5 and 7 are connected to ground when not connected to a current source. The remaining electrodes are connected to ground. Considering the neighboring electrodes 2, 4, 5 and 7, the electrodes 2, 4, 5 and 7 are connected to ground for just half of the time, and are connected to the current sources for the remaining half of the time. Averaging over time, there is no current going in or out and this can be seen as a high-impedance state.

[0044] In FIG. 7C, sequential high-speed switching is carried out in the order of "a first state where four electrodes, the electrode S the a position for stimulation, the left neighboring electrode 4, the lower neighboring electrode 7, and the left diagonally neighboring electrode 6, are connected to the current source", "a second state where four electrodes, the electrode S at the position for stimulation, the right neighboring electrode 5, the lower neighboring electrode 7, and the right diagonally lower neighboring electrode 8, are connected to the current source", "a third state where four electrodes, the electrode S at the position for stimulation, the upper neighboring electrode 2, the right diagonally upper neighboring electrode 3, and the right neighboring electrode 5, are connected to the current source", and "a fourth state where four electrodes, the electrode S at the position for stimulation, the upper neighboring electrode 2, the left diagonally upper neighboring electrode 1 and the left neighboring electrode 4 are connected to the current source". The electrodes 1 to 8 are connected to ground when not connected to the current source. The remaining electrodes are connected to ground. Considering the upper, lower, left and right neighboring electrodes 2, 4, 5 and 7, electrodes 2, 4, 5 and 7 are connected to ground for just half of the time, and are connected to the current sources for the remaining half. Averaging over time, there is no current going in or out and this can be seen as a high-impedance state. Regarding the diagonally neighboring electrodes 1, 3, 6 and 8, a state where the amount of current flowing in and out as an average over time is small compared to the case of continuing connection to the current source or ground.

[0045] FIG. 7D shows carrying out of switching between "a first state where six electrodes, the electrode S at the position for stimulation, the left neighboring electrode 4, the lower neighboring electrode 7, the left diagonally lower neighboring electrode 6, the right neighboring electrode 5 and the right diagonally lower neighboring electrode 8, are connected to the current source", "a second state where six electrodes, the electrode S at the position for stimulation, the upper neighboring electrode 2, the right diagonally upper neighboring electrode 3, the right neighboring electrode 5, the lower neighboring electrode 7, and the right diagonally lower neighboring electrode 8 are connected to the current source", "a third state where six electrodes, the electrode at the position for stimulation, the upper neighboring electrode 2, the right diagonally upper neighboring electrode 3, the right neighboring electrode 5, the left diagonally upper neighboring electrode 1, and the left neighboring electrode 4 are connected to the current source", and "a fourth state where six electrodes, the electrode S at the position for stimulation, the upper neighboring electrode 2, the left diagonally upper neighboring electrode 1, the left neighboring electrode 4, the lower neighboring electrode 7, and the left diagonally lower neighboring electrode 6". The electrodes 1 to 8 are connected to ground when not connected to a current source. The remaining electrodes are connected to ground. Considering the diagonally neighboring electrodes 1, 3, 6 and 8, the electrodes 1, 3, 6 and 7 are connected to ground for just half of the time, and are connected to the current sources for the remaining half. Averaging over time, there is no current going in or out and this can be seen as a high-impedance state. Regarding the upper, lower, left and right neighboring electrodes 2, 4, 5, and 7, a state where the amount of current flowing in and out as an average over time is small compared to the case of continuing connection to the current source or to ground.

[0046] In FIG. 7, the one electrode (current source electrode) at the position for stimulation and "8-neighboring" neighboring electrodes 1 to 8 are shown but there may also be a plurality of electrodes at the position for stimulation and the way of setting the neighboring electrodes is by no means limited to "8-neighboring". Further, in FIG. 7, a two-dimensional matrix-shaped electrode array is shown but the manner of arranging the plurality of electrodes for the electrode array is by no means limited to a matrix shape and, for example, a linear or curved one-dimensional arrangement, or arrangement of a plurality of electrodes in a concentric manner centered about a certain electrode is also possible.

[0047] The proposed procedure for high-speed localized switching goes through the following:

[0048] (1) With electrical stimulation using a half-bridge circuit that does not possess a high impedance mode,

[0049] (2) using properties that nerve axons provide time-averaging electrical stimulation that is less than its time constant,

[0050] (3) by adjusting time averaging of current flowing into/flowing out of electrodes by high-speed switching of the current source and ground,

[0051] (4) it is possible to make a state equivalent to the current flow being zero (high-impedance), and

[0052] (5) stimulation of nerve axons of deep sections is possible.

[0053] Typically, not only can the time average for the current be made zero, but by changing the ratio of time an electrode is taken to be a current source and time an electrode is put to ground, it is possible to make an arbitrary electrical field below the skin.

[B] Visual-Tactile Conversion System

[0054] In this specification, a description is given of the present invention based on a visual-tactile conversion system that is a preferred embodiment. According to the visual-tactile conversion system disclosed in this specification, in addition to the present invention, several independently established new technological ideas are incorporated. In the following description, these new technological ideas as well as the present invention will be described. The technological ideas incorporated into the visual-tactile conversion system are as described below, with [B-5] corresponding to the present invention.

Hardware:

[0055] [B-1] Hardware configuration with a low-speed camera;

[B-2] Finger mount and electrode with a round tip;

[B-3] Volume adjustment using a force sensor; and

[B-4] Measurement of stimulation current/voltage and utilization of this information. Algorithm for electrical stimulation of nerves:

[B-5] High-speed localized switching; and