(54) Title: SYSTEM AND METHOD FOR RECOGNIZING PHYSICAL OBJECTS ON AN INTERACTIVE BOARD

Fig. 6

Placing an object on the interactive surface

Detecting the object by the sensor array

Receiving the coupling values by the processor

Deriving a coupling pattern for the object by the processor

(57) Abstract: The present invention provides a system and accompanying method for recognizing physical objects on an interactive board. The system includes one or more physical objects, an interactive board comprising a sensor array of which each sensor is configured to couple with a physical object when placed within the sensor's detection range, and export the value of the coupling, and a processor configured to receive the coupling values. Once the physical object is placed on the interactive board, the processor is configured to receive coupling values from the sensors that have coupled with the physical object, and derive a coupling pattern based on the coupling values.
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SYSTEM AND METHOD FOR RECOGNIZING
PHYSICAL OBJECTS ON AN INTERACTIVE BOARD

TECHNICAL FIELD

The present invention relates to the field of interactive surfaces.

BACKGROUND

With the development of communication technology, smart devices with touch screen have become popular communication devices. These smart devices collect input information from the capacitive sensor on the touch screen; specifically, touch and gesture actions performed on the touch screen.

In the current state of the art, smart devices’ touch screens can only sense being touched or not via a binary signal which this is restrictive in terms of information input capabilities. Therefore, there is a need for a new form of touch screen capable of detecting more complex forms of input information.

SUMMARY OF INVENTION

The present invention provides a system for recognizing physical objects on an interactive board. The system comprises includes one or more physical objects, an interactive board comprising a sensor array of which each sensor configured to couple with a physical object placed within the sensor’s detection range, and export the value of the coupling, and a processor configured to receive the coupling values.

Once a physical object is placed on the interactive board, the processor is configured to receive coupling values from the sensors that have coupled with the physical object, and derive a coupling pattern based on the coupling values.

Optionally, the sensor array comprises capacitive sensors, and the coupling values are the capacitance changes caused by capacitive coupling between the physical object and the sensors that have detected the physical object.
Optionally, the sensor array comprises frequency sensitive devices with a fixed frequency, and the coupling values are the frequency changes of the frequency sensitive devices caused by coupling between the physical object and the sensors.

Optionally, the processor recognizes the identity of physical object in accordance with the shape of the coupling pattern, and derives the location of the physical object from the locations of the sensors related to the coupling pattern.

Optionally, the processor determines that the physical object is moving on the interactive board whenever the shape of the coupling pattern remains unchanged but the position of the coupling pattern changes, and that the moving direction of the physical object on the interactive board is the moving direction of the coupling pattern.

Optionally, the processor determines that a secondary action has been acted upon the physical object when the shape of the coupling pattern changes while the physical object stays stationary.

Optionally, the secondary action of a first physical object comprises placing a second physical object on the first physical object.

Optionally, the secondary action of a first physical object comprises placing a finger on the first physical object.

Optionally, the processor is further configured to determine the position of the finger touch on the first physical object in accordance with the changes in the shape of the coupling pattern.

The present invention further provides a method for recognizing physical objects on an interactive board, which comprises:

- placing a physical object on a interactive board,

- detecting the physical object by sensors of a sensor array embedded in the interactive board,

- receiving, by a processor, the value of coupling between the physical object and the sensors that have coupled with the physical object,

- deriving, by the processor, a coupling pattern of the physical object based on the coupling values.
Optionally, the method further comprises recognizing the identity of the physical object in accordance with the shape of the coupling pattern, and deriving the location of the physical object from the locations of the sensors related to the coupling pattern.

Optionally, the method further comprises determining that the physical object is moving on the interactive board whenever the shape of the coupling pattern remains unchanged but the position of the coupling pattern changes, and that the moving direction of the physical object is the moving direction of the coupling pattern.

Optionally, the method further comprises determining, by the processor, that the secondary action of a first physical object comprises placing a second physical object on the first physical object.

Optionally, the method further comprises determining that the secondary action of a first physical object comprises placing a finger on the first physical object.

Optionally, the method further comprises determining, by the processor, the position of the finger touch on the first physical object in accordance with the changes in the shape of the coupling pattern.

BRIEF DESCRIPTION OF THE DRAWINGS

To better illustrate the technical features of the embodiments of the present invention, various embodiments of the present invention will be briefly described in conjunction with the accompanying drawings. It should be obvious that the drawings are only for exemplary embodiments of the present invention, and that a person of ordinary skill in the art may derive additional drawings without deviating from the principles of the present invention.

FIG. 1 is an exemplary schematic diagram illustrating a toy car being placed upon on an interactive board in accordance with one embodiment of the present invention.

FIG. 2 is an exemplary schematic diagram illustrating the effect of placing a toy car on the interactive board upon the sensor array’s coupling pattern in accordance with one embodiment of the present invention.
FIG 3 is an exemplary schematic diagram illustrating the effect of moving a toy car across to the right upon the sensor array’s coupling pattern in accordance with one embodiment of the present invention.

FIG 4 is an exemplary schematic diagram illustrating the effect of rotating a toy car 90° upon the sensor array’s coupling pattern in accordance with one embodiment of the present invention.

FIGs. 5A, 5B, 5C, and 5D are exemplary schematic diagrams illustrating the effects of placing a physical object on top of another physical object upon the sensor array’s coupling pattern in accordance with one embodiment of the present invention.

FIG 6 is the flow chart illustrating the method for interacting with physical objects placed on an interactive board in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to various embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the embodiments, it will be understood that this is not intended to limit the scope of the invention to these specific embodiments. The invention is intended to cover all alternatives, modifications and equivalents within the spirit and scope of invention, which is defined by the apprehended claims.

Furthermore, in the detailed description of the present invention, specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be obvious to one of ordinary skill in the art that the present invention may be practiced without these specific details. In other instances, well known methods, procedures, components, and circuits are not described in details to avoid unnecessarily obscuring a clear understanding of the present invention.

In addition, while a sensor system making use of capacitive sensing between a capacitance sensor embedded on the interactive board and the objects is disclosed in connection with embodiments of the present invention, other sensor technologies such as Hall effect sensors, pressure sensors, resistance touch sensors or piezo touch
sensors can also be adapted for the purpose of continuous sensing rather than binary sensing and are within the scope of the present invention.

The present invention may be better understood and its numerous objects and advantages will become apparent to those skilled in the art by reference to the accompanying drawings.

FIG. 1 is an exemplary schematic diagram illustrating an embodiment of the present invention in which a toy car is placed upon on an interactive board. As shown in FIG. 1, the system for interacting with physical objects placed on an interactive board includes an interactive board 101, at least one physical object 102, and a processor 103. The interactive board 101 comprises a sensor array of which each sensor is configured to couple with the physical object 102 placed on top of it and export a coupling value to the processor 103. The processor 103 is connected to the sensor array of the interactive board 101 and is configured to receive the coupling values exported from all of the sensors of the sensor array.

Once the processor 103 receives the coupling values exported from the sensors of the sensor array that have experienced coupling with the physical object 102, it is configured to derive a coupling pattern based on the coupling values. Within the confines of the embodiment of the present invention, the physical object 102 is designed to be a toy car.

Within the scope of the present invention, the sensors of the sensor array can be designed to have different structures. For example, the sensors of the sensor array are capacitive sensors and the coupling values are the capacitance changes of the capacitive sensors, caused by coupling between the physical object and the sensors. Another potential option is for the sensors of the sensor array to be frequency sensitive devices with a fixed frequency, and then the coupling values are the frequency changes of the frequency sensitive devices caused by coupling between the physical object and the sensors. Other potential options for the sensor design include using single capacitor electrodes, piezoelectric units or magnetic coils.

It will be noted that, depending on the design of the sensors, the coupling values between the physical objects and the sensor array will be different. For example, for a capacitive sensor, the coupling value will be the change in capacitive value whereas when a single capacitor electrode sensor is used, the coupling value is
the coupling value between the physical object and the capacitance electrode.

In addition, the same sensor design may be used in different ways. For example, for a capacitive sensor, the coupling values can be achieved either by measuring the change in capacitance values or by measuring the frequency change after electrifying the capacitance with alternating current of a certain frequency.

As mentioned previously, the processor 103 is configured to derive a coupling pattern based on the coupling values between the physical object and the sensors of the sensor array that have experienced coupling.

FIG 2 is an exemplary schematic diagram illustrating the effect of placing a toy car on the interactive board upon the sensor array’s coupling pattern in accordance with one embodiment of the present invention. As shown in FIG. 2, the coupling pattern is in a three dimensional coordinate system in which the X axis and the Y axis are used to represent the coordinate locations of the physical object (i.e., the toy car) 102 relative to the interactive board 101. Specifically, each X, Y coordinate represents a particular sensor of the sensor array (illustrated as boxes in FIG 2).

The Z axis represents the magnitude of the coupling value. Specifically, this is the coupling value exported by the sensors. In FIG 2 the physical object 102 couples with the several sensors placed below and near it with the magnitude of the coupling varying depending on the proximity of the coupling sensor to the physical object 102.

In FIG 1 and FIG 2, the coupling pattern of the physical object 102 has been pre-stored in the processor 103. Therefore, the processor 103 identifies the physical object 102 whenever it is placed upon the interactive board by detecting and recognizing its coupling pattern. The coupling pattern is defined as the specific shape, in both relative location of coupling sensors from each other (i.e., number of sensors experiencing coupling and their relative location from each other) and each coupling sensor’s individual coupling magnitude (i.e., Z variable) attributable to a physical object when coupling with the sensor array.

The processor 103 is also configured to determine the orientation of the physical object 102 by comparing the difference in the magnitude of the coupling values experienced by coupling sensors. In the embodiment illustrated in FIG. 1 and FIG 2, the back of the toy car is designed in such a manner that it creates the strongest
coupling value with the sensor placed under it compared with the rest of the toy car. Thus, the coordinate (3, 3) in FIG. 2 experiences the strongest coupling value (biggest Z parameter value) as it is the location of the back of the toy car.

In the embodiment illustrated in FIG. 1 and FIG. 2, the processor 103 is configured to receive coupling values and subsequently derive a coupling pattern in real-time. Thus, the processor 103 determines that the physical object 102 is moving on the interactive board 101 whenever the shape of the coupling pattern remains unchanged but the position of the coupling pattern changes, and that the direction of the physical object 102 on the interactive board 101 is the direction from the start position of the coupling pattern to the end position of the coupling pattern.

FIG. 3 is an exemplary schematic diagram illustrating the effect of moving the toy car 102 across to the right upon the sensor array’s coupling pattern in accordance with one embodiment of the present invention. As shown in FIG. 2, the back of the toy car 102 is designed to create the strongest coupling value which, as mentioned previously, is the (3, 3) coordinate where the Z axis value is the highest. In FIG. 3, the user moves the toy car 102 across to the right which causes the sensor array to experience the same coupling pattern (as it is still the same object) but at a different location. Specifically, in FIG. 3, the toy car’s 102 coupling pattern has shifted up the x axis by one cell (i.e., each cell being a sensor). Thus, the back of the toy car’s 102 coordinates has changes from the original (3, 3) to the new (4, 4).

FIG. 4 is an exemplary schematic diagram illustrating the effect of rotating a toy car 120° 90° upon the sensor array’s coupling pattern in accordance with one embodiment of the present invention. In this instance, the user rotates the toy car 102 from its original position in FIG. 2 by 90° causing the coupling pattern illustrated in FIG. 4.

FIGs. 5A, 5B, 5C, and 5D are exemplary schematic diagrams illustrating the effects of placing a physical object on top another physical object upon the sensor array’s coupling pattern in accordance with one embodiment of the present invention. FIG. 5A is an exemplary schematic diagram illustrating the placement of a second physical object 502 on top of a first physical object 501 that is located on the interactive board. FIG. 5B illustrates the coupling pattern of the first physical object 501 whenever it is placed alone upon the interactive board. FIG. 5C is the coupling
pattern of the second physical object 502 whenever it is placed alone upon the interactive surface. Finally, FIG 5D illustrates the coupling pattern caused by placing the second physical object 502 on top of the first physical object 501. As with the previous scenarios described in FIG. 1, 2, 3 and 4, the coupling patterns of the physical objects 501, 502 are pre-stored in the processor 103.

As shown in FIGs. 5A, 5B, 5C, and 5D, the coupling value between the sensor array and the area on the physical objects' 501 and 502 designed to cause the strongest coupling value (the bold area of physical objects 501, 502) is 100 whereas the coupling value between the sensor array and the other areas of the physical objects' 501 and 502 is only 50. Thus, whenever the second physical object 502 is placed on top of the first physical object 501 with both bold areas (i.e., designed to create the strongest coupling areas) being at opposite ends as shown in FIG. 5D, the coupling value for the coupling pattern is changed to 130 (areas which combine a bold area and non-bolded area) and 70 (only non-bolded area) respectively.

From the above, since the processor 103 has already identified the first physical object 501, and detects that the coupling pattern has changed to the coupling pattern illustrated in FIG 5D, the processor is configured to recognize that a secondary action has been made upon the first physical object 501. The processor 103 is then configured to divide the coupling pattern illustrated in FIG 5D into two coupling patterns, the coupling pattern of the first physical object 501 and a new coupling pattern. Subsequently, the processor 103 matches the new coupling pattern to that of the second physical object (i.e., FIG 5C). In such a manner the processor is configured to deduce that the second physical object 502 was superimposed upon the first physical object 501. Other physical objects having unique coupling patterns can be recognized as superimposed upon physical objects in the same manner.

A secondary action may further include placing a finger on top of a physical object already located on the interactive surface. In such a case the processor will deduce that the object placed on top of the physical object is a finger whenever it fails to attribute the new coupling pattern as a pre-recorded coupling pattern.

FIG 6 is the flow chart illustrating the method for interacting with physical objects placed on an interactive board in accordance with one embodiment of the present invention. As shown in FIG 6, the method for interacting with physical
objects placed on an interactive board comprises:

- placing a physical object on the interactive board embedded with an array of sensors that are configured to couple with the physical object and export the coupling values to a processor (601);

- detecting the physical object by sensors of the sensor array (602),

- receiving the coupling values by the processor (603);

- deriving, by the processor, a coupling pattern for the physical object comprising both the location of the sensors having coupled with the physical object and the values of such couplings (604).

In the several embodiments of the present invention, it should be understood that the apparatus and method disclosed may be realized by other means. For example, the embodiment of the apparatus described is only schematic. For example, the division of the unit is only a division of logical function; in practice, it can be divided in other ways. For example, multiple units or components can be combined or integrated to another system, or some features can be ignored, or not executed. At another point, the mutual coupling or direct coupling or communication connection displayed or discussed can be through indirect coupling or communication connection of a number of interfaces, devices or units, which can be electrical, mechanical or otherwise.

The unit described as a separate component can be either physically separated or not, the component as display unit can be either physical unit or not, namely it can be placed in one place, or be distributed to multiple network units. By choosing part or the entire unit according to the actual need, the purpose of this embodiment can be realized.

In addition, each function unit if each embodiment of the present invention can be integrated to a processing unit or each unit physically exists alone, or two or more units are integrated to one unit. The integrated unit can be realized in the form of hardware or realized in the form of hardware plus software.

The integrated unit realized in the form of software unit, can be stored in a computer readable storage medium. The software unit is stored in a storage medium, comprising several instructions to make a computer device (e.g., a personal computer,
server, or network equipment) or processor execute part of the steps in each embodiment of the present invention. The storage medium may comprise: a U disk, mobile hard disk, read only memory read only memory (ROM), random access memory (RAM), disk or CD-ROM and other various program code storage medium.

People skilled in the art will notice that the above embodiments are only used to convey the inventive concept and should not be construed as a restriction upon the scope of the invention in itself. In practical application, the functions of the present invention can be realized by different modules and processes according to the need (e.g., internal structure of the device can be divided into different functional modules) to realize the entire or part of the functions described in the detailed description.
1. A system for recognizing physical objects on an interactive board, comprising:
   - one or more physical objects;
   - an interactive board comprising a sensor array, wherein each sensor of the sensor array is configured to couple with a physical object that is placed within the sensor’s detection range, and export the value of the coupling;
   - a processor configured to receive coupling values;
   wherein, upon a physical object being placed on the interactive board, the processor is configured to receive coupling values from the sensors that have coupled with the physical object, and derive a coupling pattern based on the coupling values.

2. The system of claim 1, wherein the sensor array comprises capacitive sensors, and wherein the coupling values are the capacitance changes caused by capacitive coupling between the physical object and the sensors that have detected the physical object.

3. The system of claim 1, wherein the sensor array comprises frequency sensitive devices with a fixed frequency, and wherein the coupling values are the frequency changes of the frequency sensitive devices caused by coupling between the physical object and the sensors.

4. The system of claim 1, wherein the processor recognizes the identity of the physical object in accordance with the shape of the coupling pattern, and derives the location of the physical object from the locations of the sensors related to the coupling pattern.

5. The system of claim 1, wherein the processor determines that the physical object is moving on the interactive board whenever the shape of the coupling pattern remains unchanged but the position of the coupling pattern changes, and that the moving direction of the physical object on the interactive board is the moving direction of the coupling pattern.

6. The system of claim 1, wherein the processor determines that a secondary action has been acted upon the physical object when the shape of the coupling pattern changes while the physical object stays stationary.
7. The system of claim 6, wherein the secondary action of a first physical object comprises placing a second physical object on the first physical object.

8. The system of claim 6, wherein the secondary action of a first physical object comprises placing a finger on the first physical object.

9. The system of claim 8, wherein the processor is further configured to determine the position of the finger touch on the first physical object in accordance with the changes in the shape of the coupling pattern.

10. A method for recognizing physical objects on an interactive board, comprising:
    - placing a physical object on an interactive board,
    - detecting the physical object by sensors of a sensor array embedded in the interactive board,
    - receiving, by a processor, the value of coupling between the physical object and the sensors that have coupled with the physical object,
    - deriving, by the processor, a coupling pattern of the physical object based on the coupling values.

11. The method of claim 10, wherein the sensor array comprises capacitive sensors, and wherein the coupling values are the capacitance changes caused by capacitive coupling between the physical object and the sensors that have detected the physical object.

12. The method of claim 10, wherein the sensor array comprises frequency sensitive devices with a fixed frequency, and wherein the coupling values are the frequency changes of the frequency sensitive devices caused by coupling between the physical object and the sensors that have detected the physical object.

13. The method of claim 10, further comprising, recognizing the identity of the physical object in accordance with the shape of the coupling pattern, and deriving the location of the physical object from the locations of the sensors related to the coupling pattern.

14. The method of claim 10, further comprising, determining that the physical object is moving on the interactive board whenever the shape of the coupling pattern
remains unchanged but the position of the coupling pattern changes, and that the moving direction of the physical object is the moving direction of the coupling pattern.

15. The method of claim 10, further comprising, determining, by the processor, that a secondary action has been acted upon the physical object when the shape of the coupling pattern changes.

16. The method of claim 15, wherein the secondary action of a first physical object comprises placing a second physical object on the first physical object.

17. The method of claim 15, wherein the secondary action of a first physical object comprises placing a finger on the first physical object.

18. The method of claim 17, further comprising, determining, by the processor, the position of the finger touch on the first physical object in accordance with the changes in the shape of the coupling pattern.
Fig. 1

Fig. 2
Fig. 5a

Fig. 5b
Fig. 5c

Fig. 5d
Fig. 6

1. Placing an object on the interactive surface
2. Detecting the object by the sensor array
3. Receiving the coupling values by the processor
4. Deriving a coupling pattern for the object by the processor
INTERNATIONAL SEARCH REPORT

International application No. PCT/CN2016/075705

A. CLASSIFICATION OF SUBJECT MATTER
   C06F 3/01(2006.01.1i)
   According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
   Minimum documentation searched (classification system followed by classification symbols)
   C06F
   Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
   CNPAT, CNKI, WPI, EP Dodgers, IEEE: object, detect, recognize, sensor, couple, pattern, image, graphic, capacitance, frequency, position, location

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>CN 105066852 A (SHI, ZHENG) 18 November 2015 (2015-11-18) claims 1-18</td>
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<td>X</td>
<td>CN 104750314 A (SHI, ZHENG) 01 July 2015 (2015-07-01) description, paragraphs [0047]-[0108], figures 3-6</td>
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<td>WO 2014209519 A1 (SYNAPTICS INCORPORATED) 31 December 2014 (2014-12-31) description, paragraphs [0017]-[0042], figures 1, 2A and 2B</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:
  "A" document defining the general state of the art which is not considered to be of particular relevance
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  "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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Date of mailing of the international search report 25 May 2016

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Form PCT/ISA/210 (second sheet) (July 2009)
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