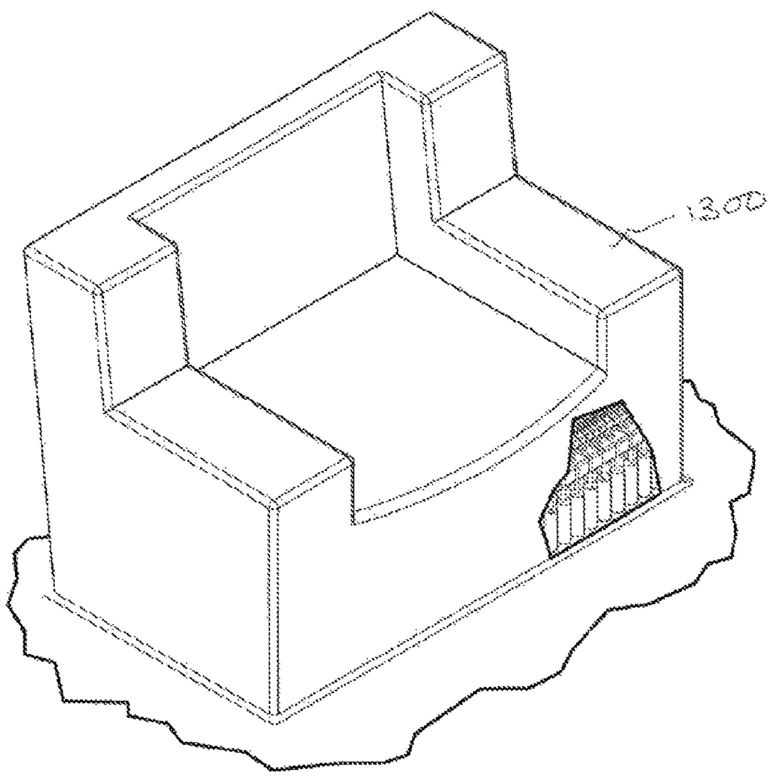

FIG. 13

DEVICE FOR PHYSICAL INTERACTION BETWEEN REMOTELY LOCATED USERS

FIELD OF TECHNOLOGY

The present disclosure relates to devices for interaction between, for example, people located remotely from each other.

BACKGROUND

Electronic devices, such as smart phones, tablet computers, laptop computers, and desktop computers have gained widespread use for a variety of functions including communications functions. Video communication functions, utilizing video chat applications, are commonly used both for business and for personal use between people located remotely from each other, for example, between parents and children living in different locations, between spouses when one or both are travelling, between colleagues working in different locations, and so forth. Thus, interactions between people are commonly carried out remotely.

Interactions between people utilizing electronic devices for communication functions are limited, for example, to voice, video, or both voice and video communication.

Head-mounted displays may also be utilized for virtual interaction between individuals to provide a more realistic interaction. Such interactions, however, are only virtual and are limited to interaction in a virtual space.

Improvements in electronic devices to provide further interaction capabilities between people located remotely from each other are desirable.

SUMMARY

An electronic device for touch translation is provided. The electronic device includes a body, a plurality of pins extending from the body, the pins including couplings to facilitate movement of a first portion of the pins relative to a second portion of the pins, the pins being controllable to control the movement of the first portion relative to the second portion and to control a force applied by the pins on an external object, sensors cooperating with the pins to detect forces externally applied to the pins, a communication subsystem for communication, over a network, with a remote electronic device, and a controller coupled to the pins, the sensors, and the communication subsystem. The controller controls the electronic device to, based on detected forces externally applied to the pins, transmit a signal to the remote electronic device for the control of the remote electronic device, and to, based on signals received from the remote electronic device, actuate ones of the pins to control movement of the first portion relative to the second portion and to control the force applied by the pins on the external object.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present disclosure will now be described, by way of example only, with reference to the attached Figures, in which:

FIG. **1** is a block diagram of an example of an electronic device for touch translation in accordance with one embodiment;

FIG. **2** is a block diagram of an example of a system for touch translation including the electronic device of FIG. **1**;

FIG. **3**A is a perspective view of one example of an electronic device in accordance with the embodiment of FIG. **1**;

FIG. **3**B is a partial side view of the electronic device of FIG. **3**A;

FIG. **3**C is a partial side view of the electronic device of FIG. **3**A;

FIG. **3**D is a perspective view of another example of an electronic device in accordance with the embodiment of FIG. **1**;

FIG. **3**E is a partial side view of the electronic device of FIG. **3**D;

FIG. **4** is a flowchart illustrating an example of a method of controlling the electronic device according to embodiments.

FIG. **5** is a block diagram of another example of an electronic device for touch translation in accordance with an embodiment;

FIG. **6** is a simplified block diagram illustrating communication between electronic devices, such as the electronic device of FIG. **5**, via a network; and

FIG. **7**A is a perspective view of another example of an electronic device in accordance with an embodiment;

FIG. **7**B is a partial side view of the electronic device of FIG. **7**A;

FIG. **7**C is a side view of an example of a pin of the electronic device of FIG. **7**A;

FIG. **7**D is a partial side view of the electronic device of FIG. **7**A with a portion of a body of the electronic device broken away;

FIG. **7**E is a side view of an example of a pin of the electronic device of FIG. **7**A;

FIG. **7**F is a partial side view of the electronic device of FIG. **7**A;

FIG. **7**G is a partial side view of an example of a pin of the electronic device, showing hidden detail;

FIG. **8**A is a side view of part of an electronic device in accordance with another embodiment;

FIG. **8**B is a side view of a pin of the electronic device of FIG. **8**A, showing additional hidden detail;

FIG. **9** is a flowchart illustrating an example of a method of controlling the electronic device according to embodiments;

FIG. **10** is a side view of a pin of part of an electronic device in accordance with another embodiment;

FIG. **11** is a side view of a pin of part of an electronic device in accordance with another embodiment;

FIG. **12** is a side view of part of yet a further example of an electronic device in accordance with yet another embodiment;

FIG. **13** is a perspective view of the electronic device of FIG. **12**, with the pins of the electronic device in the shape of a chair.

DETAILED DESCRIPTION

For simplicity and clarity of illustration, reference numerals may be repeated among the figures to indicate corresponding or analogous elements. Numerous details are set forth to provide an understanding of the examples described herein. The examples may be practiced without these details. In other instances, well-known methods, procedures, and components are not described in detail to avoid obscuring the examples described. The description is not to be considered as limited to the scope of the examples described herein.

The following describes an electronic device and a method for touch translation. The electronic device includes a body, a plurality of pins extending from the body, the pins including connections or couplings to facilitate movement of a first portion of the pins relative to a second portion of the pins, the pins being controllable to control the movement of the first portion relative to the second portion and to control a force applied by the pins on an external object, sensors cooperating with the pins to detect forces externally applied to the pins, a communication subsystem for communication, over a network, with a remote electronic device, and a controller coupled to the pins, the sensors, and the communication subsystem. The controller controls the electronic device to, based on detected forces externally applied to the pins, transmit a signal to the remote electronic device for the control of the remote electronic device, and to, based on signals received from the remote electronic device, actuate ones of the pins to control the movement of the first portion relative to the second portion and to control the force applied by the pins on the external object.

A simplified block diagram of an example of an electronic device **100** for touch translation is shown in FIG. **1**. The electronic device **100** includes multiple components, such as a main processor **102** that controls the overall operation of the electronic device **100**. The electronic device **100** may be mounted to another object or device, may include mounting brackets or geometry to facilitate mounting to another object or device, or may be in the form of a sheet for resting on a surface. According to one example, the electronic device **100** is incorporated into a case for another electronic device such as a smartphone or tablet computer. Alternatively, the electronic device **100** may be incorporated or integrated into another electronic device such as a portable electronic device, smartphone, or tablet computer. The electronic device **100** may also be generally transparent and may be overlaid on a display of another electronic device such as a smartphone or tablet computer. Thus, the display on which the electronic device **100** is overlaid may be a touch-sensitive display. Optionally, the electronic device **100** is manually removable when not in use. Alternatively, the electronic device **100** may be opaque or partially opaque and is included in a cover that covers part or all of the display **118** when utilized. For example, the electronic device **100** may be incorporated into a phone case that is manually located over the display to close the case over the display prior to touching the electronic device **100**, which may include holding the electronic device **100** to the face of the user.

The main processor **102** interacts with other components of the electronic device **100**, including, for example, a temporary storage device **104**, a memory **106**, an auxiliary input/output (I/O) subsystem **108**, a communication subsystem **110**, a power source **112**, and, optionally, other subsystems **114**. Additionally, the main processor **102** interacts with a controller **116** that is coupled to actuators **118** that are utilized to control movement of pins, also referred to as fingers, about connections or couplings within the pins.

The actuators **118** may be, for example, linear actuators, hydraulic actuators, pneumatic actuators, magnetic actuators, or any combination of different types of actuators that are coupled to parts of the pins to control movement of one portion of a pin relative to another portion of the pin or to control the elevation, or distance of an end of the pin relative to a body from which the pins extend, of one of the pins relative to the resting elevation of the pins. The controller **116** is coupled to the main processor **102** and, based on signals from the main processor **102**, controls the actuation of the actuators **118**.

The force sensors **120** are associated with the pins, for example, are located at the ends of the pins of the electronic device **100** to detect external forces that are applied to the pins, such as forces from a user's hand, finger, thumb, face, appendage, or other items held by a user applying force to the pins of the electronic device **100**. The force sensors **120** may be disposed in the pins, on the pins, under the pins, or any suitable combination of in, on, and under the pins to detect forces on the pins. Thus, an external force applied to the pins of the electronic device **100** is detected utilizing the force sensors **120**. The actuators **118** may also be utilized to apply a force, by the pins, on an external object, such as the user's hand, finger, thumb, face, appendage, or other items, held by a user applying force to the pins.

The temporary storage device **104** may be, for example, Random Access Memory (RAM) that stores data that is processed by the main processor **102**. The memory **106**, such as flash memory, is utilized for persistent storage. The memory **106** may be utilized to store an operating system and software programs or components that are executed by the processor **102**.

The optional auxiliary input/output (I/O) subsystem **108** may include an interface through which, for example, a USB controller or other peripheral device may be connected. Other input/output subsystems may also be utilized as well as other communications.

The communication subsystem **110** receives signals from a communication device such as a portable electronic device, smart phone, tablet computer, laptop or other device (not shown) and sends signals through the communication device to which the electronic device **100** is coupled. Thus, for example, the signals from the force sensors **120** or other commands from the main processor **102** may be sent via the communication subsystem **110**. The communication subsystem **110** is also responsible for receiving signals via the communication device for processing by the main processor **102** to cause actuation of the actuators **118**, via the controller **116**, in response to signals from the communication device.

The power source **112** may be one or more of rechargeable batteries, capacitors, inductive charging, inductive power, fuel cells, a port to an external power supply to power the electronic device **100**.

The systems and subsystems that interact with the main processor **102** and are described herein are provided as examples only. Other subsystems **114** may also interact with the main processor **102**.

Although not shown in the block diagram of FIG. **1**, the electronic device **100** may optionally include other devices and subsystems. For example, the electronic device **100** may include a display device or display devices for displaying information such as pictures or other information on the pins, one or more speakers for audio output, one or more cameras for capturing images, which may include video, short-range communications, proximity sensors, and other suitable devices or subsystems.

Referring to FIG. **2**, a system for touch translation including the electronic device **100** is shown. In this example, the electronic device **100** communicates with a similar electronic device **200** that is located remotely from the electronic device **100** by sending signals to the remotely located electronic device **200** via the communication device **202** to which the electronic device **100** is coupled, through a network **250** and through a remotely located communication device **204**. The electronic device **100** also receives signals from the remotely located electronic device **200** via the communication device **202**, the network **250**, and through the remotely located communication device **204**.

As indicated above, the communication device **202** may be a portable electronic device, smart phone, tablet computer, laptop or other device that is in communication with the electronic device **100** via the communication subsystem **110** of the electronic device **100**. The electronic device **100** may optionally be physically coupled to the communication device **202**. For example, the electronic device **100** may be coupled to a back side of the communication device **202**.

Similarly, the remote communication device **204** may be a portable electronic device, smart phone, tablet computer, laptop or other device that is in communication with the remote electronic device **200** via a communication subsystem of the remote electronic device **200**. The remote electronic device **200** may optionally be physically coupled to the communication device **204**.

The network **250** may include the internet and may include a cellular network in addition to the internet or as an alternative to the internet. Several communication devices may communicate through the network **250**. Other communications may also be utilized, including for example, near field, Bluetooth®, WiFi, optical, radio, or a combination of communications.

Thus, the electronic device **100** is operable to communicate with the remote electronic device **200**. When a communication session begins, signals are transmitted from the electronic device **100** to the remote electronic device **200** in response to detecting an externally applied force on the pins of the electronic device **100**. The signals are sent to the remote electronic device **200** to control the remote electronic device **200**. In response to receipt of signals at the electronic device **100**, from the remote electronic device **200**, the actuators are controlled to control movement of the pins of the electronic device **100** and force applied by the pins of the electronic device **100** on an external object, such as a user's hand, finger, thumb, face, appendage, or other items, held by a user applying force to the pins. Thus, a force applied by a user on the electronic device **100** is determined and, movement of the pins of the remote electronic device **200** is controlled and a resulting force is applied by the remote electronic device **200**. Similarly, a force applied by a remote user on the remote electronic device **200** is determined and a resulting force is applied by the electronic device.

A user pressing on the pins on the electronic device **100** at the same time that a remote user presses on the remote electronic device **200**, feels the return force caused by the user pressing on the remote electronic device **200**.

A perspective view of one example of an electronic device is shown in FIG. **3**A through FIG. **3**C. The electronic device **100** includes a body **302** in which the components illustrated in FIG. **1** are disposed. The body **302** may be rigid. Alternatively, the body **302** may be flexible while still providing protection for the components shown in FIG. **1**. The plurality of pins **304** extend from the body **302**. In the present example, the pins **304** extend generally linearly away from the body **302**. Each pin **304** includes coupling **306** such that a distal portion **308** or outer portion of the pin **304** is moveable relative the proximal portion **310** or inner portion of the pin. The proximal portion **310** is coupled to the body **302** while the distal portion **308** is coupled at the coupling **306** to the proximal portion **310**.

For the purpose of the present example, the distal portion **308** is moveable relative to the proximal portion **310**, toward and away from the body **302**. Movement of a pin **304** and any force applied by a pin on an external object that is in contact with the end of the distal portion **308** of the pin **304** or a cover or membrane coupled to the distal portion **308** of the pin **304**, is controlled by an actuator, such as a linear actuator, which may be, for example, a hydraulic actuator or pneumatic actuator. The linear actuator is coupled to the controller to thereby control sliding movement of the distal portion **308** relative to the proximal portion **310** of the pin **304**, and force applied by the pin **304**. In this example, coupling comprises a telescoping coupling and the sliding movement of the distal portion **308** relative to the proximal portion **310** is a telescoping movement.

For the purpose of this example, the pins **304** are covered by a flexible, elastic membrane **312** such as a latex, flexible PVC, CyberSkin® or a combination of flexible, elastic materials. Thus, in this example, the pins **304** and membrane **312** are part of a user interface of the electronic device **100**.

The flexible, elastic membrane **312** may also be comprised of multiple layers of materials. For example, the flexible, elastic membrane **312** may include a first layer **314** that couples to at least some of the pins **304**, for example, by a mechanical interlock with sockets in the layer or an adhesive layer that facilitates application of forces by the pins **312**, away from the body **302** and toward the body **302**. The flexible, elastic membrane **312** may include a second layer **316** of, for example CyberSkin®, and a third layer **318** of, for example, a very thin latex. The very thin latex may be replaceable.

Alternatively, heads **320** may be disposed on the ends of the pins **304** and the heads are larger in diameter than the body of the pins **304**, as illustrated in the example of FIG. **3**D and FIG. **3**E. In this example, no membrane **312** is present. The heads **320** may be a different material or materials than the pins **304**.

Referring again to FIG. **3**A through FIG. **3**C, the plurality of the pins **304** extend from the body **302**, in a dense array of pins **304** that are each, individually actuatable. In addition to being actuatable, the pins **304** are depressible by an externally applied force. Such an externally applied force is detected utilizing the force sensors **120**. The force sensors may be coupled to the pins such that each pin is associated with a respective force sensor for detecting the externally applied force on that associated pin.

In accordance with the present example, the pins **304** are small relative to a human finger, thumb, hand, appendage, or face and are disposed in a dense array on the body **302** such that an external force exerted, for example, by a human finger, is exerted on a plurality of the pins **304**. Thus, force may be applied to tens or hundreds of pins **304** by a user's finger pressing on the electronic device **100**. As a result of the relatively high number and density of pins **304**, a force is applied on the pins **304**, which together are moved in the shape of the finger or other object that applies the force.

Referring again to FIG. **2**, when an external force is applied to the pins **304**, sufficient to cause the distal portion **308** of some of the pins **304** to move toward the body **302**, signals are transmitted to the remote electronic device **200** that is in communication with the electronic device **100**. When no external force is applied to pins at the remote electronic device **200**, the pins at the remote electronic device **200** that correspond to the pins **304** to which the force is applied at the electronic device **100**, are moved. The corresponding pins at the remote electronic device **200** are moved by moving the distal portion of the pins away from the body.

Thus, the ends of the pins **304** are moved toward the body **302** at the electronic device **100** to provide a depression in the surface that generally follows the contour and surface profile of the object, such as a finger, that applied the force to the pins **304**. At the remote electronic device **200**, ends of the corresponding pins are moved away from the body to form a projection that generally follows the contour and surface profile of the object that applied the force to the pins **304**. The projection formed at the remote electronic device **200** is formed by the pins covered by the elastic membrane, giving the general appearance of the object that applied the force to the pins **304** at the electronic device **100**.

In this example, the distal ends **308** of the pins **304** are moved at the electronic device **100** to form a depression in the surface of the membrane **312**, and the distal ends of the pins are moved at the remote electronic device **200** to form a corresponding projection in the surface of the membrane. Thus, the pins at the remote electronic device **200** are moved in the opposite direction as the pins at the electronic device **100** to generally form an inverse profile.

When an external force is applied to the pins **304** at the electronic device **100**, and an external force is applied to corresponding pins at the remote electronic device **200**, the corresponding pins at the remote electronic device **200** apply a force to the external object applying a force at the remote electronic device **200**. Similarly, the pins **304** at the electronic device **100** apply a force on the object applying the external force at the electronic device **100**. The force applied by the pins at the remote electronic device **200** to the external object, generally corresponds in magnitude to the external force applied to the pins **304** at the electronic device **100**. The force applied by the pins **304** to the external object at the electronic device **100** generally corresponds in magnitude to the external force applied to the pins at the remote electronic device **200**.

A flowchart illustrating a method of controlling an electronic device, such as the electronic device **100** is shown in FIG. **4**. The method may be carried out by software executed, for example, by the main processor **102** of the electronic device **100**. Coding of software for carrying out such a method is within the scope of a person of ordinary skill in the art given the present description. The method may contain additional or fewer processes than shown or described, and may be performed in a different order. Computer-readable code executable by at least one processor to perform the method may be stored in a computer-readable medium, such as a non-transitory computer-readable medium.

A communication session is initiated **402** between the electronic device **100** and the remote electronic device **200**. The communication session is started by one or both of the electronic device **100** and the remote electronic device **200**. To initiate the communication session, the electronic device **100** and the remote electronic device perform a handshake process, for example, in response to user selection of an option to begin communicating with the remote electronic device **200**. The communication session is secured utilizing known secure communications techniques, including, for example, encryption and decryption to provide security in transmission.

Initiation of a communication session may also include user authentication or identification. For example, knowledge-based identification, such as a passcode or a personal identification number, may be utilized. Alternatively or in addition, biometric identification, such as fingerprint, facial recognition, palm print, or geometry, or other biometric identification may be utilized. Such biometric identification may be carried out by pressing a hand, face, or other body part against the interface of the electronic device **100**. A comparison is then made with stored data relating to the user's identification to confirm that the user is an authorized user of the electronic device **100**. The electronic device may also identify contours of details of the hand or other body part and, optionally measure temperature to confirm the temperature of the person for use in authentication. Such biometric identification utilizing an imprint of a hand or other body part against the interface increases security over biometric identification methods of other devices. The length of time that the communication session lasts may be limited. For example, after a threshold period of time, the communication session may be discontinued unless authentication is repeated.

During the communication session, externally applied forces on the interface of the local electronic device **100** are detected utilizing the force sensors **120**. In response to detecting an externally applied force on the interface at **404**, signals are transmitted to the remote electronic device **200** at **406** to actuate the actuators to control movement of portions of the pins about the connections or couplings to thereby control movement and forces applied by the pins of the remote electronic device **200**.

Signals are also received at the local electronic device **100**. The signals are received from the remote electronic device **200** in response to externally applied forces that are detected at the remote electronic device **200**.

In response to receipt of signals at the local electronic device at **408**, the actuators **118** are actuated at **410** to control movement of portions of the pins about the couplings to thereby control movement and forces applied by the pins **304** of the local electronic device **100**.

Because the pins **304** of the electronic device **100** include couplings **306** to facilitate movement of the distal portion **308** relative to the proximal portion **310**, the pins **304** are movable toward and away from the body **302** and are operable to apply a force to an object touching the pins **304**. In addition, the pins **304** are controlled to form a shape, such as a projection, that generally follows the contours and surface profile of an object touching the interface of a remote device that is in communication with the electronic device **100**. Utilizing the movement of the pins **304** and force application, the electronic device **100**, in cooperation with a remote electronic device **200**, simulates touch between two people that are each utilizing a respective one of the electronic devices.

Utilizing such electronic devices **100**, **200**, touch contact is simulated to give the users the perception of touch. For example, a first user that presses on the pins **304** of the local electronic device **100**, while a second user presses the pins of the remote electronic device **200**, which is in communication with the local electronic device **100**, perceives touch contact with the second user. For example, if both users rest their hands on the respective interface, the first user perceives that he or she is resting a hand on a hand of the second user. Similarly, the second user perceives that he or she is resting the hand on the hand of the first user. In another example, facial contact is perceived when the users press their faces against the interface.

Latency introduced from various sources such as transmission time, processing time, and actuation, may be of the order tens of milliseconds or greater. To reduce the problems introduced by latency and thus a lack of synchronization between the two electronic devices **100**, **200**, the software stored, for example, in the memory **106** at each electronic device, is utilized to smooth out actions and reactions to generally maintain the simulation of touch and facilitate perception of touch by each user.

The communication session or parts thereof may optionally be recorded by storing information relating the communication session. For example, received signals from an electronic device may be recorded by storing related information in the memory, such as the memory **106**. For example, the signals received from a remote electronic device in response to a user placing his or her hand on the remote electronic device, may be stored and utilized later to reproduce the simulation of touch after the communication session has ended.

In the above-described method, the electronic device **100** enters a communication session with the remote electronic device **200** to simulate touch at both the electronic device **100** and at the remote electronic device **200**. Optionally, the application of force and movement of the pins may occur at an electronic device, such as the electronic device **100**, independent of a communication session with another electronic device. Signals may then be transmitted, for example, by a social networking platform, to share the signals with a recipient or with multiple recipients. For example, a touch may be broadcast to multiple recipients. In one example, a user places his or her lips on the electronic device and kisses the interface. The signals resulting from the kiss may be stored remotely for another user or users to obtain. For example, a movie star may make a kiss available for a plurality of fans to receive on their own electronic devices.

In another example, signals may be received at the electronic device **100** from a plurality of remote electronic devices and the signals may be combined, modified, averaged, or any combination thereof. Referring to the example of the movie star making a kiss available for a plurality of fans, the fans, in return, may make a kiss available for the movie star. Thus, a plurality of touches may be, for example, averaged to provide a combined response. Alternatively, a single, representative response, which may be from a single user, may be provided, where that response falls within a predetermined range of feedback.

According to another example, the electronic device **100** may be utilized by moving the user interface and applying forces to a user to simulate interaction with a virtual person or object.

A simplified block diagram of another example of an electronic device **100** for touch translation is shown in FIG. **5**. In the example shown and described in FIG. **1**, the electronic device **100** is utilized in conjunction with a communication device, such as a smartphone, tablet computer, or laptop computer, in order to communicate over a network with a remote electronic device. In the example shown in FIG. **5**, the electronic device **500** may be utilized without connecting to a second device. Thus, the electronic device **500** in this example is operable to communicate over a network without the use another communication device.

Many of the elements or components referred to in FIG. **5** are similar to the elements or components in FIG. **1**. For simplicity and clarity of illustration, the reference numerals are raised by 400 to indicate corresponding or analogous elements.

The electronic device **500** includes multiple components, such as a main processor **502** that controls the overall operation of the electronic device **100**. As indicated, the electronic device **500** is operable to communicate, over a network, with a remote electronic device. The electronic device **500** in this example, may be any suitable size, depending on the application or intended use.

The main processor **502** interacts with other components of the electronic device **500**, including, for example, a temporary storage device **504**, a memory **506**, an auxiliary input/output (I/O) subsystem **508**, a communication subsystem **510**, a power source **512**, and, optionally, other subsystems **514**. Additionally, the main processor **502** interacts with a controller **516** that is coupled to actuators **518** that are utilized to control movement of the pins about connections or couplings within the pins.

The functions of many of the components are similar to those described with reference to FIG. **1** and are therefore not described in detail again herein.

In the present example, communication functions are performed through the communication subsystem **110**. Data received by the electronic device **100** is decompressed and decrypted by a decoder **522**. The communication subsystem **510** receives signals from and sends messages to a network (not shown).

The main processor **502** may also interact with other components such as a speaker **524**, a microphone **526**, a display **528**, one or more cameras **530**, and short-range communications **532**.

The speaker **524** outputs audible information converted from electrical signals, and the microphone **526** converts audible information into electrical signals for processing. The display **528** may be any suitable display or displays for displaying information, for example, on the pins. The display **528** may project an image or may be embedded in the pins or on heads that are disposed on the pins in order to display information, such as images, on the pins.

The camera or cameras **530** are utilized to obtain images or video of the user of the electronic device **500**. Optionally, the cameras **530** may be utilized to obtain images or video of the user's surroundings as well. Each of the cameras includes the functional components for operation of the camera, including the lens, the image sensor, and, optionally, a light sensor and light source, such as infrared light emitting diodes (LEDs). The cameras may be one or more of visual light cameras, 3D sensing cameras, light field cameras, forward looking infrared cameras, near infrared cameras, ultraviolet cameras, or other imaging devices.

The short-range communications **532** may be utilized to perform various communication functions. For example, the short-range communications **532** may include Bluetooth or infrared (IR) communications capability for communicating with another electronic device, a peripheral device, or accessory.

Referring to FIG. **6**, a system for touch translation including the electronic device **500** is shown. In this example, the electronic device **500** communicates with a similar electronic device **600** that is located remotely from the electronic device **500** by sending signals to the remotely located electronic device **600** via the network **250**. The electronic device **500** also receives signals from the remotely located electronic device **600** via the network **250**. Thus, no communication device is utilized in the present example of the electronic device **500** for communication via the network **250**. The electronic device **500** is operable to communicate directly over the network **250**.

Thus, the electronic device **500** is operable to communicate with the remote electronic device **600**. When a communication session begins, signals are transmitted from the electronic device **500** to the remote electronic device **600** in response to detecting an externally applied force on the pins of the electronic device **500**. The signals are sent to the remote electronic device **600** to control the actuators and thereby control the movement of pins and forces applied by the pins at the remote electronic device **600**. In response to receipt of signals at the electronic device **500**, from the remote electronic device **600**, the actuators are controlled to control movement of the pins of the electronic device **500** and forces applied by the pins of the electronic device **500** on an external object, such as a user's hand, finger, thumb, face, appendage, or other items, held by a user applying force to the pins. Thus, a force applied by a user on the electronic device **500** is determined, movement of the pins of the remote electronic device **600** is controlled, and a resulting force is applied by the remote electronic device **600**. Similarly, a force applied by a remote user on the remote electronic device **600** is determined and a resulting force is applied by the pins of the electronic device **500**. The operation of the electronic device **500** may be similar to the operation of the electronic device **100** and thus, the operation is not further described herein.

The method described above and shown in FIG. **4** is also applicable to the electronic device shown in FIG. **5**. The method may be carried out by software executed, for example, by the main processor **502** of the electronic device **500**. Details of the method shown in FIG. **4** and described above are also applicable to the electronic device **500** and are therefore not described again herein.

As with the electronic device **100**, the pins of the electronic device **500** include couplings to facilitate movement of portions of the pins and to facilitate application of a force to an object touching the pins. In addition, the pins are controlled to form a shape, such as a projection, that generally follows the contours and surface profile of an object touching the interface of the remote device **600** that is in communication with the electronic device **500**. Utilizing the movement of the pins and force application, the electronic device **500**, in cooperation with a remote electronic device **600**, simulates touch between two people that are each utilizing a respective one of the electronic devices. Utilizing such electronic devices **500**, touch contact is simulated to give the users the perception of touch.

The force that is applied by the electronic device **500** on the user or the force that is applied by the remote electronic device **600** on the remote user is controlled such that only forces that are within a predetermined range are transmitted. For example, signals that result from forces that are deemed to be outside of a safe range, for example, that may result in blunt trauma or sharp forces that may cause injury are not transmitted or are not utilized by the receiving electronic device. Alternatively, such forces may be altered, for example to reduce the speed of the force, reduce the sharpness, reduce the magnitude, or any suitable combination of these alterations in force.

One or both the remote electronic device **600** and the local electronic device **500** may compare the force or value representative of the force to a threshold limit to determine whether the force is within predetermined safety limits. This method may be carried out, for example in the method shown and described above with reference to FIG. **4**. Thus, the method is carried out by software executed, for example, by the main processor **502** of the electronic device **500**. Coding of software for carrying out such a method is within the scope of a person of ordinary skill in the art given the present description. Additional or fewer processes may also be performed and computer-readable code executable by the processor **502** to perform the method may be stored in memory **506**.

Thus, as part of the process, for example, at **404** of FIG. **4**, the processor **502** of the electronic device **500** may compare the force or a value representative of the force to a threshold limit stored in memory **506**. In response to determining that the force or value meets or exceeds the threshold limit, the processor **502** of the electronic device **500** does not transmit the associated signals to the remote electronic device **600** such that the force is not applied to user of the remote electronic device **600**. On the other hand, in response to determining that the force or value is less than the threshold limit stored in memory **506**, the signals are transmitted and the force is applied to the user of the remote electronic device **600**.

In addition, as part of the process, for example, at **408** of FIG. **4**, the electronic device **500** may compare signals received from the remote electronic device **600** to predetermined values prior to actuating actuators to apply forces, by the local electronic device **500**, to the user. In response to determining that the force or value meets or exceeds the threshold limit, the processor **502** of the electronic device **500** does not actuate the actuators such that the force is not applied to user of the local electronic device **500**. On the other hand, in response to determining that the force or value is less than the threshold limit stored in memory **506**, the force is applied to the user of the remote electronic device **600**.

The size or shape, such as the width across which the force is applied may also be utilized such that forces from very sharp objects are not transmitted to the user. For example, the threshold limit may vary depending on the dimensions, such as width, across which the force is applied to the pins of the electronic device **500**. Thus, for example, the electronic device **500** may maintain a lookup table in memory **506** and the threshold limit that is utilized for the comparison is identified from the lookup table and is dependent on dimensions including length and width of the applied force.

Optionally, the output may be scaled relative to the input such that, for example, inputs provided by a baby or a person with neuromuscular damage, which are by nature relatively weak, are amplified by some factor. Such scaling is also useful where one of the users desires touch that is stronger or weaker than the other user normally provides.

A perspective view of another example of an electronic device is shown in FIG. **7**. Although the electronic device **500** described with reference to FIG. **5** is referred to in the present description with reference to FIG. **7**, the present description is equally applicable to the electronic device **100** described herein with reference to FIG. **1**.

The electronic device **500** includes a body **702** in which the components illustrated in FIG. **1** are disposed. The body **702** may be rigid. Alternatively, the body **702** may be flexible while still providing protection for the components therein. The plurality of pins **704** extend generally away from the body **702**. In the present example, the pins **704** each include a plurality of couplings **706**, which are articulating joints. The couplings **706** in each pin **704** may include more than one type of articulating joint to facilitate various types of movements of portions of the pins **704**. Although three joints **706** are illustrated in the Example of FIG. **7**, fewer or more joints may be utilized to facilitate movement of the portions of the pins **704**. The articulating joints may include, for example, hinge joints, prismatic or sliding joints, revolute joints, or any suitable combination of joints or other couplings. The couplings together provide a linkage to facilitate movement in more than one axis. Thus, the portions of the pins **704** are coupled together about couplings to facilitate movement in all directions, as shown in FIG. 7B. In addition, all or a subset of the pins **704** may be coupled to the body **702** utilizing a coupling, for example, to facilitate gliding movement of the pins **704** relative to the body **702**.

Movement of the pins **704** about the couplings **706** may be controlled by wires **708**, for example, that couple portions of the pins **704** to the body **702** or to other portions of the pins **704**, as illustrated in FIG. 7C. The wires **708** may be controlled by actuation of the actuators **518**. For example, the wires may be pulled when actuators **518** of the electronic device **500** are actuated to move the heads **714** on the pins **704** about a coupling. Optionally, some or all of the pins **704** may be disposed on rollers **712** on the body **714** to facilitate movement of the pins **704** relative to the body **714**, as shown in FIGS. 7A and 7D.

The pins **704** are movable along the body **702** in a sliding or gliding motion, movable, toward and away from the body **702**. Different portions of the pins **704** are also moveable relative to the body **702** to facilitate movement of the pins **704** in other directions. Movement of the pins **704** and any force applied by a pin **704** on an external object that is in contact with a head **714** on the pin **704**, is controlled by multiple actuators that cooperate to control movement and force applied by the pin **704**. Thus, the heads **714** on the pins **704** are movable in three dimensions facilitating flexion, extension, rotation, adduction, abduction, or any combination thereof, of the pins **704**.

In this example, heads **714** are mounted on the ends of the pins **704**. The heads **714** are geometrically shaped to include a plurality of facets **716** and are coupled to the pins **704** to facilitate rolling of the heads **714** relative to the pins **704** to select which of the facets **716** is exposed or directed outwardly. Thus, the head **714** may be rolled to expose any one of, for example, four facets **716** depending on the application. Each facet **716** may have different material properties to provide different sensations to the touch, as illustrated in FIG. 7E and FIG. 7F. For example, the four facets **716** may include one facet covered by a material such as latex or CyberSkin®, a second facet covered with very fine wisps of hair or hair-like material on a silicone or material base, a third facet covered by a more dense coat of hair; and a fourth facet covered by a cloth material. Thus, depending on which of the facets **716** is exposed at the end of each of the pins **704**, the heads **714** are utilized to simulate the feel of different surfaces or textures.

As in the embodiment described herein with reference to FIG. **3**, a plurality of the pins **704** extend from the body **702**, in a dense array of pins **704** that are, individually actuatable and each individual actuator within the pins is actuatable. In addition to being actuatable, the pins are depressible or flexed by an externally applied force. Such an externally applied force is detected utilizing the force sensors **520**. The force sensors **520** are disposed on the pins **704** to detect externally applied static or dynamic forces including, for example, compressive force, frictional force, tensile force, torsion, and any combination of such forces.

The pins **704** are small relative to a human finger, thumb, hand, appendage, or face and are disposed in a dense array on the body **702** such that an external force exerted, for example, by a human finger, is exerted on a plurality of the pins **704**. Thus, force may be applied to tens of pins **704**, hundreds of pins **704**, or more, by a user's finger pressing on the electronic device **500**. As a result of the relatively high number and density of pins **704**, such a force is applied on the pins **704**, which together generally follow the contour and surface profile of the object that applied the force to the pins **304**.

Because, the pins **704** are moveable in multiple axes in response to an externally applied force or in response to signals received via the communication subsystem **510**, for example, and are operable to apply force in multiple directions against an external object, more complex touch interaction in which forces are applied in more than one direction or plane may be simulated. In addition, further contours and movement of the object that applied the force to the pins **304** may be formed in a similar, remote electronic device in communication with the local electronic device **500**.

According to one example, an electronic device **500** may be held up to the throat of a user while a doctor manipulates a remote device that the doctor is using to simulate the feel of the glands of the user of the electronic device **500**. Thus, the doctor manipulates the pins on the remote device such that the pins **704** apply a light force against the glands of the user. The size and contours of the glands may be determined by the doctor based on the reaction forces on the pins **704**, which are utilized at the remote device to simulate the throat, which is the object to which the force is applied and that is applying the reaction forces against the pins **704**. With sufficient sensitivity, a doctor can also detect the pulse as the pulse is simulated at the remote device.

Alternatively, the electronic device **500** may be utilized to simulate a physical handshake between remotely located users, hand holding, cheek touching, and any other suitable touch interaction.

In addition, with movement of the heads **714** relative to the body **702**, for example, in a sliding or gliding motion, a rubbing or friction force may be simulated. To facilitate simulation of rubbing or friction, the electronic device **500** may optionally introduce noise into signals sent to a remote electronic device or received from the remote electronic device such that the movement of the heads **714** relative to the user is not smooth.

Referring again to FIG. **6**, when an external force is applied to the pins **704**, sufficient to cause flexion or movement of the pins **704** relative to the body **702**, signals are transmitted to the remote electronic device **600** which is in communication with the electronic device **500**. When no external force is applied to pins at the remote electronic device **600**, the pins at the remote electronic device **600** that correspond to the pins **704** to which the force is applied at the electronic device **500**, are moved. The corresponding pins are moved by moving the heads on the pins in an opposite direction relative to the body.

Thus, the heads **714** on the pins **704** are moved in a direction relative to the body **702** at the electronic device **500**, for example, providing a depression in the surface that generally follows the contour and profile of the object, such as a finger, that applied the force to the pins **704**. At the remote electronic device **600**, the heads on the corresponding pins are moved in an opposite direction relative to the body, for example, forming a projection that generally follows the contour and profile of the object that applied the force to the pins **704**. The projection formed at the remote electronic device **600** is formed by the heads on the pins, giving the general appearance of the object that applied the force to the heads **714** on the pins **704** at the electronic device **500**.

Thus, the shape formed by the movement of the heads **714** on the pins **704** relative to the body **702** when an external force is applied to the heads **714** at the electronic device **500**, is the inverse of the shape formed by the movement of the heads on the pins at the remote electronic device **600**. For example, a user pressing down with a hand on the heads **714** on the pins **704** presses with the palm toward the body **702** of the electronic device **500**. For the remote electronic device **600** in communication with the electronic device **500**, the shape that is formed follows the contours of the hand, with the palm of the hand facing away from the body of the remote electronic device **600**.

When external forces are applied to the heads **714** on the pins **704** at the electronic device **500**, and external forces are applied to heads on corresponding pins at the remote electronic device **600**, the heads on the corresponding pins at the remote electronic device **600** apply forces to the external object applying the forces at the remote electronic device **600**. Similarly, the heads **714** on the pins **704** at the electronic device **500** apply forces on the object applying the external force at the electronic device **500**. The forces applied by the pins at the remote electronic device **600** to the external object generally correspond in magnitude and direction to the external forces applied to the heads **714** on the pins **704** at the electronic device **500**. The forces applied by the heads **714** on the pins **704** to the external object at the electronic device **500** generally correspond in magnitude and direction to the external forces applied to the heads on the pins at the remote electronic device **600**.

Utilizing the movement of the heads **714** on the pins **704** and force application, the electronic device **500**, in cooperation with a remote electronic device **600**, simulates touch between two people that are each utilizing a respective one of the electronic devices. Utilizing such electronic devices **500**, touch contact is simulated to give the users the perception of touch.

As described above, software may be utilized to smooth out actions and reactions to generally maintain the simulation of touch and facilitate perception of touch by each user to compensate, at least in part, for latency introduced from various sources.

In addition to simulating touch, the heads **714** may optionally be utilized to emit audio. For example, the heads **714** may be moved together to collectively emit audio, similar to a speaker.

The heads **714** may optionally be operable to be heated or cooled or both heated and cooled, for example utilizing a heating or warming fluid within the pins **704**. Alternatively, a heating filament may be disposed within or around each head **714** or pin **704**. Utilizing a heating element or fluid, the heads **714** may be heated, for example to about the skin temperature of the sender. In addition, a thermocouple may be included in the pins **704** or in the heads **714** to measure the temperature of the pins **704** or the heads **714**.

In addition to detecting forces and to simulating forces or objects applied to a remote electronic device, the heads **714** on the pins **704** or the flexible, elastic membrane may be utilized to detect touches. For example, a patterned layer or layers of indium tin oxide may be deposited on the surface of the heads or on the surface of the elastic membrane for detecting touches thereon. For example, sensors may be disposed on or near the outer surface of the electronic device **500** for mutual-capacitance touch sensing.

Capacitive touch sensors may be used independently or in conjunction with other sensors to obtain input, for example to identify external contact with the device. For example, capacitive touch sensors may be used to distinguish between input that is a result of contact with skin, which is sensed utilizing capacitive sensors, or with a non-conductive object, which is not sensed utilizing capacitive sensors. The signals provided to the remote electronic device **600** may include such information to alter the tactile sensations provided to the user of the remote device **600**. For example, in response to determining that the input is a result of contact with the skin, signals are sent to cause heating of the interface to simulate skin contact. In response to determining that the input is not a result of skin contact, the signals sent to the remote electronic device **600** do not result in heating of the interface. The recipient at the remote electronic device **600** may alter the touch interaction to scale the simulated contact, for example amplifying or reducing the force, to change the temperature, or to make any other suitable modification.

In another aspect, sensors, including capacitive touch sensors or proximity sensors may be utilized to modify, turn on, or turn off data transmission, reception, or implementation. For example, the electronic device **500** may be utilized to transmit signals to the remote electronic device **600** when the electronic device **500** is not being held up to the ear of the user. The electronic device may also modify the touch data or discontinue sending signals that result from the user holding the electronic device **500** being held up to the user's ear, such as for voice communication.

Referring to FIG. **7**A, pores **718** in the body **702** are distributed generally evenly across the surface of the body **702**, between the pins **714**. Alternatively, pores may be concentrated in specific areas. The speaker **524** shown in FIG. **5** may be located in the body **702** to output audible information through the pores **718** and thus, at least some of the pores **718** are utilized as audio channels. Similarly, the microphone may be located in the body **702** to receive audible information through the pores.

The pores **718** shown in FIG. **7**A are pores in the surface of the body **702**. Alternatively, pins that include the pores may extend from the body **702**. In the example in which the pores are included in the pins, the pins that include the pores do not include heads **714**. For example, the pins may extend in between four heads **714** such that the pore is disposed between the four heads **714**. Such pores may be utilized as audio channels. Alternatively, the pins that do not include heads **714** may be utilized as fluid conduits to express gas or liquid therefrom. The gas or liquid may be disposed in one or more reservoirs disposed in the body **702** and expressed via one or more of the pins that do not include heads **714**.

Optionally, pores **720** may be disposed in some of the heads **714**, as illustrated in FIG. **7**G. Some of the pores **718** are utilized to expel fluid, such as water, or to expel gas, such as air or to create suction. Thus, these pores **718** may be in communication with a reservoir, for example, to expel gas or liquid therefrom or in communication with a vessel to create a pressure difference to cause suction through the pores. Multiple pores may be disposed in each head **714** of at least some of the heads **714** to carry out various functions simultaneously.

In the example described above with reference to FIG. **7**, a head **714** is disposed on each pin **704**. Rather than pores **718** disposed in the body **702** of the electronic device **500**, the pores may be disposed in the head **714** on the pins **704**. Optionally, the pins **704** may have a hollow section or fluid conduit **722** in communication with a reservoir **724** for the passage of fluid through at least part of the pins **704** and through pores in the head **714**.

Such pores may also be utilized for cleaning. For example, a cleaning fluid may, optionally be loaded into the device and expelled through the pores for cleaning the heads **714** on the pins **704** and the body **702**. In this example, the pins **704** may move such that the heads **714** move relative to the body **702** in more than one direction to distribute the cleaning fluid across the electronic device and for self-cleaning.

According to another example embodiment, the pins **704** are covered by a flexible, elastic membrane **812** such as a latex, flexible PVC, CyberSkin® or a combination of flexible, elastic materials, as illustrated in FIG. **8**A and FIG. **8**B. In this example, the elastic membrane may include the pores

820 in communication with one or more hollow passages 822 or fluid conduits in the pins 704. The hollow passages 822 may be in fluid communication with one or more reservoirs, such as a liquid reservoir 824 and a gas reservoir 826.

Alternatively, the flexible elastic membrane may be coupled to the pins 704 and fluid may be pumped into areas in the flexible elastic membrane or a reservoir below the flexible elastic membrane to inflate the flexible elastic membrane, for example, to fill in areas between pins. The fluid may be warmed or cooled such that the fluid provides heat or is cool to the touch for improved simulation of touch.

Utilizing such pores 820, air or gas may be expelled, for example, to simulate blowing of air, and air may be sucked inwardly to create suction, for example, to simulate a kiss when a user at a remote device has his or her lips on the remote electronic device. The pores may also be utilized to detect when a person blows air onto the electronic device 500, by detecting changes in air pressure, sound, or both air pressure and sound, and pores at the remote electronic device may be utilized to expel air. The pores may also be utilized for the passage of sound, or light. Optionally, fine hair or hair-like material may be moved through the pores to simulate fine wisps of hair on human skin, for example.

As indicated, the pores may also be utilized for cleaning. The cleaning fluid may be expelled through the pores for cleaning the elastic membrane 812. The pins 704 may move relative to the body 702 to distribute the cleaning fluid across the membrane. Alternatively or in addition, the elastic membrane 812, may be wiped clean by the user.

In the above-described embodiments, the pins 704 are generally evenly distributed in an array across the body 702 and extend from the body 702. The pins 704 may be different sizes and may include different articulating joints or other couplings. For example, the pins 704 may be disposed on the body 702 such that the heads 714 of the pins 704 are disposed in different layers relative to the body 702. The pins 704 may be offset from each other but are disposed at different distances from the body. Thus, a pin may extend a greater distance from the body 702 than an adjacent pin. In one example, three layers of pins may be disposed on the body 702. The use of different layers of pins facilitates movement at greater depths, for example, for simulating a handshake or a hug. The stacked heads 714 also facilitate movement of the heads to cause a change in volume, for example, as heads move around from a stacked position to project outwardly, laterally or otherwise. The heads 714 on the pins may also be generally stacked on each other on the body 702.

As indicated above, the heads 714 may include displays 528 embedded therein or disposed thereon to display an image or images on the heads 714 on the pins 704. Images may be displayed on sides of the heads 714 as well as a top. When the pins are stacked, the images on the tops of the heads 714 and on the sides of the heads 714 provide depth to the image. The heads 714 or portions of the heads 714 may also be transparent such that an image or images are displayable through the heads 714. Each head 714 may include a single pixel or a plurality of pixels, similar to pixels of a liquid crystal display (LCD), for example. Together, the pixels on the heads 714 are utilized to display information, such as an image. Thus, the controller 516 and the main processor 502 may be utilized to identify the location of each of the heads 714 and to coordinate the color and brightness of the pixels of the heads 714 to provide the image.

Alternatively, a flexible display may be utilized on the pins such that the pins cause movement and flexing of the display. In this example, the display is disposed on the pins and is operable to display information such as images.

Alternatively, the heads 714 may be a set color. Rather than displays incorporated into the pins 704 or heads 714, images may be projected onto the heads 714. Images may also be displayed on the sides of the pins, to the extent that the sides of the pins are exposed. In this case, the pins themselves include displays embedded therein or disposed thereon. Alternatively, images may be projected onto the pins.

The pins may include optical fibers or similar elements that transmit visual data through the pins. Such fiber optic or similar elements may be utilized in conjunction with pin positioning to provide image depth.

Optionally, the cameras 530 may be utilized to obtain images or video of the user's surroundings as well. Each of the cameras includes the functional components for operation of the camera. Video or images from multiple cameras may be combined by programmatically stitching together the video or images.

The cameras 530 may be utilized to obtain images of video of the user and part of the user at which contact occurs. The images or video may be provided generally in real time or near real time.

Additionally, the pins 704 are movable relative to the body 702. The pins 704 are movable along the body 702 in a sliding or gliding motion, and movable toward and away from the body 702. Different portions of the pins 704 are also moveable relative to the body 702 to facilitate movement of the pins 704 in other directions. The pins 704 may be moved closer together or farther apart on the body 702. For example, the heads 714 on the pins or ends of the pins may be moved closer together by the various actuators controlling the couplings.

Optionally, the pins 704 may be grouped such that groups of the pins 704 may move together relative to the body 702. For example, the groups of pins 704 may be coupled to an intermediate seat or base that is coupled to the body 702. Sets or clusters of pins may swivel or pivot together on the base, relative to the body 702, about a point or axis. Sets or clusters of pins may also move together with the base, away from the body 702 or toward the body 702.

The movement pins 704 is controlled programmatically to facilitate the movement of individual pins 704 together as a group and to control the movement of sets of pins 704 together. Thus, for example, when a set of pins 704 move together on a base, relative to the body, other pins may move to accommodate the movement of the set of pins, such that the movement of pins 704 does not interfere with movement of other pins 704.

The movement of groups of pins together also facilitates the simulation of more complex touch interactions in which forces are applied in more than one direction or plane, by comparison to the simulation of a surface or applied force in one direction.

When grouped together, the pins, along with the base on which the pins are disposed, may be removed and loaded on the body, for example, similar to the loading of a cartridge. Thus, pins that are worn or not working may be replaced by replacing a cartridge that includes a plurality of the pins.

Alternatively, the heads of the pins may be replaceable, for example, in the circumstance in which the heads wear out faster than the pins. The heads may be detachable or decouplable and the pins and heads programmatically controlled such that the heads are decoupled from the pins and new, replacement heads are coupled to the pins. For example, the pins may extend into a cartridge that includes replacement heads, where a replacement head is attached, and the pins are then retracted.

In addition, cartridges of pins may be selected based on the material or materials on the heads on the pins. For example, a cartridge may be selected to simulate a surface of a hand or to simulate clothing. Thus, rather than having different facets on the heads on the pins, cartridges of pins may be selected to simulate different surfaces.

The body may be any suitable size. As indicated above, the electronic device may be incorporated into a case for a smart phone. The body may also be much larger. For example, the body may be incorporated into a case or a part of a tablet computer. The body may be the size of a desk, small or large, or may be the size of a mattress. Two electronic devices in communication with each other may also be different sizes.

In the example of FIG. **6**, the electronic device **500** may be the size of a desk. The remote electronic device **600**, however, may be incorporated into a case for a smart phone. The electronic device may be configured to compensate for differences in size of the electronic device, for example, to fill in parts of an object for which signals or information is not transmitted.

A flowchart illustrating a method of controlling an electronic device, such as the electronic device **500** is shown in FIG. **9**. The method may be carried out by software executed, for example, by the main processor **102** of the electronic device **100**. Coding of software for carrying out such a method is within the scope of a person of ordinary skill in the art given the present description. The method may contain additional or fewer processes than shown or described, and may be performed in a different order. Computer-readable code executable by at least one processor to perform the method may be stored in a computer-readable medium, such as a non-transitory computer-readable medium.

The method is carried out during a communication session with a remote electronic device, for example, at **410** or between **408** and **410** in the method of FIG. **4**. The signals are received at the local electronic device **500**, from the remote electronic device **600**, in response to externally applied forces that are detected at the remote electronic device **600**.

Based on the signals received, the object is identified **902**. For example, the signals received may be signals from fingers touching the remote electronic device. In this example, the electronic device **500** determines that the fingers extend to the edges of the interface and are part of a hand.

The electronic device **500** identifies, at **904**, a matching file stored in memory based on the identification of the object at **902**. The matching file includes information for providing signals to actuators **518** to simulate the fingers and hand of the user of the remote electronic device **600**. For example, the electronic device **500** may identify a specific user's hand based on identifying features including the shape and contours of the fingers. Alternatively, the electronic device **500** may identify a suitable hand by size and shape to go with the fingers identified at **902**.

In addition to actuating the actuators to simulate the portions of the object that touched the interface at the remote electronic device **600**, actuators **518** are actuated to simulate the missing parts of the object utilizing the file identified at **904**. Thus, in the example of the fingers touching the remote electronic device **600**, in addition to actuating the actuators **518** to simulate the fingers at the electronic device **500**, actuators **518** are actuated to control movement and forces applied by pins to simulate the hand.

Thus, the electronic device **500** is operable to add or fill in parts of objects. This method is particularly useful in the example in which the sizes of the electronic devices differ.

As indicated above, the body may be any suitable size. In addition, the body may take any suitable shape. For example, the body may envelop the user. Such a configuration is useful, for example, for simulating a hug or for virtual-reality applications. Other shapes may also be desirable, including a mattress, a chair, or other shape.

Signals sent to the remote electronic device **600** as a result of touch interaction with the electronic device **500** may also be scaled based on the size of each electronic device **500** and the remote electronic device **600**. For example, signals resulting from touch contact may alter the area of touch contact at the remote electronic device **600**. A ratio may be set automatically based on device sizes. For example, an 8" electronic device in communication with a 4" remote electronic device, may scale touch contact or movements or both by a factor of 2. Alternatively, scaling may be manually entered or may be determined based on predetermined rules. Alternatively, a smaller area of the electronic device **500** may be utilized such that the area of the interface of the electronic device **500** that is utilized is equivalent to the area of the interface of the remote electronic device **600**.

Optionally, sensors, such as an accelerometer or other suitable sensors, may be utilized detect movement of the electronic device, for example, when the entire electronic device **500** is being moved, for example, while a user is holding the device in a hand or hands. The electronic device **500** may also determine that no active movement is detected, for example, when the electronic device **500** is set down on a table and is stationary for a threshold period of time. A threshold force may be utilized to determine whether or not to send signals to the remote electronic device **600**. Different thresholds may be utilized to determine whether or not to transmit signals resulting from touch interaction depending on whether the electronic device **500** detects movement of the entire device or detects that the device is stationary. For example, an electronic device **500** that is stationary for 10 seconds, may utilize a higher threshold than when the electronic device **500** detects active movement, such that a greater force is required to cause the electronic device **500** to send signals to cause the remote electronic device **600** to apply a force.

Another example of an electronic device is shown in FIG. **10**. In this example, a flexible elastic membrane **1012** is coupled to pins **1004**. The pins **1004** each include a fluid conduit **1020** that extends through the pin to a reservoir **1022** in the body **1002**. The fluid conduit **1020** is utilized for fluid communication between the reservoir **1022** and a respective pocket **1024** between layers of the flexible elastic membrane **1012**. The flexible elastic membrane includes a plurality of pockets **1024** for receiving fluid from the reservoir **1022**. The fluid may be a gas or a liquid or both gas and liquid. Thus, fluid may be pumped into the pockets **1024** to inflate the flexible elastic membrane **1012**. In this example, the pins **1004** are coupled to the flexible elastic membrane **1012** and the flexible elastic membrane **1012** is moved by increasing or decreasing the fluid in the pockets **1024**, thereby expanding or collapsing the pockets **1024**. When a pocket expands as fluid is pumped into the pocket, the outer surface of the flexible elastic membrane **1012** is moved outwardly, away from the body **1002**. When a pocket collapses, the outer surface of the flexible elastic membrane **1012** is moved inwardly, toward the body **1002**. Thus, the outer surface of the flexible elastic membrane **1012** is moveable relative to the body **1002**.

Actuators **1018** control fluid movement from the reservoir **1022** to the pockets **1024**. The actuators **1018** are utilized to cause the fluid to flow along the respective pins **1004** and thereby cause movement of the outer surface of the flexible elastic membrane **1012** relative to the body **1002**. Thus, each actuator is individually controllable to control the movement of parts of the outer surface of the flexible elastic membrane **1012**. The movement of the flexible elastic membrane **1012** is controlled to simulate touch contact. The fluid may be warmed or cooled, utilizing a heating element or a cooling fluid disposed in the area **1026** around the fluid conduit **1020** such that the fluid provides heat or is cool to the touch for improved simulation of touch.

Force sensors are also associated with the flexible elastic membrane **1012**, for example, to detect external forces applied to the flexible elastic membrane **1012**.

The method shown in FIG. **4** and described herein is also applicable to the electronic device shown in FIG. **10**. The method may be carried out by software executed, for example, by a main processor (not shown) of the electronic device. Details of the method shown in FIG. **4** and described above are also applicable to the electronic device **500** and are therefore not described again herein.

Thus, during a communication session, externally applied forces on the interface of the local electronic device **1000** are detected and, in response, signals are transmitted to the remote electronic device. Signals are also received at the local electronic device **1000** in response to externally applied forces that are detected at the remote electronic device.

In response to receipt of signals at the local electronic device at **408**, the actuators **1018** are actuated at **410** to control movement of portions of the flexible elastic membrane **1012** to thereby control movement and forces applied by the flexible elastic membrane **1012**.

Because the flexible elastic membrane **1012** is movable toward and away from the body **302**, the flexible elastic membrane **1012** is operable to apply a force to an object touching the flexible elastic membrane **1012**. In addition, the flow of fluid into the pockets **1024** is controlled to form a shape, such as a projection, that generally follows the contours and surface profile of an object touching the interface of a remote device that is in communication with the electronic device **1000**. Utilizing the movement of the flexible elastic membrane **1012** and force application, the electronic device **1000**, in cooperation with a remote electronic device, simulates touch between two people that are each utilizing a respective one of the electronic devices.

Yet another example of an electronic device is shown in FIG. **11**. In this example, a flexible elastic membrane **1112** is coupled to the body **1102**. The flexible elastic membrane **1112** includes a plurality of pockets **1124** for receiving fluid therein. Fluid conduits **1120** extend through an upper surface of the body **1102** to a reservoir **1122** in the body **1102**. The fluid conduits **1120** are utilized for fluid communication between the reservoir **1122** and respective pockets **1124** between layers of the flexible elastic membrane **1112**. The fluid may be a gas or a liquid or both gas and liquid. Thus, fluid may be pumped into the pockets **1124** to inflate the flexible elastic membrane **1112**. The flexible elastic membrane **1112** is moved by increasing or decreasing the fluid in the pockets **1124**, thereby expanding or collapsing the pockets **1124**. When a pocket expands as fluid is pumped into the pocket, the outer surface of the flexible elastic membrane **1112** is moved outwardly, away from the body **1102**. When a pocket collapses, the outer surface of the flexible elastic membrane **1112** is moved inwardly, toward the body **1102**. Thus, the outer surface of the flexible elastic membrane **1112** is moveable relative to the body **1102**.

A controller controls fluid movement from the reservoir **1122** to the pockets **1124** and from the pockets **1124** to the reservoir **1122**. The controller is utilized, in conjunction with valves, to cause the fluid to flow through the fluid conduits **1020**, which include apertures in a surface of the body **1102** and thereby cause movement of the outer surface of the flexible elastic membrane **1112** relative to the body **1102**. Thus, the controller, which may include valves, for example, controls the movement of parts of the outer surface of the flexible elastic membrane **1112**. The movement of the flexible elastic membrane **1112** is controlled to simulate touch contact. The fluid may be warmed or cooled such that the fluid provides heat or is cool to the touch for improved simulation of touch.

Force sensors are also associated with the flexible elastic membrane **1112**, for example, to detect external forces applied to the flexible elastic membrane **1112**.

The method shown in FIG. **4** and described herein is also applicable to the electronic device shown in FIG. **11**. The method may be carried out by software executed, for example, by a main processor (not shown) of the electronic device. Details of the method shown in FIG. **4** and described above are also applicable to the electronic device **500** and are therefore not described again herein.

Thus, during a communication session, externally applied forces on the interface of the local electronic device **1100** are detected and, in response, signals are transmitted to the remote electronic device. Signals are also received at the local electronic device **1100** in response to externally applied forces that are detected at the remote electronic device.

In response to receipt of signals at the local electronic device at **408**, the controller controls movement of portions of the flexible elastic membrane **1112** to thereby control movement and forces applied by the flexible elastic membrane **1112**.

Because the flexible elastic membrane **1112** is movable toward and away from the body **1102**, the flexible elastic membrane **1112** is operable to apply a force to an object touching the flexible elastic membrane **1112**. In addition, the flow of fluid into the pockets **1124** is controlled to form a shape, such as a projection, that generally follows the contours and surface profile of an object touching the interface of a remote device that is in communication with the electronic device **1100**. Utilizing the movement of the flexible elastic membrane **1112** and force application, the electronic device **1100**, in cooperation with a remote electronic device, simulates touch between two people that are each utilizing a respective one of the electronic devices.

Referring to FIG. **12** and as indicated above, pins **1204** may be disposed on a body **1202** such that the heads **1214** of the pins **1204** are disposed in different layers relative to the body **1202**. Thus, the heads **1214** on the pins are generally stacked on the body **1202**. Stacking of heads **1214** facilitates detection of forces and movement at greater depths, for example, for simulating a handshake or a hug. The stacked heads **1214** also facilitate movement of the heads to cause a change in volume, for example, as heads move around from a stacked position to project outwardly, laterally or otherwise. Images may be displayed on sides of the heads **1214** as well as a top. When the pins are stacked, the images on the tops of the heads **1214** and on the sides of the heads **1214** provide depth to the image.

The pins **1204** are grouped such that groups of the pins **1204** move together relative to the body **1202**. For example, outer groups of pins **1230** are disposed on intermediate groups of pins **1232**, which are disposed on inner groups of pins **1234**. In this example, the pins **1204** of the outer groups of pins **1230** are smaller than the pins **1204** of the intermediate groups of pins **1232** and the pins **1204** of the intermediate groups of pins **1232** are smaller than the pins **1204** of the inner groups of pins **1232**. Thus, a plurality of pins of an outer group of pins **120** is disposed on one of the intermediate pins **1232**. Similarly, a plurality of pins of an intermediate group of pins is disposed on one of the inner pins **1234**.

Movement of one of the inner groups of pins **1234** results in movement of the associated intermediate groups of pins **1232** and the associated outer groups of pins **1230**. The outer groups of pins **1230**, the intermediate groups of pins **1232**, and the inner groups of pins **1234** include respective couplings or joints facilitating movement of the pins in three dimensions. Thus, the groups, also referred to as clusters of pins may swivel or pivot together relative to the body **120**. The movement of the pins **1204** is controlled programmatically to facilitate the movement of individual pins **1204** together as a group and to control the movement of groups of pins **1204** together.

The movement of groups of pins facilitates the simulation of complex touch interactions. In addition, the pins **1204** may move to form complex shapes, such as the chair **1300** illustrated in FIG. **13**.

The described embodiments are to be considered as illustrative and not restrictive. The scope of the claims should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole. All changes that come with meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed is:

1. An electronic device for touch translation, the electronic device comprising:

a body;

a plurality of pins extending from the body, the pins including couplings to facilitate movement of a first portion of the pins relative to a second portion of the pins, the pins being controllable to control the movement of the first portion relative to the second portion and to control a force applied by the pins on an external object;

a plurality of heads disposed on the pins, each head moveable about a respective coupling in more than one axis relative to a corresponding pin,

wherein each head including a plurality of facets and each facet of the plurality of facets has a different material property to provide a different tactile sensation;

sensors cooperating with the pins to detect forces externally applied to the pins;

a communication subsystem for communication, over a network, with a remote electronic device;

a controller coupled to the pins, the sensors, and the communication subsystem to:

based on detected forces externally applied to the pins, transmit a signal to the remote electronic device for the control of the remote electronic device;

receive response signals from the remote electronic device;

based on the response signals received from the remote electronic device, actuate ones of the pins to control the movement of the first portion relative to the second portion and to control the force applied by the pins on the external object.

2. The electronic device according to claim **1**, comprising actuators associated with the pins and coupled to the controller to control movement of the first portion of the pins relative to the second portion of the pins.

3. The electronic device according to claim **2**, wherein the actuators comprise at least one of linear actuators, hydraulic actuators, pneumatic actuators, or magnetic actuators.

4. The electronic device according to claim **1**, wherein the electronic device is configured to not transmit a signal from the electronic device to the remote electronic device when the detected forces exceed a threshold limit.

5. The electronic device according to claim **1**, wherein the pins extend generally linearly away from the body.

6. The electronic device according to claim **5**, wherein the second portion of the pins is coupled to the body and the first portion is coupled to the second portion and slideable linearly relative thereto.

7. The electronic device according to claim **1**, wherein ends of the pins are covered by a flexible elastic membrane.

8. The electronic device according to claim **7**, wherein the flexible elastic membrane includes a plurality of layers.

9. The electronic device according to claim **8**, wherein a first layer of the plurality of layers is coupled to ends of at least some of the plurality of pins and a second layer of the plurality of layers is coupled to the first layer.

10. The electronic device according to claim **9**, wherein a third layer of the plurality of layers comprises a replaceable outer layer coupled to the second layer.

11. The electronic device according to claim **7**, wherein the flexible elastic membrane includes a plurality of fluid-receiving pockets therein, for receiving fluid therein to inflate portions of the flexible elastic membrane.

12. The electronic device according to claim **7**, wherein the flexible elastic membrane includes pores in communication with fluid conduits that extend through the pins to expel fluid through the pores.

13. The electronic device according to claim **1**, wherein the first portions of the pins are depressible toward the body and extendable away from the body.

14. The electronic device according to claim **1**, wherein the communication subsystem is configured to communicate with a portable electronic device for sending signals to the remote electronic device via the portable electronic device and receiving response signals from the remote electronic device via the portable electronic device.

15. The electronic device according to claim **1**, wherein the communication subsystem is directly couplable to a network to send signals to the remote electronic device and to receive response signals from the remote electronic device.

16. The electronic device according to claim **1**, wherein the pins are controlled to apply the force to the external object to simulate the force applied to pins of the remote electronic device.

17. The electronic device according to claim **16**, wherein the pins are controlled to apply forces to the external object that are less than a threshold force.

18. The electronic device according to claim **17**, wherein the pins are controlled such that forces that are greater than the threshold force are not applied by the pins to the external object.

19. The electronic device according to claim **1**, wherein the signal is transmitted to the remote device in response to detecting the force externally applied to the pins, and the signal is transmitted to simulate the force at the remote electronic device.

20. The electronic device according to claim **18**, wherein in response to detecting that the force externally applied to the pins exceeds a threshold force, the signal is not transmitted to the remote device.

21. The electronic device according to claim **1**, wherein the pins comprise a third portion coupled to the body, and wherein the second portion of the pins is coupled to and moveable relative the third portion and the first portion is coupled to and movable relative to the second portion.

22. The electronic device according to claim **21**, wherein the couplings utilized to couple the first portion, the second portion, and the third portion of the pins facilitate movement of the ends of the pins in more than one axis.

23. The electronic device according to claim **21**, wherein the third portion of the pins is moveable relative to the body.

24. The electronic device according to claim **1**, wherein the pins are slidable relative to the body.

25. The electronic device according to claim **1**, wherein movement of the pins is controllable to emit audio by movement of a plurality of the pins.

26. The electronic device according to claim **1**, wherein the facets being selectively directed outwardly by the movement of the heads of the pins about the coupling to the pins.

27. The electronic device according to claim **1**, wherein the temperature of the heads is controlled by heating or cooling the heads.

28. The electronic device according to claim **1**, wherein the heads include touch sensors disposed thereon.

29. The electronic device according to claim **1**, comprising pores disposed in the heads and fluidly coupled to a reservoir to expel fluid therefrom.

30. The electronic device according to claim **29**, wherein the pins comprise a fluid conduit for fluidly coupling the pores in the heads to the reservoir.

31. The electronic device according to claim **1**, comprising pores disposed in the heads and fluidly coupled to a vessel for creating a pressure differential to cause suction through the pores.

32. The electronic device according to claim **1**, wherein pins are stacked on each other such that pins of a first layer are disposed on the body and pins of a second layer are disposed on the heads that are disposed on the pins of the first layer.

33. The electronic device according to claim **32**, wherein the heads of the pins of the second layer include a plurality of facets for displaying images thereon.

34. The electronic device according to claim **1**, comprising pores disposed in the body, between the pins.

35. The electronic device according to claim **34**, comprising a speaker disposed in the body for audio output via a plurality of the pores.

36. The electronic device according to claim **35**, comprising a microphone disposed in the body for audio input via one or more of the pores.

37. The electronic device according to claim **1**, comprising a plurality of layers of pins including a first layer of pins extendable a first distance from the body, and a second layer of pins extendable a second distance from the body, the first distance being different than the second distance.

38. A method of controlling an electronic device including a plurality of pins extending from the body, the pins including couplings to facilitate movement of a first portion of the pins relative to a second portion of the pins, the pins being controllable to control the movement of the first portion relative to the second portion and to control a force applied by the pins on an external object, a plurality of heads disposed on the pins, each head moveable about a respective coupling in more than one axis relative to a corresponding pin, wherein each head including a plurality of facets and each facet of the plurality of facets has a different material property to provide a different tactile sensation, sensors cooperating with the pins to detect forces externally applied to the pins, a communication subsystem for communication, over a network, with a remote electronic device, and a controller coupled to the pins, the sensors, and the communication subsystem, the method comprising:

initiating communication with the remote electronic device;

detecting forces externally applied to the pins;

based on detected forces externally applied to the pins, transmitting a signal to the remote electronic device for controlling the remote electronic device to simulate the detected force externally applied to the heads coupled to the pins;

receiving response signals from the remote electronic device, the response signals in response to remote forces detected at the remote device;

based on signals received from the remote electronic device in response to remote forces detected at the remote electronic device, actuating ones of the pins to control the movement of the first portion relative to the second portion and to control the force applied by the heads on the pins on the external object to simulate the force detected at the remote electronic device.

39. The method according to claim **38**, wherein initiating communication comprises performing a handshake process.

40. The method according to claim **38**, wherein initiating communication comprises a user authentication or identification process.

41. The method according to claim **38**, comprising, based on the response signals received from the remote electronic device, determining a magnitude of the remote force applied at the remote electronic device, comparing the magnitude to a threshold value, and actuating the pins of the electronic device to simulate the remote force applied at the remote electronic device in response to determining that the magnitude is less than the threshold value.

42. The method according to claim **41**, comprising, in response to determining that the remote force applied at the remote electronic device is greater than the threshold value, actuating the pins of the electronic device to apply an altered force to the external object such that the altered force is less than the threshold value.

43. The method according to claim **38**, comprising determining a magnitude of the detected forces applied to the pins of the electronic device and, in response to determining that the magnitude of the detected forces exceed a threshold value, interrupting transmitting the signals to the remote electronic device such that the signal related to the detected forces that exceeds the threshold value is not transmitted to the remote electronic device.

44. The method according to claim **38**, comprising identifying, by the electronic device, a remote object applying the remote force based on the response signals received from the remote electronic device.

45. The method according to claim **44**, utilizing additional stored information based on the identification of the remote object applying the remote force, to actuate further pins to simulate additional parts of the remote object at the electronic device.

46. The method according to claim **38**, comprising detecting touches utilizing touch sensors disposed on the heads disposed on the pins of the electronic device.

47. The method according to claim **38**, wherein in response to detecting a touch utilizing capacitive touch sensors disposed on the heads disposed on the pins of the electronic device, heating the heads to simulate skin contact.

48. The method according to claim **38**, comprising storing information relating to the communication to reproduce a simulation of the force detected at the remote electronic device at a later time, after the communication with the remote electronic device ends.

49. The method according to claim **38**, comprising displaying images on the heads disposed on the pins.

50. A non-transitory computer-readable medium having stored thereon, computer- readable code executable by at least one processor of a computing device to perform the method of claim **38**.

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