Method and toy element for generating a computer-readable representation of a construction made of toy building elements

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(54) METHOD AND TOY ELEMENT FOR GENERATING A COMPUTER-READABLE REPRESENTATION OF A CONSTRUCTION MADE OF TOY BUILDING ELEMENTS

(57) A method of generating a representation of a construction (114) made of interconnected toy building elements (101;102;103) comprising at least a first building element (101) and a second building element (102); comprising: measuring (801) an electrical impedance through the construction at one or more frequencies via a first contact area (110) touching at least the first building (101) element and via a second contact area (112) touching at least the second building element (102); generating (802) a computer-readable impedance profile comprising a representation of the electrical impedance at the one or more frequencies; retrieving (803) a classification model configured to classify the computer-readable impedance profile among a group of classes, comprising classes which are associated with a construction representation for presenting an audio and/or visual representation of the construction (114); and performing classification (804) of the computer-readable impedance profile, using the classification model, and using the construction representation to present (805) the audio and/or visual representation (116) of the construction (114).

There is also provided a toy element and a set of toy building elements comprising elements made from graphene.

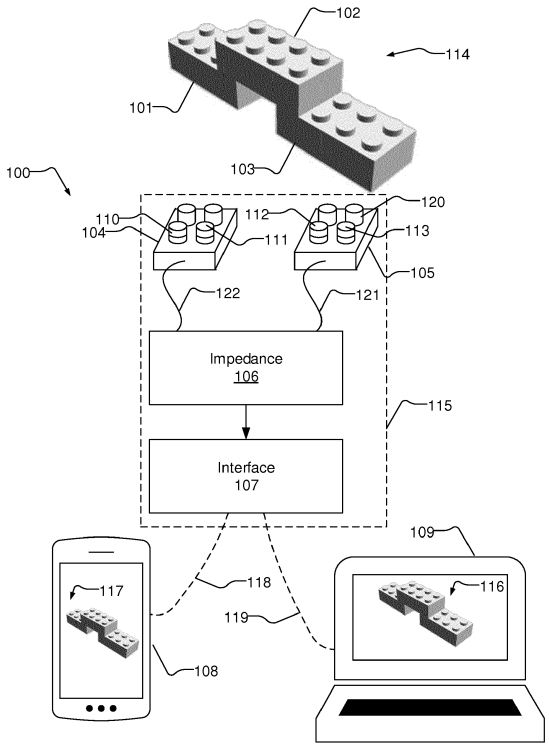

Fig. 1

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Description

[0001] Toy building elements, typically known as toy bricks or bricks, have been very popular for decades and continue to be popular even though computer games and other types of game and playing apps and the like are taking over many types of traditional ways of playing.

[0002] It has been realized by many toy manufacturers that computer programs and apps for tablet computers and smart-phones may enrich the play experience when working in unison with or interconnected with physical toy elements.

[0003] However, especially for construction building sets by which various constructions may be assembled, there has not been an interface available for robustly and cost effectively obtaining a computer representation of the construction.

RELATED PRIOR ART

[0004] Known methods for obtaining a representation of a construction made of toy building elements are based on acquiring a visual image and performing image processing to reveal a representation of the construction e.g. a spatial description describing mutual spatial relationships between building elements and referring to an electronic library of predefined building elements. However such methods requires a camera, are sensitive to ambient light conditions, involves the problem that some portions of a construction may be visually hidden to a camera and requires complex image processing, which requires processing power.

SUMMARY

[0005] There is provided a method, implemented on an electronic system, of generating a representation of a construction made of interconnected toy building elements comprising at least a first building element and a second building element that are electrically conductive or semi-conductive; comprising:

- measuring an electrical impedance through the construction made of interconnected toy building elements at one or more frequencies via a first contact area touching at least the first building element and via a second contact area touching at least the second building element;

- generating a computer-readable impedance profile comprising a representation of the electrical impedance at the one or more frequencies;

- retrieving a classification model configured to classify the computer-readable impedance profile into one or more classes, comprising classes which are associated with a construction representation for presenting an audio and/or visual representation of the construction; and

- performing classification of the computer-readable impedance profile, using the classification model, and presenting the audio and/or visual representation of the construction using the construction representation.

[0006] The electronic system, e.g. comprising a personal computer, smart phone or tablet computer, may perform the method or only some steps thereof on an ongoing or looping basis while a construction is being built by a person interconnecting the toy building elements.

[0007] The method then presents the audio and/or visual representation of the construction at hand that is actually being built by the person. When classes are properly defined it is possible to discriminate at least one construction at hand from another and compose the construction representation to give audio and/or visual feedback to the person. The feedback may indicate whether a construction correctly matches a selected reference construction and/or whether a construction correctly matches a step or sequence of steps of a building instruction on how to build a selected reference construction. This will greatly improve the experience in a play involving the method and the building elements.

[0008] Toy building elements that are inter-connectable to build constructions are widely known, e.g. under the trademarks LEGO, Fischer Technique, etc. Conventionally, such toy building elements are made from a plastics material such as ABS. However, as explained in greater detail below toy building elements can be made from a material that is electrically conductive or semi-conductive while still preserving at least some of their known properties which may be properties enabling frictional coupling between elements.

[0009] The classification model configured for classifying the computer-readable impedance profile may be selected and configured as it is known in the art. In some aspects the classification model is trained on computer-readable impedance profiles obtained by measuring the impedance of a range of different constructions and attaching classification labels such as 'correct', 'step 1/2', 'step 2/2', and 'unknown' or according to another naming convention. A classification model may be a nearest neighbour model, a Support Vector Machine, SVM, or another type of classification model.

[0010] In some aspects a classification model is trained and downloaded from a server computer, e.g. via the Internet, to the electronic system as it is known in the art. The classification model may be updated via downloading at intervals.

[0011] The classification labels may be associated with construction representations e.g. by being stored in an appropriate data structure. The construction representation may comprise a graphical representation of a construction that has the same or a similar impedance profile.

The graphical representation may comprise one or more of: a spatial description of the mutual relation of elements in the construction, a type description or identifier, an image, a video sequence and an audio sequence. Thus, having determined a class from the impedance profile, construction representations relevant for the class may be retrieved and presented.

[0012] The presentation of the audio and/or visual representation of the construction may be rendered on a graphics display, on print and/or via an audio system.

[0013] The measuring of an electrical impedance may be performed at one or more predefined frequencies as it is known in the art. The impedance may be measured via an analogue-to-digital converter at the predefined frequencies and arranged in an appropriate data structure such as in an array of measurement values to generate the computer-readable impedance profile.

[0014] The contact areas touching at least some of the building elements are arranged where frictional coupling or another type of coupling between elements take place. The contact areas may be arranged on or integrated with upwardly extending studs that are arranged in a modular array for frictional coupling with one or both of inner sides of a downwardly extending walls of a box-shaped or differently shaped element and a downwardly extending deformable round skirt arranged inside the element.

[0015] In some embodiments measuring the electrical impedance and generating a computer-readable impedance profile are performed by a first electronic device which is interconnected with the first toy building element and second toy building element and which is configured to transmit the computer-readable impedance profile via a wired or wireless connection to a second electronic device configured to the retrieving of the classification model, the performing of the classification and the rendering of the audio and/or visual representation of the construction.

[0016] The transmission may take place via a wired or wireless connection and appropriate electronic circuitry. In some embodiments a Bluetooth (TM) connection is us used for transmitting the computer-readable impedance profile.

[0017] Thus, the electronic system comprises the first electronic device and the second electronic device. The second electronic device may be a computing device with a graphical user interface, such as a personal computer, a tablet computer, a smart phone, or a smart watch, communicating with the first electronic device, which may be an interface device configured to apply an electrical interrogation signal to the construction via the first contact area and to acquire a measurement signal from the construction via the second contact area.

[0018] In other aspects the method is performed by an integrated electronic computing device with an interface configures as the interface device mentioned above and a graphical user interface.

[0019] In some embodiments the measuring of the electrical impedance comprises measuring an impedance at DC, and wherein the representation of the electrical impedance at one or more frequencies in the computer-readable impedance profile is normalized relative to the impedance at DC.

[0020] This provides for a more robust classification of constructions. Impedance at DC is also denoted resistance.

[0021] In some embodiments the measuring of the electrical impedance comprises measuring and generating the impedance profile to comprise one or more of: an impedance magnitude, an impedance phase shift, and an in-phase component and a quadrature-phase component.

[0022] It may be sufficient, for reliably distinguishing constructions, to measure an impedance magnitude. Measuring an impedance phase shift or a complex impedance at the one or more frequencies or at other frequencies provides for distinguishing whether a construction is being touched or not.

[0023] In some embodiments the impedance profile comprises an impedance phase shift or a quadrature-phase component and wherein the classification model comprises a class which is associated with a special effect representation for rendering an audio and/or visual representation of the construction with a special effect in accordance with the special effect representation.

[0024] The class which is associated with a special effect representation may be selected, when a construction is being touched. A separate classification model may be used to determine whether a construction is being touched e.g. by using a threshold based discrimination.

[0025] In some embodiments the first contact area and the second contact area are comprised by an array of contact areas that are individually or group-wise addressable via an electronic circuit (308); wherein the method comprises: via the electronic circuit applying an interrogation signal at one or more contact areas comprising the first contact area and measuring a response signal at one or more contact areas comprising the second contact area.

[0026] The interrogation signal may comprise a DC offset which opens an electronic switch and an AC signal at the one or more frequencies. The AC signal may comprise a frequency and/or phase swept signal. Thereby a compact and cost effective circuit is provided.

[0027] The interrogation signal and the response signal may be applied and measured, respectively according to a search strategy for generating an impedance profile which most strongly discriminates the construction from other constructions.

[0028] There is also provided a computer program product configured to perform the method set out above, when run on a computer, wherein the method is a computer-implemented method run on a computer.

[0029] There is also provided a computer program product configured to:

- receive a computer-readable impedance profile

comprising a representation of an electrical impedance at the one or more frequencies;

- retrieving a classification model configured to classify the computer-readable impedance profile among a group of classes, comprising classes which are associated with a construction representation for rendering an audio and/or visual representation of the construction; and

- performing classification of the computer-readable impedance profile, using the classification model, and using the construction representation to render the audio and/or visual presentation of the construction.

[0030] There is also provided a toy element for generating a representation of a construction made of interconnected toy building elements comprising: a first coupling structure with a first contact area and a second coupling structure with a second contact area; and an electronic unit configured to:

- measure an electrical impedance at one or more frequencies via the first contact point and the second contact point both touching a construction made of interconnected building elements and coupled to the first coupling structure and the second coupling structure;

- generate a computer-readable impedance profile comprising a representation of the electrical impedance at the one or more frequencies; and

- transmit the computer-readable impedance profile via a wired or wireless connection.

[0031] In some embodiments the first coupling structure and the second coupling structure are arranged in a spatial array of coupling structures.

[0032] The spatial array may be a modular array such that building elements can be attached in the same way at different positions which are spaced apart by modular steps in one, two or three dimensions. The spatial array of coupling structures may allow for interconnection of the building elements only at certain angles such as at right angles.

[0033] In some embodiments the first coupling structure and the second coupling structure comprise studs arranged on a substantially plane platform.

[0034] The studs may extend upwardly and constitute a male connection structure that is interconnectable by frictional coupling with a female connection structure which comprises one or more downwardly extending sidewalls and a downwardly extending round skirt. Alternatives to frictional coupling are possible via clamps, rivets, nots and bolts and other types of mechanical coupling.

[0035] In some embodiments the first coupling structure and the second coupling structure comprise studs and at least a portion of one or more of the studs is made from an electrically conductive material, such as a metal, or a semi-conductive material, such as a plastics material mixed with a metal or graphite.

[0036] There is also provided a set of toy building elements comprising a toy building element as set out above and a set of interconnectable toy building elements made of a semi-conducting material.

[0037] In some embodiments the set of toy building elements are made from a composition of a plastics material and graphene.

[0038] The toy building elements may have an electrical conductivity in a range selected from the groups of:

1. 1*10-10 S/m to 1*106 S/m

2. 1*10-7 S/m to 1*105 S/m

3. 1*10-7 S/m to 1*103 S/m

4. Above 1*10-7 S/m

[0039] Where S/m denotes the SI-unit Siemens per meter. The first range, comprises electrical conductivity for toy building elements made from a metal. The Second range comprises electrical conductivity for toy building elements made from ABS-plastic with a graphene monolayer (pristine). The third range comprises electrical conductivity for toy building elements made from ABS-plastic with rGO (0.4wt%-5.6wt%). The third range is useful at least for measuring capacitive impedances.

[0040] In some embodiments the set of toy building elements comprises a toy building element as set out above and comprising a computer program product or a computer programmed to:

- receive a computer-readable impedance profile comprising a representation of an electrical impedance at the one or more frequencies;

- retrieving a classification model configured to classify the computer-readable impedance profile among a group of classes, comprising classes which are associated with a construction representation for rendering an audio and/or visual representation of the construction; and

- performing classification of the computer-readable impedance profile, using the classification model, and using the construction representation to render the audio and/or visual representation of the construction.

[0041] Here and in the following, the terms 'electronic system', 'unit' and 'device' are intended to comprise any circuit and/or device suitably adapted to perform the func-

tions described herein. In particular, the above term comprises general purpose or proprietary programmable microprocessors, Digital Signal Processors (DSP), Application Specific Integrated Circuits (ASIC), Programmable Logic Arrays (PLA), Field Programmable Gate Arrays (FPGA), special purpose electronic circuits, etc., or a combination thereof.

BRIEF DESCRIPTION OF THE FIGURES

[0042] A more detailed description follows below with reference to the drawing, in which:

fig. 1 shows a block diagram of an electronic system for classifying a construction made of toy building elements;

fig. 2 shows a platform for building elements accommodating an electronic circuit for measuring and communicating an AC impedance measurement to a computer;

fig. 3 shows a block diagram of an electronic circuit for measuring and communicating an AC impedance measurement from the platform for toy building elements to a computer;

fig. 4 shows a range of curves representing a magnitude component of AC impedance measurements for different constructions of toy building elements;

fig. 5 shows different constructions of toy building elements;

fig. 6 shows the range of curves representing a magnitude component of AC impedance measurements and an indication of different measurement frequencies;

fig. 7 shows a range of curves representing a phase component of AC impedance measurements for different constructions of toy building elements; and

fig. 8 shows a flowchart of generating a computer-readable characterization of a construction made of interconnected toy building elements.

DETAILED DESCRIPTION

[0043] Fig. 1 shows a block diagram of an electronic system for classifying a construction made of toy building elements. The electronic system 100 comprises a first electronic device 115 which communicates with a second electronic device such as a smart-phone 108 or a laptop computer 109 and serves as an interface between a construction 114 made of interconnected toy building elements 101, 102, 103 and second electronic device. The first electronic device 115 communicates with a second electronic device via a communication connection 118, 119 which may be a wired or wireless connection e.g. according to USB, Bluetooth (TM) and/or a Wi-Fi standard.

[0044] The first device 115 has a wired connection to at least two different contact areas 110, 111; 112, 113. The contact areas are in this embodiment integrated at a top portion of studs, generally designated by reference numeral 120, wherein the studs are arranged on a first platform 104 and a second platform 105. Each platform comprises in this embodiment four studs. The contact areas 110, 111; 112, 113 may touch one or more inner sides of sidewalls of the building elements 101, 102, 103 and/or a round skirt arranged inside the building elements.

[0045] The contact areas 110; 111, 112; 113 are connected via electrical connections 121, 122 to a unit 106 which is configured to measure an AC impedance at one or more frequencies and in some embodiments also a DC impedance (resistance) between electrical connections 121, 122. A circuit for measuring AC and DC impedance is known in the art. Integrated circuits conventionally used for estimating a body-fat-percentage may be used for measuring AC and DC impedance. The unit 106 may output an impedance profile as an analogue or digital signal e.g. in accordance with the I2C protocol to thereby generate a computer-readable impedance profile comprising a representation of the electrical impedance at the one or more frequencies.

[0046] A unit 107 is coupled to receive the impedance profile from the unit 106 and serves as an interface for the communication with the second electronic device 108;109 external to the first electronic device 115.

[0047] The second electronic device is programmed to receive the impedance profile and to retrieve a classification model configured to classify the computer-readable impedance profile into one or more classes. The classification model has a representation of a decision boundary distinguishing classes from each another. The classification model may be a decision tree, a K-nearest neighbours algorithm, a Support Vector Machine, etc. as it is known in the art. The classification model may be stored locally at the second computing device and/or downloaded from a server computer. The classification model is trained as it is known in the art to distinguish different constructions made of building elements.

[0048] One or more of the classes may be represented by a classification label. Such a classification label may be associated with a construction representation for presenting an audio and/or visual representation of the construction e.g. as described in US 6,389,375. The construction representation may comprise codes for rendering a construction on a graphical display or for playback of another type of audio/visual media. The construction representation may also or alternatively comprise a code for raising an event - e.g. for raising an event of playing a presentation and/or of entering a user interface wizard and/or of entering a chapter of human-computer interac-

tions.

[0049] Then, the second electronic device may perform classification of the computer-readable impedance profile, using the classification model, and presenting the audio and/or visual representation of the construction using the construction representation. The audio representation may comprise sound effects, music, and/or speech.

[0050] The toy building elements may have an electrical conductivity in a range selected from the groups of: $1*10^{-10}$ S/m to $1*10^{6}$ S/m; $1*10^{-7}$ S/m to $1*10^{5}$ S/m; $1*10^{-7}$ S/m to $1*10^{3}$ S/m and above $1*10^{-7}$ S/m, wherein S/m denotes the SI-unit Siemens per meter. In some embodiments the building elements are made from a plastics material mixed with a carbon material such as Graphene or reduced graphene oxide or graphene related materials or other 2D-materials or a mix thereof.

[0051] Fig. 2 shows a platform for building elements accommodating an electronic circuit for measuring and communicating an AC impedance measurement to a computer. The platform 201 comprises a housing 202 accommodating the electronic circuit for measuring and communicating an AC impedance measurement to a computer or another electronic device. The platform 202 comprises an array with rows and columns of coupling structures, generally designated by reference numeral 203, in the form of upwardly extending studs with a contact areas for establishing electrical contact with building elements placed for coupling with the coupling structures on the platform. The coupling units are arranged in a modular array, equidistantly, for frictional coupling with one or both of inner sides of a downwardly extending walls of a box-shaped element and a downwardly extending deformable round skirt arranged inside the building elements. In some embodiments, other types of building elements may be used e.g. cylindrically shaped elements.

[0052] Fig. 3 shows a block diagram of an electronic circuit for measuring and communicating an AC impedance measurement from the platform for toy building elements to a computer. The block diagram comprises an array, generally designated 301, of contact areas arranged in rows and columns. Each contact area is connected to a switch circuit 304 which is electrically connected to the contact area, a row line and a column line. Row lines, such as R1 and R2 are connected to a row interrogation circuit 302 and column lines, such as C1 and C2, are connected to a column sensing circuit 303. An addressing circuit 305 controls the row interrogation circuit 302 and the column sensing circuit 303 to obtain impedance profiles in co-operation with impedance measurement unit 306 between selected ones or groups of contact areas e.g. by scanning. The impedance profiles are communicated to a second electronic device such as a personal computer 307.

[0053] The switch circuit 304 is shown in greater detail and comprises a 'row terminal', a 'column terminal' and an 'electrode terminal'. The 'row terminal' is connected to the row line; the 'column terminal' is connected to the column line; and the 'electrode terminal' is connected to the contact area of the coupling unit. The row interrogation circuit 302 applies a signal to the 'row terminal' such that the transistor 310 opens and such that an interrogation signal for measuring the impedance at DC and one or more frequencies is applied to the contact area - e.g. via an interrogation signal comprising a DC component and one or more AC components. The column sensing circuit 303 receives a signal via diode 309 at selected one or more columns. Contact areas may then be addressed row-by-row one or more at a time via the row interrogation circuit 302 and column-by-column one or more at a time via the column sensing circuit 303. Columns and rows are used for convenience, but they may be interchanged or laid out in a different spatial configuration.

[0054] Fig. 4 shows a range of curves representing a magnitude component of AC impedance measurements for different constructions of toy building elements, which are shown in fig. 5. The range of curves 401, 402 and 403 are recorded from impedance measurements across a wide range of frequencies and at a fine frequency resolution. The magnitude component of the AC impedance measurements are normalised with respect to a DC impedance and is dimensionless. The curves represent impedance profiles comprising a relatively large number of values due to the fine frequency resolution; however far fewer values may be sufficient.

[0055] The curve 401 is measured across contact areas A and B of the construction 114; curve 402 is measured across contact areas A and B of the construction 502, and curve 403 is measured across contact areas A and B of the construction 503. The constructions are all made of building elements with connection units arranged in a 2-by-4 array.

[0056] As can be seen for the curves shown in fig. 4 different classification models may distinguish the impedance profiles from each other and hence distinguish the constructions from each other.

[0057] Fig. 6 shows the range of curves representing a magnitude component of AC impedance measurements and an indication of different measurement frequencies. Also here the impedance measurements are normalised with respect to the impedance at DC. The measurement frequencies may be chosen as indicated by OC1, OC2 and OC3 which are located at three different frequencies e.g. at about 220Hz, 4kHz, and 58 kHz. Such a limited number of frequencies e.g. less than 20, 10 or 5 frequencies may be sufficient to achieve satisfying classification.

[0058] Fig. 7 shows a range of curves representing a phase component of AC impedance measurements for different constructions of toy building elements. The curve 701 is measured across contact areas A and B of the construction 114; curve 702 is measured across contact areas A and B of the construction 502, and curve 703 is measured across contact areas A and B of the

construction 503. The phase component of AC impedance measurements may be included in the impedance profile.

[0059] Fig. 8 shows a flowchart for a method, implemented on an electronic system, of generating a computer-readable characterization of a construction made of interconnected toy building elements. The method comprises the steps of:

- measuring 801 an electrical impedance through a construction made of interconnected toy building elements;
- generating 802 a computer-readable impedance profile comprising a representation of the electrical impedance at the one or more frequencies;
- optionally: transmitting 806 the computer-readable impedance profile to an computer; and receiving 807 the computer-readable impedance profile at the computer;
- retrieving 803 a classification model configured to classify the computer-readable impedance profile into one or more classes;
- performing classification 804 of the computer-readable impedance profile, using the classification model;
- rendering 805 an audio and/or visual representation of the construction as it estimated to be based on the classification.

[0060] In some embodiments the classification model is downloaded and/or updated from a server computer 808, such as cloud based server computer.

[0061] Although the above embodiments have been described with reference to toy building elements using a particular frictional coupling mechanism and a particular modular system, it should be noted that other types of toy building elements may be used such as toy building elements based a connection mechanisms comprising e.g. rivets, bolts and nuts or other types of connection mechanisms such as glue.

Claims

1. A method, implemented on an electronic system, of generating a representation of a construction (114) made of interconnected toy building elements (101;102;103) comprising at least a first building element (101) and a second building element (102) that are electrically conductive or semi-conductive; comprising:

   - measuring (801) an electrical impedance through the construction made of interconnected toy building elements at one or more frequencies via a first contact area (110) touching at least the first building (101) element and via a second contact area (112) touching at least the second building element (102);
   - generating (802) a computer-readable impedance profile comprising a representation of the electrical impedance at the one or more frequencies;
   - retrieving (803) a classification model configured to classify the computer-readable impedance profile into one or more classes, comprising classes which are associated with a construction representation for presenting an audio and/or visual representation of the construction (114);
   - performing classification (804) of the computer-readable impedance profile, using the classification model, and presenting (805) the audio and/or visual representation (116) of the construction (114) using the construction representation.

2. A method according to claim 1, wherein measuring the electrical impedance and generating a computer-readable impedance profile are performed by a first electronic device (115) which is interconnected with the first toy building element (101) and second toy building element (102) and which is configured to transmit the computer-readable impedance profile via a wired or wireless connection (118;119) to a second electronic device (108;109) configured to the retrieving of the classification model, the performing of the classification and the rendering of the audio and/or visual representation of the construction.

3. A method according to claim 1 or 2, wherein the measuring of the electrical impedance comprises measuring an impedance at DC, and wherein the representation of the electrical impedance at one or more frequencies in the computer-readable impedance profile is normalized relative to the impedance at DC.

4. A method according to any of claims 1-3, wherein the measuring of the electrical impedance comprises measuring and generating the impedance profile to comprise one or more of: an impedance magnitude, an impedance phase shift, and an in-phase component and a quadrature-phase component.

5. A method according to claim 4, wherein the impedance profile comprises an impedance phase shift or a quadrature-phase component and wherein the classification model comprises a class which is associated with a special effect representation for rendering an audio and/or visual representation of the construction with a special effect in accordance with the special effect representation.

6. A method according to any of claims 1-5, wherein the first contact area and the second contact area

are comprised by an array of contact areas that are individually or group-wise addressable via an electronic circuit (308); wherein the method comprises:

- via the electronic circuit (308) applying an interrogation signal at one or more contact areas comprising the first contact area (110;111) and measuring a response signal at one or more contact areas comprising the second contact area (112;113).

7. A computer program product configured to perform the method as claimed in any of the preceding method claims, when run on a computer, wherein the method is a computer-implemented method run on a computer.

8. A computer program product configured to:

- receive (807) a computer-readable impedance profile comprising a representation of an electrical impedance at the one or more frequencies;
- retrieving (803) a classification model configured to classify the computer-readable impedance profile among a group of classes, comprising classes which are associated with a construction representation for rendering an audio and/or visual representation of the construction; and
- performing classification (804) of the computer-readable impedance profile, using the classification model, and using the construction representation to render (805) the audio and/or visual presentation of the construction.

9. A toy element (200) for generating a representation of a construction made of interconnected toy building elements comprising:

a first coupling structure with a first contact area and a second coupling structure with a second contact area; and
an electronic unit configured to:

- measure an electrical impedance at one or more frequencies via the first contact point and the second contact point both touching a construction made of interconnected building elements and coupled to the first coupling structure and the second coupling structure;
- generate a computer-readable impedance profile comprising a representation of the electrical impedance at the one or more frequencies; and
- transmit the computer-readable impedance profile via a wired or wireless connection.

10. A toy element according to claim 9, wherein first coupling structure and the second coupling structure are arranged in a spatial array of coupling structures.

11. A toy element according to claim 9 or 10, wherein the first coupling structure and the second coupling structure comprise studs arranged on a substantially plane platform.

12. A toy element according to any of claims 9-11, wherein the first coupling structure and the second coupling structure comprise studs and at least a portion of one or more of the studs is made from an electrically conductive material, such as a metal, or a semi-conductive material, such as a plastics material mixed with a metal or graphite.

13. A set of toy building elements comprising a toy building element according to any of claims 9-12 and a set of interconnectable toy building elements made of a semi-conducting material.

14. A set of toy building elements according to claim 13, wherein the set of toy building elements are made from a composition of a plastics material and graphene.

15. A set of toy building elements comprising a toy building element according to any of claims 9-14 comprising a computer program product or a computer programmed to:

- receive a computer-readable impedance profile comprising a representation of an electrical impedance at the one or more frequencies;
- retrieving a classification model configured to classify the computer-readable impedance profile among a group of classes, comprising classes which are associated with a construction representation for rendering an audio and/or visual representation of the construction; and
- performing classification of the computer-readable impedance profile, using the classification model, and using the construction representation to render the audio and/or visual representation of the construction.

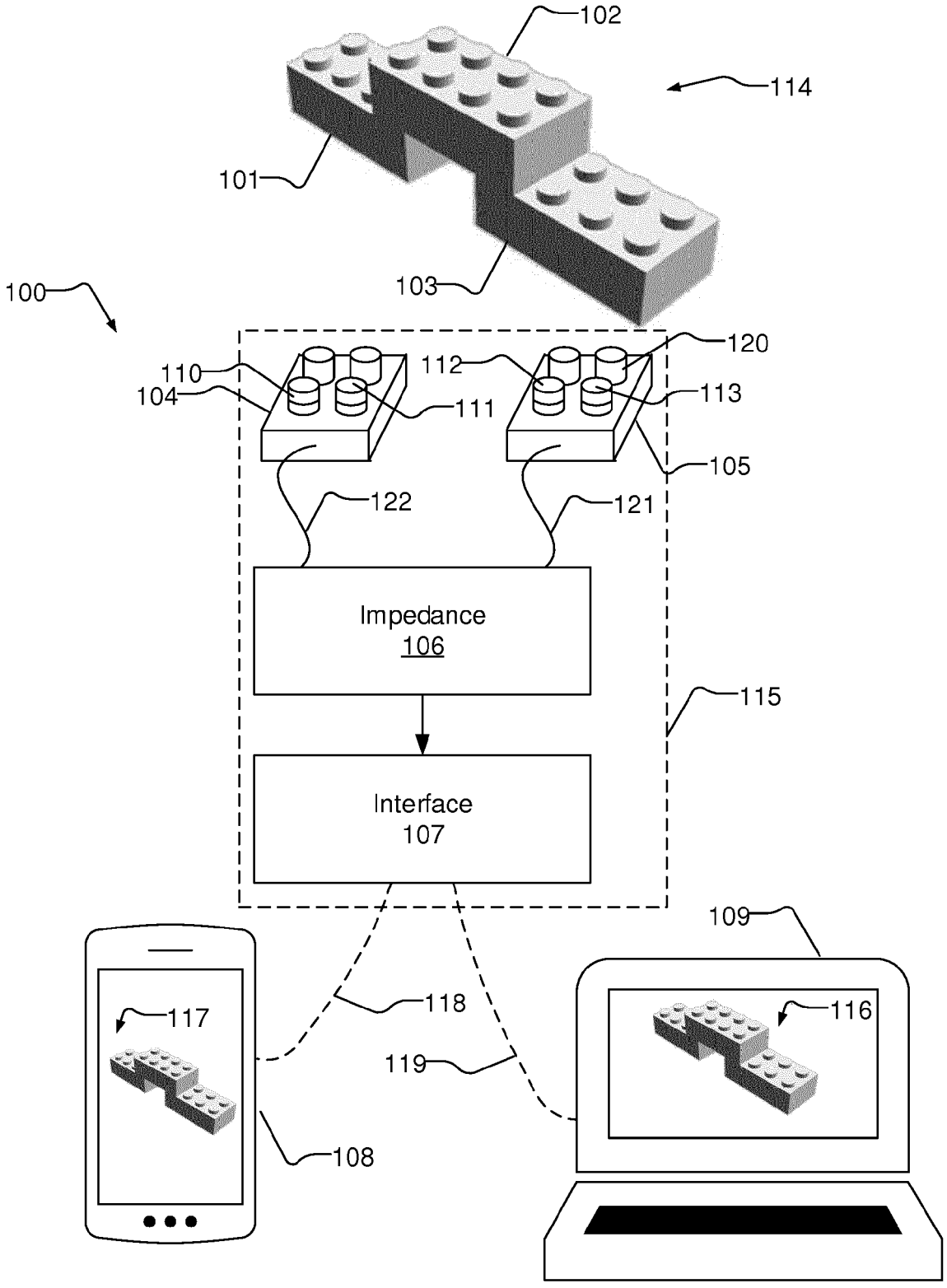
102
114
101
103
100
120
110
112
104
111
113
105
122
121
Impedance
106
115
Interface
107
109
117
118
116
119
108

Fig. 1

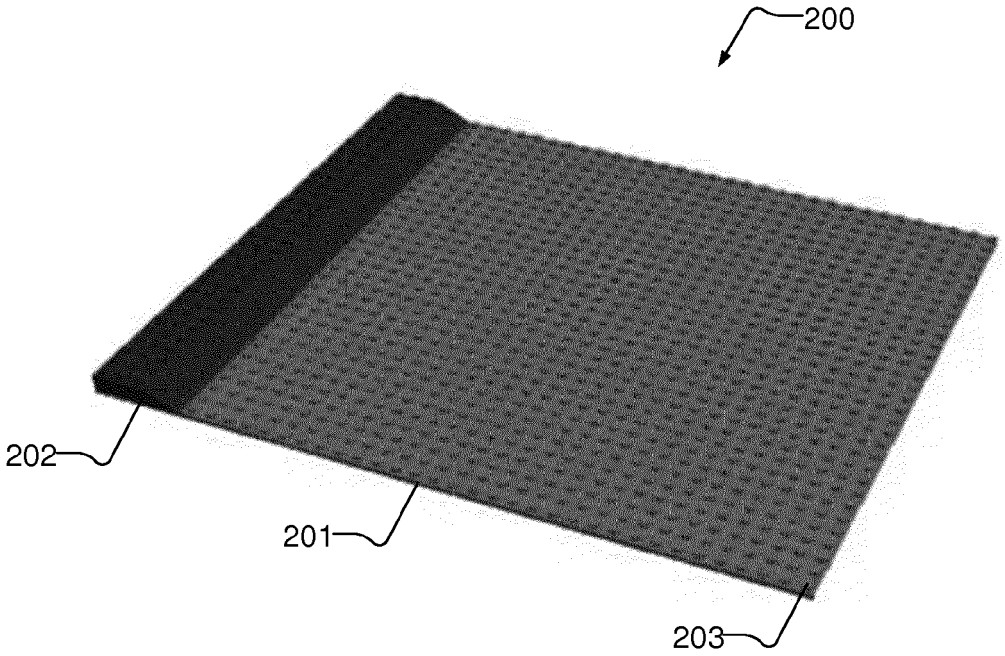
200
202
201
203

Fig. 2

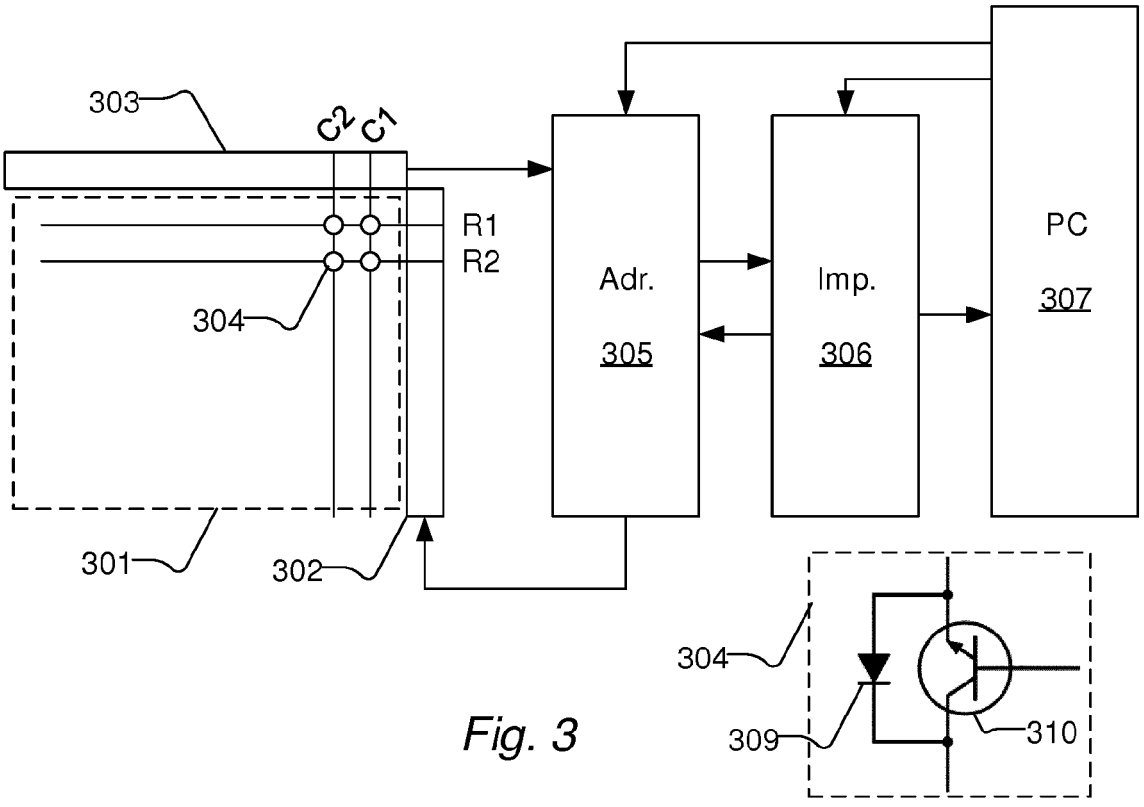
303
C2
C1
R1
R2
304
301
302
Adr.
305
Imp.
306
PC
307
304
309
310

Fig. 3

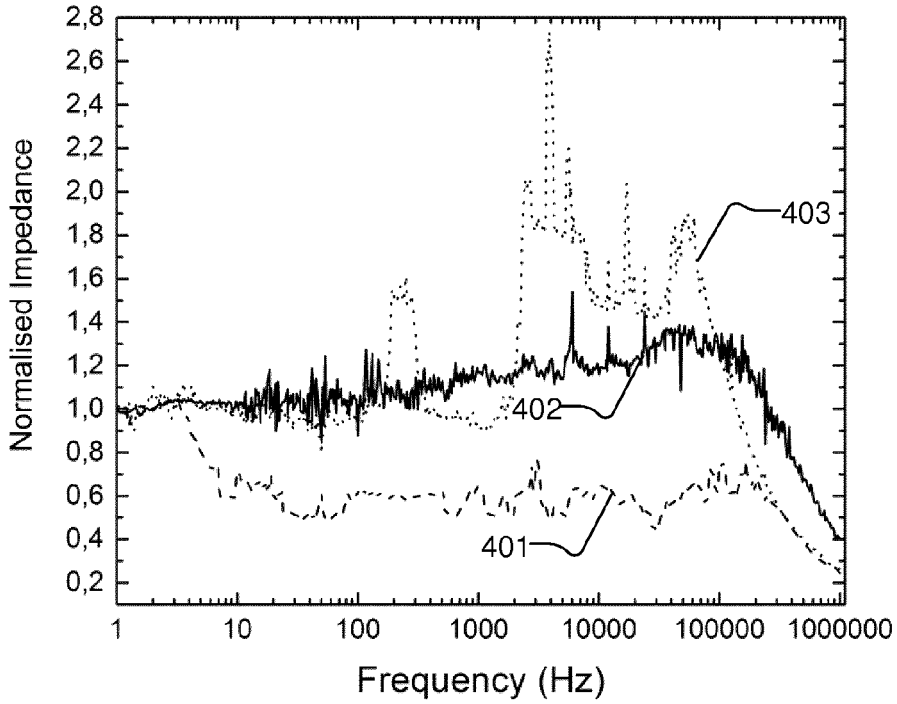
Normalised Impedance
2,8
2,6
2,4
2,2
2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
1
10
100
1000
10000
100000
1000000
Frequency (Hz)
403
402
401

Fig. 4

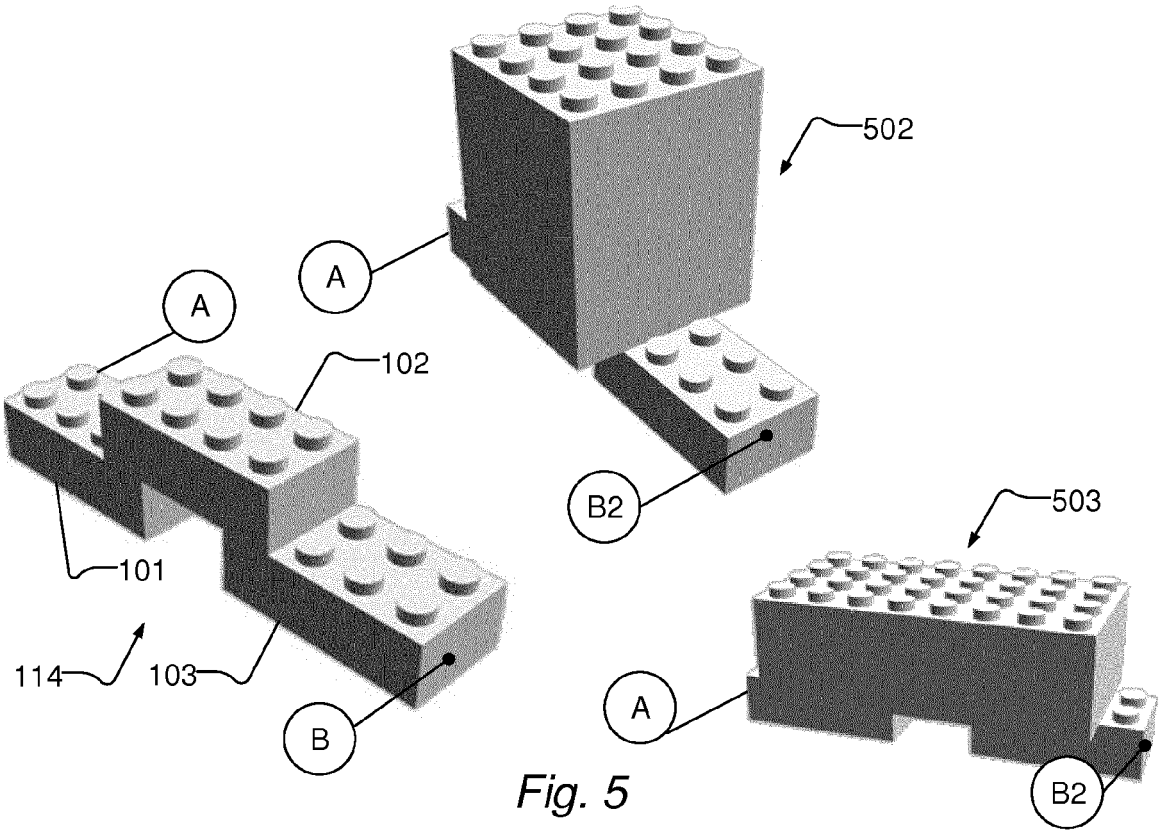
502
A
A
102
101
114
103
B
B2
503
A
B2

Fig. 5

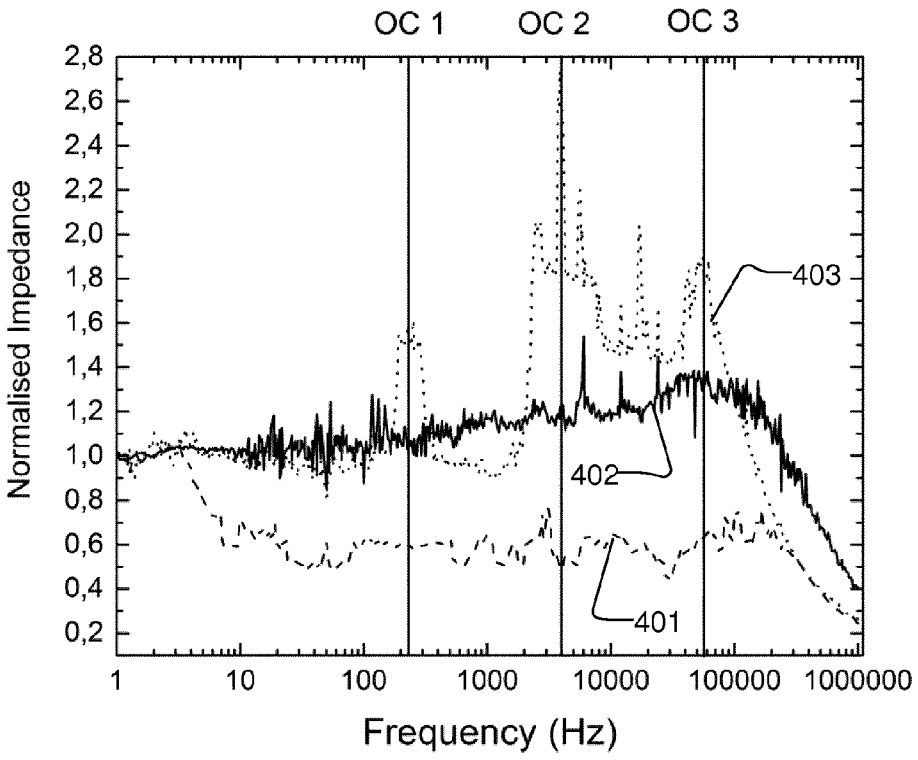
OC 1
OC 2
OC 3
Normalised Impedance
2,8
2,6
2,4
2,2
2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
403
402
401
1
10
100
1000
10000
100000
1000000
Frequency (Hz)

Fig. 6

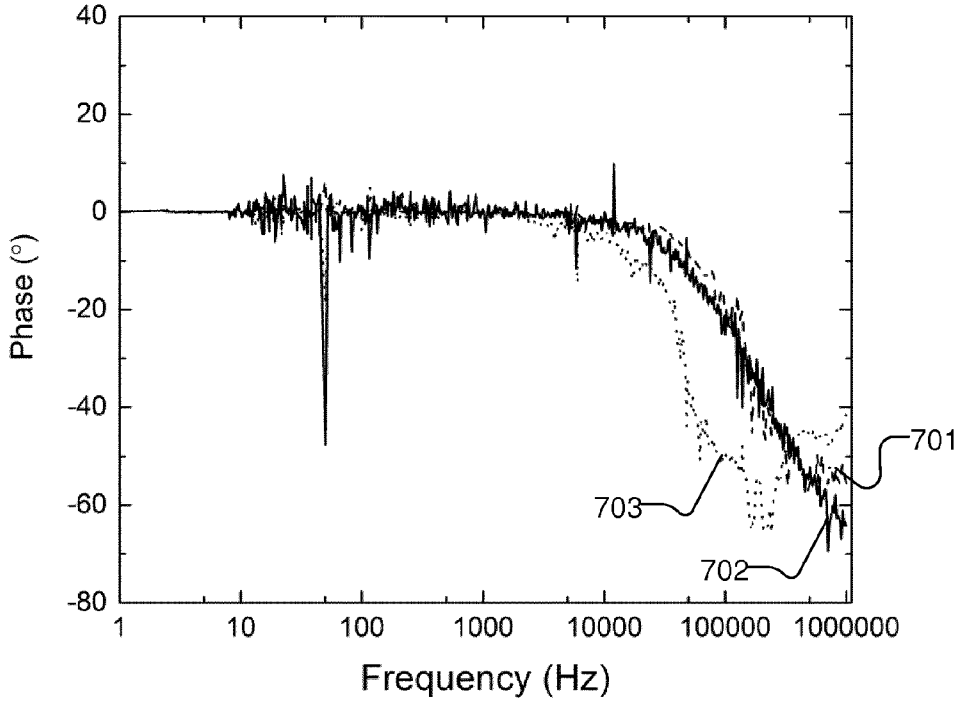
Phase (°)
40
20
0
-20
-40
-60
-80
701
703
702
1
10
100
1000
10000
100000
1000000
Frequency (Hz)

Fig. 7

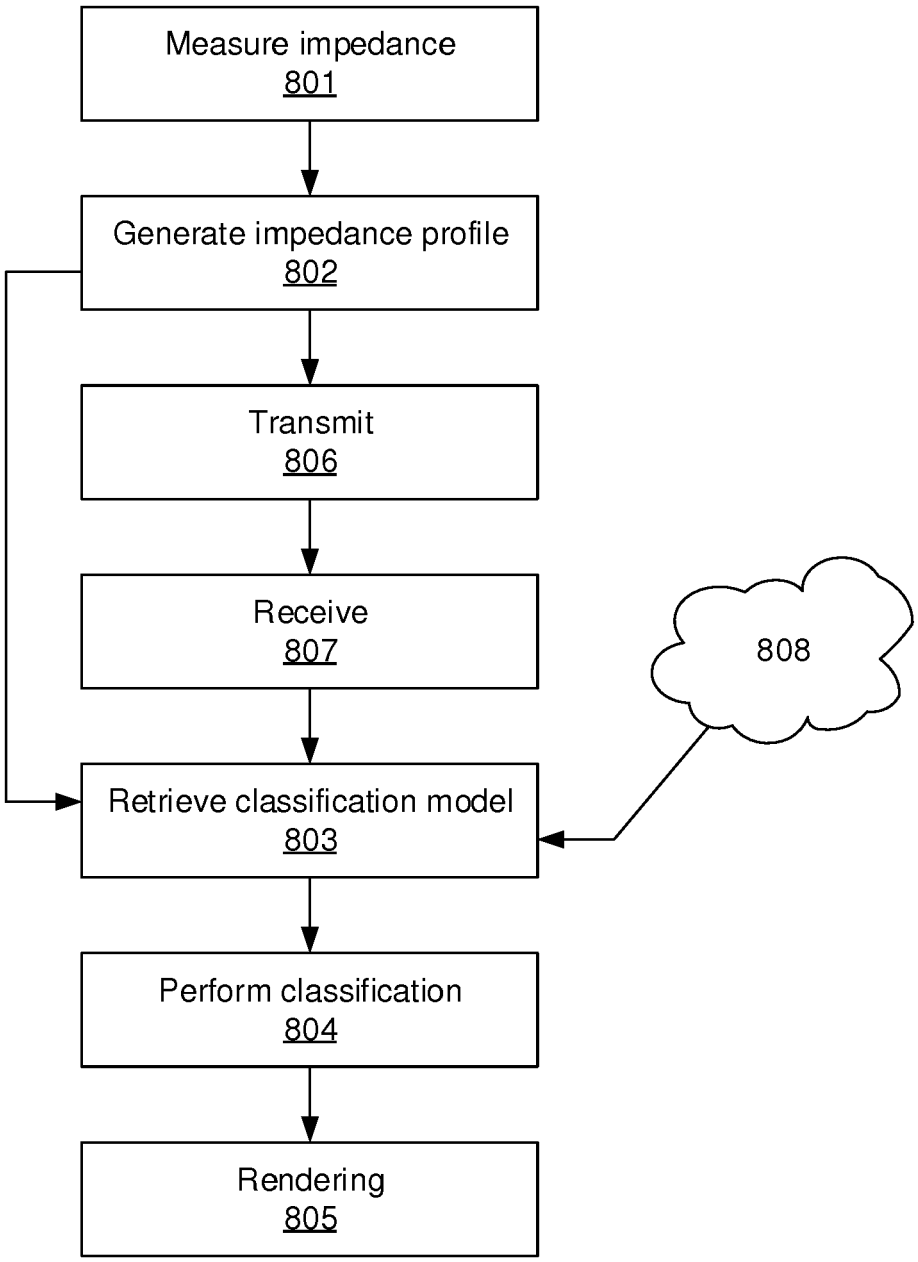
Measure impedance
801
Generate impedance profile
802
Transmit
806
Receive
807
808
Retrieve classification model
803
Perform classification
804
Rendering
805

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 16 19 0718

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A	* page 22, line 22 - page 29, line 21; figures *	1-6	

X	EP 1 271 415 A1 (GATEWAY INC [US]) 2 January 2003 (2003-01-02)	7-15	
A	* paragraph [0011] - paragraph [0045]; figures *	1-6	

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A	* page 19, line 19 - page 39, line 29; figures *	1-6	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	24 March 2017	Lucas, Peter

CATEGORY OF CITED DOCUMENTS

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