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Controlling a Drone by the Tongue – A Pilot Study on Drone Based Facilitation of Social Activities and Sports for People with Complete Tetraplegia

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***Abstract*— Tetraplegia is a devastating condition, resulting in severe disability and isolation from social activities and entertainment. Drones may provide a severely paralyzed individual the possibility of participation in drone-sports and thereby in social interaction and further it may give a sense of freely moving. However, individuals with tetraplegia currently lack options for controlling a drone. Researchers at Aalborg University have developed a wireless intraoral tongue computer interface (ITCI) for disabled users. This study investigates the possibility of controlling a drone by the ITCI. One able-bodied experimental participant controlled the drone using a standard keyword, the ITCI while keeping it in the hand, and by mounting the ITCI inside the mouth and using the tongue. The performance of the ITCI was compared with respect to the keyboard. The mean distance from the target and the mean flight time were 36% and 16% greater when using the ITCI inside the mouth with respect to controlling by the keyboard.**

I. Introduction

Tetraplegia is a condition of losing voluntary motor function in the four limbs (legs and arms). This means a long life of extreme disability, complete lack of independence and very low quality of life. These individuals are susceptible to depression and anxiety because of their condition [1]. Thus, there is an increasing demand for systems that can provide them the possibility of engaging in activities within sports and leisure. This may help them to socialize with friends and improve their quality of life. Drones can provide the possibility of sports and social interaction for disabled individuals as can they embody greeting gestures [2] and give a sensation of mobility.

Tongue functionality usually remains intact after an SCI. Sophisticated motor control and manipulation capability, non-invasive access to tongue motion and fatigue-resistant characteristic of tongue muscle fibers are features that have resulted in the development of tongue-operated assistive technologies. Several tongue-based interfaces have been introduced and tested recently. In some of them, a set of switches are embedded in a mouthpiece that is mounted under the hard palate. The switches are activated either by a pressure from the tongue tip [3] or by the effect of a ferromagnetic material attached on the tongue on inductive sensors [4]. Ghovanloo et al. [5] used magnetic sensors to monitor the tongue movement and convert it to control commands for electronic devices. Further, the "Think-a-Move" system analyzes the acoustic patterns generated by flicking the tongue to the gum and identifies the intended commands [6]. Detecting the tongue movement by optic sensors [7] and by processing EEG signals [8] are other approaches for designing a tongue-operated assistive device.

An inductive tongue control interface (ITCI) was recently developed [4][9] and used for different applications as an interface for electronic devices. Incorporating 18 sensors, a dedicated mousepad and a keypad, it is currently the tongue-based computer interface that facilitates the highest number of command signals. This study, as a proof of concept, examined the deployment of the ITCI as a control interface for a drone.

II. Methods

The ITCI consists of a mouthpiece unit (MU), a central unit (CU) and an activation unit (AU) (Fig. 1). It provides the functionality of a wireless keyboard, mousepad or joystick. A commercial version of this system, the iTongue, is available by TKS-Technologies [10].

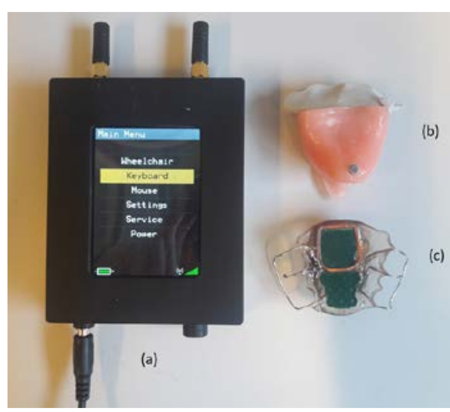

Fig. 1. The inductive tongue control interface modules. a: The central unit, b: The activation unit on a phantom tongue, c: The mouthpiece

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The MU is mounted intraorally under the hard palate. A ferromagnetic activation unit attached to the tongue it activates the sensors on the MU. The CU receives the sensor signals, processes them, and transmits data to the PC using Bluetooth communication. The Parrot AR Drone 2.0 Power edition was interfaced with a laptop by Wi-Fi connection and a dedicated software (ArDroneController_1.6 [11]).

One able-bodied 27 years-old male participated in the study. Three control modalities were assessed and each modality was studied using eight trials (2 rounds with 4 targets, totally 24 trials). The task in each trial was to "takeoff" the drone from the initial point, fly it to a position above one of the targets, and finally land the drone on the target point. The initial point of the drone was at the center of a circle with 3 meters diameter and the targets were 4 points on the circumference. The control modalities were: 1) using a standard computer keyboard, 2) using the ITCI while keeping it in the hand, and 3) by mounting the ITCI inside the mouth and using the tongue. During the trials, the subject was in front of a laptop screen and facing to the flight field. Visual Feedback software from the iTongue system used to provide a graphical feedback of the sensor that is currently activated.

We measured the flight time, from takeoff to landing, and the distance from the center of the drone to the target point after landing manually by a stopwatch and a tape measure respectively in each trial. Average values and standard deviations of these two parameters were calculated.

III. Results

The abled-bodied participant succeeded in controlling the drone with the keyboard, the manually activated MU and by intraoral tongue activation of the MU. The mean value and standard deviation (Std.) of the distance from target and the flight time for each modality are shown in Table 1. Furthermore, the deviation of the mean values obtained from control methods by ITCI with respect to keyboard control were calculate (Dev.). Using the keyboard was the most accurate method with a mean error of 14 cm. The mean error in reaching the targets with the ITCI was 27 cm and 19 cm using hand and tongue respectively. The mean flight time for all the modalities was similar (25 s, 24 s and 29s); however, it took 16% more time to control the drone with the tongue comparing with the keyboard.

TABLE 1. PERFORMANCE OUTCOMES FOR THE THREE CONTROL MODALITIES

	Distance from Target [cm]			**Flight Time [s]**		
	Mean	***Std***	***Dev.***	***Mean***	***Std***	***Dev.***
Keyboard	14	12	-	25	5	-
ITCI_Manually	27	17	93%	24	6	4%
ITCI_byTongue	19	11	36%	29	13	16%

IV. Discussion

This study was conducted as a proof of concept to assess the feasibility of controlling a drone using the ITCI. It was shown that it is possible to control the drone by the tongue using the ITCI with an error of 19 cm while the accuracy of using a standard keyboard was 14 cm. We should consider the dimensions of the drone (52x52 cm) when interpreting the mean error values (14, 27, 19 cm). It shows that the errors are less than 52% of the drone diameter suggesting that all the three methods resulted in a successful performance.

In this experiment, the subject was trained for using the ITCI by the tongue for 30 minutes prior to the trials. More training could improve the proficiency of the user in utilizing the ITCI and lead to a higher accuracy in reaching the targets.

V. Conclusion

To our knowledge, this study for the first time demonstrated that it is possible to control a drone by the tongue. Thereby, the ITCI provides a possibility for individuals with tetraplegia to control a drone and socialize through e.g. drone sports. Future work will include tongue-based 3D control of the drone for more complicated tasks and experiments with more able-bodied and disabled participants.

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