[B-6] Reduction of stimulation period duration.

[B-0] Overall Configuration of Visual-Tactile Conversion System

[0056] FIG. **8** is a view showing an overall configuration for a visual-tactile conversion system provided with the high-speed localized switching method of the present invention. This system has an electro-tactile display and a camera. A preferred embodiment of the visual-tactile conversion system has a mouse-shaped device as shown in FIG. **9**. An electro-tactile display T comprised of an electrode array is provided on an upper surface of the device, and a camera C is provided on a lower surface of the device. The electrode array comprises 64 electrodes arranged in a matrix shape with vertical rows of sixteen electrodes and horizontal rows of four electrodes. The diameter of each electrode of the electrode array is 1 mm, with an interval in a vertical direction being 1.25 mm, and an interval in a horizontal direction being 2.5 mm. The 64 electrodes can be selectively connected to a current source or to ground via a 64 channel half-bridge circuit.

[0057] The camera is designed to cover magnification factor from one to 16. For all magnification scales, the size of images obtained by the camera is the same as the size of the electro-tactile display or larger. For example, in the case of sixteen times magnification, it is necessary for a 1/16 partial image to be displayed with at least sixteen pixels (number of electrodes) in the vertical direction. The camera requires at least 256 (=16×16) pixels in the vertical direction. The camera is equipped with a CMOS image sensor as an imaging device, and has a performance of 50 [fps] at 352×288 pixels. Moreover, an intensity value of a position corresponding to 16×4 electrodes (average value of pixel values of a pixel region corresponding to one electrode) is calculated from image information (352×288 pixels) obtained by the camera.

[0058] A control section of the visual-tactile conversion system is comprised of an MPU, FPGA for tactile display use, and FPGA for camera use. The MPU acquires image intensity information inputted by the CMOS image sensor via the FPGA for camera use, and instructs the presentation of stimulation pattern information to the FPGA for tactile display use based on the acquired information. The FPGA for tactile display use switches over the switches of the half-bridge circuit and selectively connects electrodes to current sources or to ground so as to supply current to the electrodes in such a manner as to present predetermined stimulation pattern information. The visual-tactile conversion system has an input section that is inputted with information such as pressing force from a finger, skin impedance, and current volume adjustment etc. Current supplied to the electrodes is then regulated as necessary based on this inputted information. Further, the visual-tactile conversion system is capable of exchanging information with a desktop computer via an input/output section.

[B-1] Visual-Tactile Conversion in Combination with the Camera

Background and Object

[0059] The OPTACON is known as a system for carrying out visual-tactile conversion using a tactile display in combination with a camera. The OPTACON is a device that converts optical information inputted from a small-type camera into vibrations of pins so as to enable reading of characters and shapes by finger. With the OPTACON, the output of high-speed image measuring apparatus (a camera) correlates directly to stimulation intensity of each stimulating pin. The OPTACON uses mechanical vibrations to provide stimulation but the inventors of this application have developed the same kind of system using electrical stimulation. In the case of the OPTACON, the camera is held in the right hand and tactile sensations are presented to the left hand, whereas with the device developed by the inventors of this application, the camera is mounted on the tactile display, and is handled using the same hand. According to the visual-tactile conversion system of the prior art, the update period for the camera and the stimulation is in the order of 200 frames per second regardless of whether the stimulation is mechanical stimulation or electrical stimulation.

[0060] Current cameras such as for mobile phones etc. are much more prevalent and have become miniaturized. If such products proliferating the market are utilized, it is possible to make visual-tactile display at a much cheaper price than at present, and it is thought that this will play a role in causing the use of such display to become more widespread amongst the visually impaired. However, the now widespread small-type cameras only have image updating periods in the order of 15 fps and this information therefore cannot be used as is in tactile display. This is because tactile sensing has a time resolution in the order of 5 ms. Research has therefore been exhaustively made into how to adopt visual-tactile conversion system so as to make use of low speed cameras.

[Resolving Means 1 (Interpolation Using Velocity During Use of Low-Speed Cameras)]

[0061] First, current velocity is calculated from the newest image and a past image. This is possible by using well-known correlation calculations for between images. Next, the movement thereafter is estimated using the calculated velocity and stimulation is carried out in line with this estimation. As a result, for example, stimulation is possible every 200 fps, i.e. every 5 ms, even if camera image information is only acquired every 15 fps, i.e. every 66 ms. The situation here is shown in FIG. **10**. The size of the image acquired by the camera is sufficiently large compared to the stimulation region. In this example, movement in a right upper direction is calculated, with stimulation taking place during movement of the stimulation region to the upper right taking place as a result. When image acquisition takes place every 66 ms and stimulation takes place every 5 ms, velocity is calculated every one image acquisition, and stimulation occurs 66/5=13 times based on this velocity and image. It is still preferable to prepare other means for this velocity detection because calculation cost of the calculation of correlation between images is high. For example, preparation of a separate velocity detection mechanism used in a mechanical or optical mouse may also be considered.

[Resolving Means 2 (Making High-Speed by Utilizing Interlaced Scanning in the Case of Using an Interlaced-Type Camera)]

[0062] Many of the cameras that are currently prevalent conform to standards such as NTSC, PAL and SECAM, etc. These cameras adopt interlacing methods. Namely, first, just half of the scanning lines of all of the scanning lines are scanned every other line and the remaining half are then scanned (FIG. **11**). Namely, two vertical scans are carried out to pick-up one image. A stimulation pattern is generated every