FlyingBuddy2: A Brain-controlled Assistant for the Handicapped

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ABSTRACT
The motor impaired people have much limit in moving. The devices augmenting their mobility will be much helpful for improving their living experiences. This poster develops a brain-controlled assistive system, called *FlyingBuddy2*, to aid the handicapped in mobility. It uses the brain EEG signals to directly control a quadrotor. Signals from an EEG headset are transmitted wirelessly to a computer, then the decoded brain signals are converted to trigger the quadrotor to move in 3D space. Three applications are developed: thinking to play games, thinking to see, and thinking to take pictures.

Author Keywords
Assistive technology, brain-computer interface, quadrotor.

ACM Classification Keywords
K.4.2 [Social Issues]: Assistive technologies for persons with disabilities.

General Terms
Design, Human Factors.

INTRODUCTION
According to the 2011 WHO's world report on disability [1], about 15% of the world's population lives with some form of disability, of whom 2-4% experience significant difficulties in functioning. Governments are finally recognizing that people with disabilities face significant barriers to recreation, sport, and wellness, and that access to these opportunities are more critical to people with disabilities than those without disabilities. For example, people with physical disability (such as quadriplegic) are often trapped in a wheelchair. They cannot go anywhere they want to go by themselves, or play games with the normal people. It is becoming a very important factor of a smart environment that how well it can facilitate the handicapped [2, 3].

In recent years, brain-computer interface is becoming a natural way to augment human capabilities by providing a direct communication pathway between the brain and an external device, and is particularly relevant as an aid for disabled people. The BCI technology can be seen as a special assistive technology [4]. At the same time, consumer oriented EEG headsets are becoming considerably cheaper and easy-to-use. There are many BCI-based applications emerging in the pervasive computing community. Andrew et al. designed a NeuroPhone system, which allows neural signals to drive mobile phone applications on the iPhone using Emotiv EPOC EEG headset [5]. Haapalainen et al. use a wireless EEG headset and other sensor devices to measure the psycho-physiological signals for assessing cognitive load [6]. And EEG signals have already attracted the interest of researchers in fatigue prediction [7] and game developers [8].

In this poster, we develop an EEG controlled quadrotor named FlyingBuddy2. It is an extension on our previous work [9], in which we developed an intelligent flying system named FlyingBuddy. The main difference between FlyingBuddy2 and FlyingBuddy is that the former is also suitable for people who have a difficulty in interacting with outside world through traditional ways (such as voice and action). With the camera installed in AR.Drone's bottom and front, it can augment mobility and perceptibility of the handicapped.

SYSTEM OVERVIEW
The system architecture of FlyingBuddy2 is illustrated in Figure 1. It is composed of three components: signal processing, control strategy, and AR.Drone control application. The EEG data acquisition device uses the Emotiv EPOC EEG headset, which is a commercial product. It can be effortlessly set up and connected to a computer. AR.Drone is a quadrotor. It has an ultrasound telemeter for altitude measures, two cameras separately mounted in the bottom and front, and many other motion sensors.

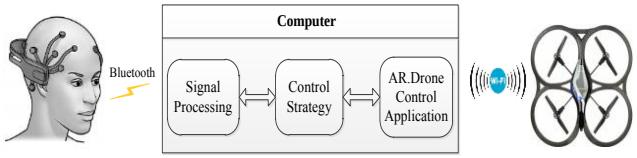

Figure 1. System Architecture

AR.Drone control application module gets commands from control strategy module, and sends it to the AR.Drone through Wi-Fi. Also it constantly receives the video streams and motion parameters from the sensors. Signals processing module evaluates real time brainwave activity to discern the intents of the user. The amplitude of filtered brain signals is used as feature that reflects ERD/ERS, by means of quantification of different temporal-spatial patterns, we could detect three motor imagery brain activities: think left,

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UbiComp'12, September 5-8, 2012, Pittsburgh, USA.

think right, and think push. Eye blinking and tooth clenching can introduce artifacts to EEG signals, which can also be detected and converted to specific control commands.

In our control strategies, we use "think left hard" to take off/land, "think left lightly" (It can be distinguished from the former by signal strength) to fly clockwise, "think right" to fly forward, "think push" to fly up, "clench" to fly down, "neutral (idle)" to hover, "blink" to take pictures. Sometimes we trigger the "fly clockwise" order when we think left to land, but this doesn't matter at all.

USER SCENARIOS

The handicapped are often trapped in a wheelchair for their dysfunction. After someone can smoothly control the FlyingBuddy2, it could be a good assistant (see figure 2) and enhance his ability to do the things he could not do before. When the system is utilized, the following scenarios can be demonstrated.

Figure 2. FlyingBuddy2 and the Handicapped

Thinking to Play Games

Games can bring happiness. In this video, we design a boxing game, in which the handicapped could play with the normal people. One boxer is the FlyingBuddy2, and the other boxer is the AR.Drone which is driven by handheld devices. The loser is the one who first falls to the ground or flies out of the box ring. The handicapped can use "fly up", "fly down" and "fly forward" to escape the enemy's attack, use "fly down" to pressure on the enemy, and "fly forward" to push the enemy out of the edge of boxing ring. It is very funny and full of challenging. Other games, such as race and VR games, can also be designed for FlyingBuddy2.

Thinking to See

People with physical disabilities often must rely upon assistive devices such as wheelchairs, crutches, canes, and artificial limbs to obtain mobility, and cannot gain access to inaccessible building or scenery. FlyingBuddy2 can be used as a telescope, real-time video stream from both cameras will be sent to the laptop screen which is in front of the handicapped via Wi-Fi.

Thinking to Take Pictures

FlyBuddy2 can be used as a mobile camera. The disabled can mind control AR.Drone to the right place, adjust the front camera's position and angle, through the real-time video on the screen, he could choose which scene he wants. By continuously blinking four times, he could trigger the camera to take pictures, and the picture will pop up on the laptop screen instantly. Thus, FlyingBuddy2 can be used to photography and play self-timer.

CONCLUSION

We develop a system to augment mobility and perceptibility of the handicapped, and implement three applications: thinking to play games, thinking to see, thinking to take pictures. We believe this system will enrich life of the disabled. The more intelligent the plane is, and more advanced the BCI technology is, the more we can do. Maybe one day in the future, the handicapped can use brain to drive a mini plane in which they were seated, and go anywhere they want to go.

ACKNOWLEDGEMENTS

This work is partly supported by Qianjiang Talent Program of Zhejiang (2011R10078).

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