DEVELOPMENT OF THE INTEGRATED TONGUE OPERATION SYSTEM TO CONTROL A POWERED WHEELCHAIR AND AN AAC DEVICE FOR SERIOUSLY DISABLED PEOPLE

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SUMMARY
We have tried to develop an Integrated Tongue Operation System (ITOS) to control a PWC and an AAC device for seriously disabled people. The targets were operated through a mouthpiece type remote controller by users' tongue movement. This remote controller has 4 RFID IC chips, but no battery. In this paper, the specifications of the ITOS were explained, and the evaluation was carried out.

The results suggest that the ITOS would be effective and possible to apply to feasible using for serious disability people.

INTRODUCTION
There are a lot of kinds of impairment, and their causes and the symptoms are various. People with high level cervical cord injury, muscular dystrophy, or Amyotrophic Lateral Sclerosis (ALS) can move only their eyes, mouth, teeth and tongue voluntarily, but they can't move their hands and fingers in order to operate even assistive devices i.e. an electric Powered Wheelchair (PWC). In the more severe cases, disabled people can't speak. This limits their ability even to communicate their needs and wants to caregivers.

For the devices to control PWCs, chin control system is very popular, also voice, head, and eye motion control systems are applied. The tools for Augmentative and Alternative Communication (AAC), transparent communication boards, speech generating devices and static communication devices are common. But each system has its own merits and demerits. Therefore, there are many requirements in the development of new operation devices for such seriously disabled people.

We have tried to develop an Integrated Tongue Operation System (ITOS) to control a "PWC" and a "PC as an AAC device". Those targets are operated through a mouthpiece type remote controller by users' tongue movement[1]. In our laboratory, we have focused on tongue movement to develop a new operation device for severely disabled people. The tongue can move quickly and accurately, and the most of seriously disabled people can move their tongue voluntarily. These factors indicate that the tongue has sufficient potential to operate some control devices.

This is a preliminary work to develop the ITOS. In this paper, we will explain specifications of the ITOS to control a "PWC" and to operate a "PC's mouse" to use it as an AAC device. Then we evaluated the effectiveness of this system.

DESIGN SPECIFICATION AND MECHANISM

THE GENERAL DESIGN AND OPERATION SYSTEM FOR A PWC

The ITOS consists of the mouthpiece type remote controller that operated by users' tongue, RFID identifier (TR3-MD001E, Takaya Corporation, Japan), PWC (MC-16, Suzuki, Japan) and its control unit (cRIO 9014 with NI9263, National Instruments, USA; following referred to as cRIO). The mouthpiece type remote controller would be inserted into the user's mouth and fixed on the upper jaw. This remote controller has 4 IC chips of passive type RFID transponder. Since they can generate electricity by electro-magnetic induction, and they can transmit their ID codes without a battery. This remote controller has 4ch of movement functions of FORWARD, BACKWARD, RIGHT and LEFT to operate a PWC. The receiving antenna of the RFID identifier would be set near the user's mouth, like a "Hands Free Microphone". The system configuration is illustrated in Fig. 1.
INVESTIGATION OF EFFECTIVENESS OF THE ITOS

OPERATIVENESS OF THE PWC

To investigate the operativeness of the ITOS, the driving course was set as shown in Fig. 2. 4 healthy (able-bodied) male candidates drove a PWC using by ITOS in "Momentary mode" (PWC keeps moving only while the remote controller's switch was depressed), "Latch Mode" (a single switch push directs the PWC to move continuously for a period of time) and by a normal joystick. The driving times by the ITOS and by a joystick were measured. Each candidate drove 5 times and the average time and standard deviation were calculated.

OPERATIVENES OF THE "TONGUE MOUSE SYSTEM" FOR ACC

To investigate the operativeness of the "Tongue Mouse System" as the AAC mode of the ITOS, 5 healthy male candidates input prescribed sentence by the "Tongue Mouse System" mode of ITOS and by a normal mouse. Each candidates input 10times and the average time and standard deviation were calculated.

RESULTS AND DISCUSSIONS

OPERATIVENESS OF THE PWC

Table 1 shows the results of required time to input the prescribed sentence using by a normal mouse and by "Tongue Mouse System" mode of ITOS.

Table 2 shows the results of required time to input the prescribed sentence using by a normal mouse and by "Tongue Mouse System" mode of ITOS.

Table 1: Course driving times by a Normal Joystick and by the ITOS.

<table>
<thead>
<tr>
<th>Operating Application</th>
<th>Operating Mode</th>
<th>Driving Time (mean ± 1S.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Joystick</td>
<td>---</td>
<td>50.6 ± 1.6</td>
</tr>
<tr>
<td>Mouthpiece Type Remote Controller</td>
<td>Momentary Mode</td>
<td>102.9 ± 30.3</td>
</tr>
<tr>
<td></td>
<td>Latch Mode</td>
<td>92.3 ± 23.1</td>
</tr>
</tbody>
</table>

Table 2: Input time of the prescribed sentence using by a Normal Mouse and the Tongue Mouse System mode of ITOS.

<table>
<thead>
<tr>
<th>Input Modes</th>
<th>Settelle Time for Decision [sec]</th>
<th>Required Time [sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Mouse</td>
<td>by Click</td>
<td>12.6 ± 1.7</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>41.7 ± 1.5</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>57.2 ± 5.3</td>
</tr>
<tr>
<td>Tongue Mouse</td>
<td>/ by Finger</td>
<td>70.0 ± 5.2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>80.3 ± 2.8</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>81.7 ± 15.4</td>
</tr>
<tr>
<td>Tongue Mouse</td>
<td>/ by Tongue</td>
<td>85.3 ± 5.7</td>
</tr>
</tbody>
</table>

OPERATIVENES OF THE "TONGUE MOUSE SYSTEM" FOR ACC

There is no significant difference between the results of finger and tongue operation of "Tongue Mouse System". The input time was mostly depending on the setting of the automatically-input-time. The input time of by "Tongue Mouse System" was around 1.5 times as long as by normal mouse's. This suggest that the "Tongue Mouse System" mode of ITOS would be effective and it's has the possibility to apply to feasible using.

CONCLUSIONS

We have tried to develop the ITOS to control a PWC and an AAC device for seriously disabled people. They are operated through a mouthpiece type remote controller by users' tongue movement. The remote controller has 4 RFID IC chips, but no battery. In this paper, the specifications of the ITOS were explained, and the evaluation was carried out. The PWC driving time by the ITOS was about up to 2 times as long as by a normal joystick's time. The required time to input the prescribed sentence using by Tongue Mouse System mode of ITOS was around 1.5 times. They still are within a permissible range. These suggest that the ITOS would be effective and it's has the possibility to apply to feasible using.

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REFERENCES