Development of Pointing Device to Use Vision for People with Disability

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Abstract

Persons suffering from ALS disease present symptoms of muscular deteriorations. Muscular deteriorations often impede communicating actions like uttering voice or pushing buttons. In order to support their communication, a device to use vision is proposed. This device can be settled apart from the bed of the patient. This means the device do not interfere with the nursing care. This device is developed for ALS patients who have ability to move his head intentionally. The head movement is measured by an original compact vision system. Corresponding to the head movement, the computer mouse on the computer display is moved. This device enables fast input operations. This device is applied to ALS patients. Applicability of this input device is confirmed.

1. Introduction

Everybody should be able to enjoy his independent life. However, patients suffering from ALS (Amyotrophic Lateral Sclerosis) are difficult to live independent lives. They need intensive cares by care-workers. As a typical symptom of ALS patients their muscular functions deteriorate rapidly. In two or three years after the onset of the disease, patients are obliged to use artificial respirators since even the breathing action becomes difficult. Once they start to use the artificial respirator, uttering voice becomes impossible. In such a physical situation, they are usually confined to bed and possible physical actions are limited to slight movements of head, fingers, lips or eyes. Therefore, their relationships with society are extremely limited. However, recent development of computer technology and network technology brought great benefits to those peoples.

Using the computer and network system, they can communicate and talk with others in far places even if they are confined to bed. Computer systems to support their communication are already commercialized. But difficulties remain at input devices for them. Considering the deteriorated muscular ability, some input devices for ALS patients were developed. Those input deices are categorized as a stand type and a wearable type [1]. The stand type devices include touch switches, laser sensors and vision sensors. These devices are usually attached to the bed or table and used to detect some body movements. The wearable type devices introduce sensors like acceleration, angle, strain and EMG (Electromyogram) sensors that are attached to the patient’s body. These sensors measure physical movement or condition of the patient body and input signal is activated based on the data measured.

Input devices to use a vision system have distinguished advantages over the other devices that the devices can be applied to ALS patients in a variety of ways [2], [3]. The vision device can be settled apart from the bed. This means care workers can be free from annoying sensors, wires and mechanical parts around the bed. Furthermore, the device can be applied to detect various body movements like lips, fingers, eyebrow as well as eyeball. It is also important to note that the vision devices have a supreme feature to reject miss-operation by introducing tactful image processing. Vision techniques only to process images of eyeball were already reported since eyeball movement remains possible even if the physical situations of ALS patients become serious [2], [3], [4].

In this paper an input device to use vision for ALS patients are proposed. An image processing technique is introduced to extract intentional slight body movements.

This input device corresponds to a two-dimensional pointing device [5]. This input device requires the operator’s remaining ability to move his or her head two-dimensionally. The input device measures the two-dimensional head movement of the operator. The operator is requested to wear an LED mark on his forehead. The raster coordinates of the LED mark are obtained by an image processing board. The board is compactly composed of one FPGA chip and one chip CPU.

This input device is incorporated into the computer system to support communication of the patient. In order to test the applicability, this communication system is applied to ALS patients. Test results revealed the feasibility of the system.

2. Configuration of Communication Device

Proposed communication systems are composed of a computer, a remote controller and an input device as shown Fig.1. In the computer communication software developed for the people with disability is installed. And a remote controller is composed of an infrared light remote controller. As an input device composed of a camera and an image processing board is employed. The input device is used to detect the body movement of the user. By processing the sequential image of the body, intentional movement of the body is extracted. Once the intentional movement is detected, the control signal is transferred to the personal computer.

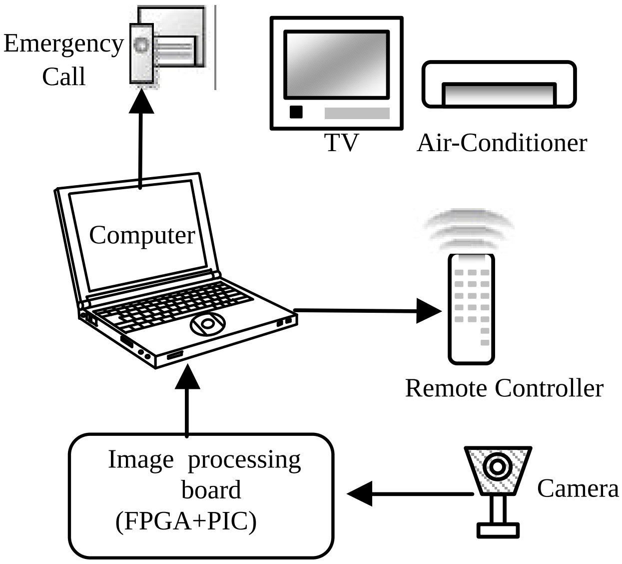

Fig. 1 Configuration of communication device

This system is applied able to detect variety of body movements like lips, eyes, and fingers. Considering the application to ALS patient with capability to move his head two-dimensionally, an efficient input device is recommended. In Fig.2, a proposed pointing device is shown where a LED light reflector is attached to the forehead of the operator. A compact image processing board detects the raster coordinates of the LED light in the image. The image processing board is composed of one FPGA (Altera EPM9320ALC84-10) and one CPU chips (PIC16F876: Microchip Co. Ltd.). The logic circuit implemented on one FPGA chip executes the real time image processing.

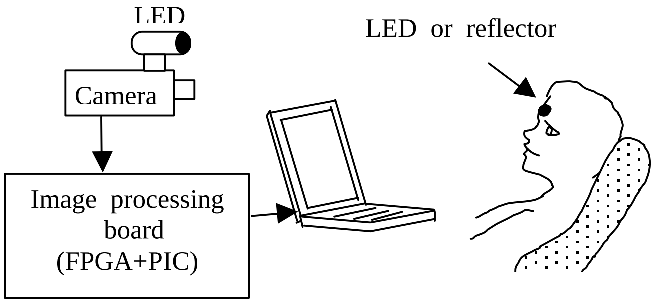

Fig.2 Pointing device to use vision

Immediately after the movement is detected, the communication software in the computer responds. The communication software has two main functions to write texts and to control various home electric appliances. Using these functions, the user can call family members at home, talk with them and enjoy TV programs he wants.

3. Detection of Head Movement

At every frame the image processing board detects raster coordinates of the brightest pixel in the image. Firstly every image is converted to binary one by considering the maximal brightness obtained in the preceding image. An example of resultant binary image is shown in Fig.3. The proposed image processing board detects the leftmost and the rightmost horizontal coordinates of the bright cluster as U_L and U_R. Similarly, the top and the bottom vertical coordinates V_T and V_B of the bright cluster are detected.

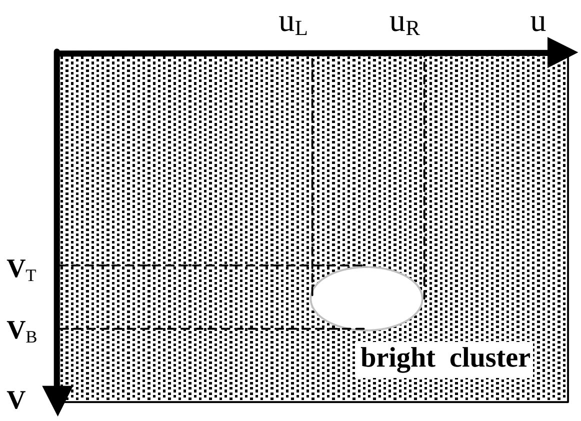

Fig.3 Image of bright cluster

Fig.4 shows the block diagram of the logic circuit to perform the real-time image processing. From the video signal, the Sync. Signal generator extracts horizontal synchronous signals H and vertical synchronous signals V.

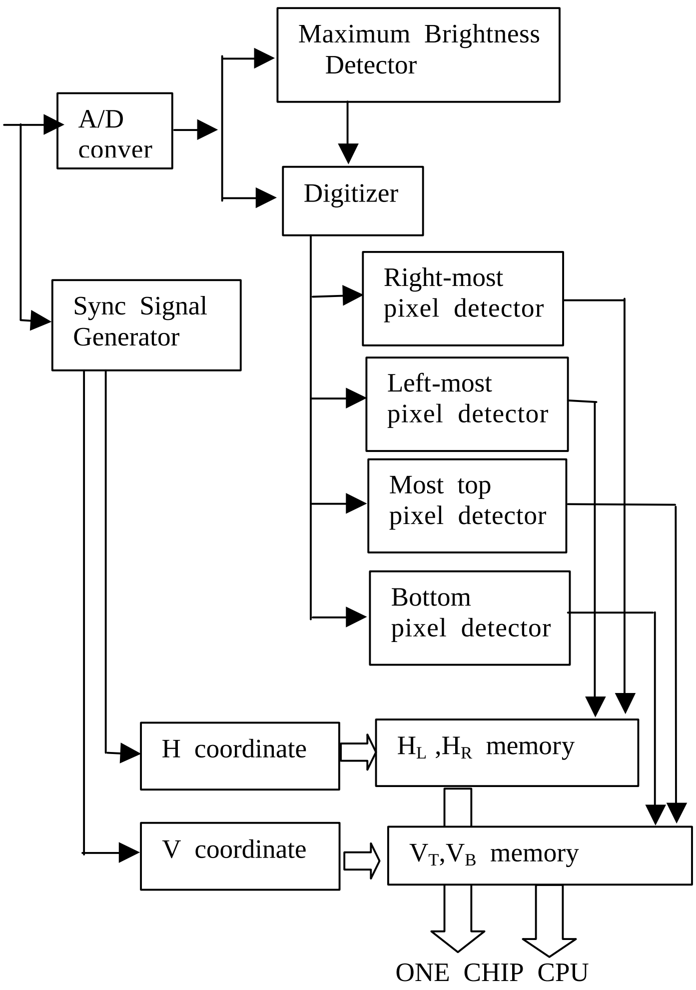

Fig.4 Block diagram of image processing

Using these H and V signals, horizontal coordinate (H coordinate) and vertical coordinate (V coordinate) of every pixel can be determined.

At the maximum brightness detector the video signal is converted to 8-bit digital data and the brightest pixel in the image is extracted. At Digitizer the video signal converted to binary one based on the threshold level. From the binary image, the value U_L, U_R, V_T and V_B in Fig.3 are obtained. An image of the target LED is shown in Fig.5.

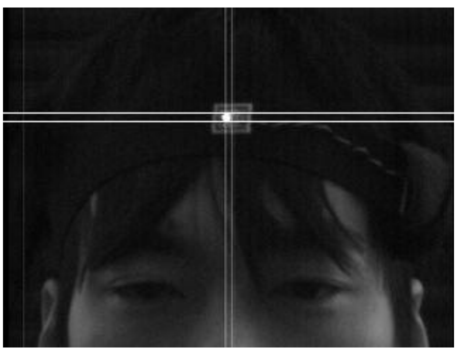

Fig.5 Image of target LED

The data are transferred to one chip CPU. The one-chip CPU checks the size of the rectangular. Once the size is allowable, the central coordinates of the bright cluster are transferred to the computer. The computer uses the raster coordinates of LED light as the positioning data of the computer mouse.

4. Evaluation of Pointing Accuracy and Field Test

Pointing accuracy of the input device explained in section 3 was evaluated by healthy examinees without any physical disability. The data obtained by the pointing device were used to locate the mouse pointer on the computer display in proportion to the head movement. A camera (CCD sensor with 570H×480V resolution) was settled 200cm apart from the examinee. The examinee was requested to move his head so that the mouse pointer traced the rectangular shape in the computer display. One example of the test result is shown in Fig.6. The examinee moved his head 4cm in the horizontal direction and 3 cm in the vertical direction. The positioning error in the computer display

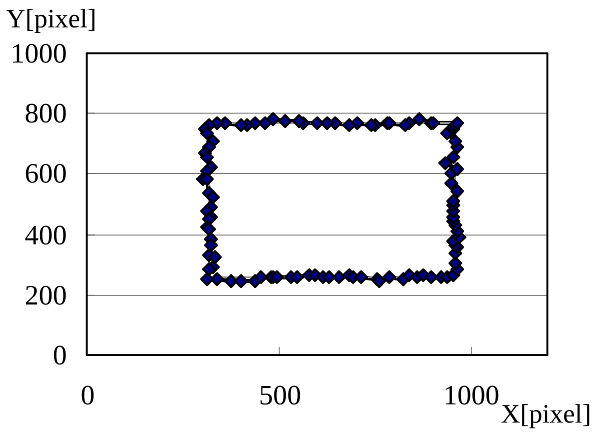

Fig.6 Tracing test along rectangular

was less than 10 pixels, which corresponds to about one percent in the horizontal and vertical direction on the display. Five examinees tried to trace the rectangular on the computer display. The positioning accuracy was less than 10 pixels. The required time was shown in Table 1.

Table 1 Time required to trace rectangular

User No.	1	2	3	4	5
Time Required	26 sec	36 sec	53 sec	38 sec	54 sec

The pointing device was applied to write a text. A computer display of the communication software is shown in Fig.7. In the lower half of this display many buttons were arranged. To each button one character or one function was allocated. Moving the computer mouse onto the target button and keeping it on the target button for a pre-specified interval ? T the desired character is selected.

By selecting the desired characters sequentially, desired text could be completed as shown in the upper half of the display.

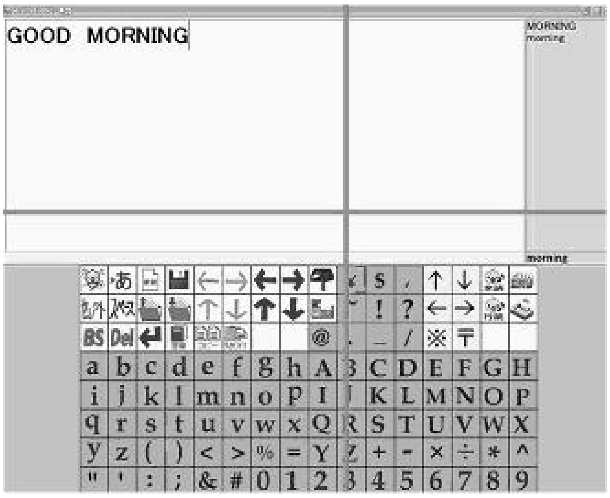

Fig.7 Computer display of communication system

Using this communication system, examinees wrote the text “GOOD MORNING” under two values of ? T. Table 2 shows time required to write the text. For ? T=0.5sec, all examinees finished to write the text “GOOD MORNING” in 30 seconds. This means one character takes around 2.5 second to select. For ? T=1.0sec, around 40 seconds are required. The speed was compared with that of conventional communication system to use a touch sensor. Conventional system always required more than three minutes.

Table 2 Time required to write “GOOD MORNING”

User No.	1	2	3	4	5
Trial 1 $\Delta T = 0.5$ s	26	28	22	29	26
Trial 2 $\Delta T = 1.0$ s	34	39	33	43	35

Fig.8 shows a prototype of the proposed image processor board, where one FPGA, one PIC (one chip CPU) and one A/D converter chips are mounted. This one PIC communicates with the computer via serial communication line.

This system was applied to an ALS patient who was difficult to move his hands. He succeeded to operate the communication system effectively using proposed input device as shown in Fig.9.

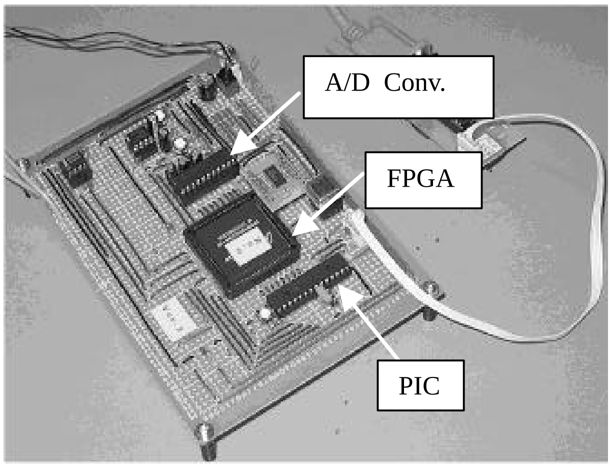

Fig.8 Image processing board

Fig.9 Operation by two-dimensional input device

5. Conclusions

A vision sensor is proposed as an effective input device of a communication system. Different from the conventional devices like a touch sensor and a push button, the proposed vision sensor could extract operator’s intentional movement with enough accuracy rejecting disturbing body movements. A distinct feature of this technique is that vision sensor is used as a two-dimensional pointing device. This device enabled fast operations of the communication system. Communication systems to employ this vision device were applied to ALS patients. The patients successfully could communicate with their families and operate electric devices by using the communication device.

In this paper we focused on the simple and robust algorithm to use vision sensor for the ALS patients. Considering various symptoms of the ALS patients, also other algorithms need to be developed based on the remaining ability of the ALS patient.

References

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