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A wireless brainwave-driven system for daily-life analyses and applications

Wei-Yen Hsu

Department of Information Management, National Chung Cheng University, No. 168, Sec. 1, University Rd., Min-Hsiung Township, Chiayi County 621, Taiwan

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ABSTRACT

Smartphones have become more popular in our lives. We will no longer need to use our hands to control phones to do such things as take pictures, switch music, or make phone calls in the future; we will use our brains: all that can be controlled with the use of brainwaves instead. In this study, we implement a novel system that contains the most commonly used functions of a smartphone, including camera use and music play, with an app that uses brainwave controls. In addition, we also provide an essential daily-use function which can remind us to concentrate when we drive, study, or do something important. Under the proposed system, when the wireless brainwave instrument is worn, brainwave signals transfer to the smartphone via Bluetooth automatically and execute the aforementioned functions. Experimental results indicate that the present system is effective and suitable for such applications in our lives. In the future, some more related applications will be developed with brainwave control for practical daily-life uses.

1. Introduction

According to the National Communications Commission (NCC), the number of mobile subscribers in Taiwan in the first quarter of 2016 was 29.19 million. The penetration rate of mobile phones was 126%, which means that Taiwan's population should have at least one phone each. Thus, we can see that Taiwan's mobile communication is universal and that phone technology has become a product widely accepted by users. The data show that user age has been a declining trend in mobile phone usage. Because of demand and expectations, phone use has gradually become more diverse and convenient, from initial commercial use into the daily lives of people and as an indispensable necessity at work (Jokela et al., 2015). As technology advances, smartphones also progress and provide more and more innovative features for the user (Bert et al., 2014). Nokia led the early innovations which have since evolved into today's Apple and Samsung smartphones. Several years ago, the largest mobile phone corporation was Nokia. At that time, the phone was not only used for talking, but could also be used to listen to music, take pictures, play games, and surf the internet; it was multi-function electronic media.

However, the phone was still not as good as a "Walkman" or a regular camera at that time. Time flies, and the biggest phone leader has changed (Agar, 2013). Apple and Samsung are now the largest smartphone corporations. With their latest products, the iPhone7 + and Note7, respectively, whether in the camera or music, there are more changes than ever believed possible for camera and music applications. The Walkman is almost non-existent now, having been completely replaced by the smartphone. Smartphones now have great capacity, a small size, excellent sound quality, and rich features in music apps, allowing users to enjoy more music and changing the music and the music-player industries. The need for a separate camera, too, has almost been replaced by the smartphone, due to clear picture quality, a fast camera speed, and intuitive operation. What's more, the smartphone's camera app also

E-mail addresses: shenswy@gmail.com, shenswy@mis.ccu.edu.tw.

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can crop, edit, decorate, and upload to social networking sites to share photos with friends instantly (Luo et al., 2014; Tanbeer et al., 2014; Buettner, 2016). Smartphones have been integrated into our lives, bringing a variety of conveniences. However, there are still inconvenient times to use the phone. For example, when we take group pictures and make sure everyone is in the picture, including ourselves, but it's difficult to hold the phone and press the shutter oneself; we want to find someone to help but can't and we have to use the troublesome camera timer. Some people are used to listening to music while driving or running in order to enhance vitality or relieve boredom and tedium, but the song heard may be one we don't want to hear, and we are afraid of causing an accident or being slowed down by interacting with the mobile phone, so we can only endure while the song finishes.

In addition, we often hear in daily news about accidents caused by tired drivers, resulting in serious injury or death. These tired drivers face time and monetary costs from injuries and legal problems, not to mention that these accidents might also result in someone's family being shattered and cause a lifetime of regret (Redelmeier et al., 2012). Although we believe that drivers understand how serious the dangers are of falling asleep at the wheel, because of working long hours, not having enough sleep, and so on, many drivers find it difficult to avoid driving when tired (Rodgers et al., 1995; Haghighi et al., 2013). In a survey of motorists, more than 4% had in the previous months dozed off while driving. According to a report by the United States' Centers for Disease Control and Prevention, the tired driver has become one of the main causes of traffic accidents in that country. The U.S. National Highway Traffic Safety Administration estimates that every year five thousand to six thousand traffic accidents are associated with driving when tired. According to European Union (EU) statistics, in Europe there are about one hundred thousand car accidents a year, involving about one hundred twenty-five thousand car crash victims. Just over 8% of European accidents are caused by drowsy driving, leading to nearly seven thousand deaths a year. In the United Kingdom, twenty percent of fatal accidents and twenty-five percent of all car accidents are caused by driving when tired. According to the Taiwan Area National Freeway Bureau, in Taiwan, the category of "tired driver" accounted for over three percent of all of traffic accidents 3.2%. At first glance this does not seem high, but the reality is even more serious: not included in the calculation is that drivers were lost in a reverie but the reality is even more serious: not included in the calculation is the fact that many drivers get lost in a reverie or self-hypnosis without – yet – causing an accident.

A recent Harvard study showed that a normal brain spends, on average, forty-seven percent of time lost in thinking. It further found that a roaming brain is an unhappy brain. People live too short in the world, but spend nearly half their waking lives lost in wandering thought; isn't that a tragedy? In our focus process, we are often distracted by a thought. We spend time worrying about this thought before realizing that, in fact, it was simply underlying anxiety, and now time has quickly passed away. Viewing social networking sites for trends, talking, gossiping, replying to messages… so many trivial things distract our attention and also cause more anxiety, excitement, and unnecessary emotion (Hsu, 2010, 2015a; Crowley et al., 2010; Li and Li, 2014; Hariharan et al., 2016). With the result that we didn't focus on our work or study and now time's up; important things haven't been finished and now we have to spend more time to make up for it, creating a vicious circle that may lead to grades going down or work efficiency being lowered, and other negative effects.

To improve these circumstances, our research uses a new sporty and portable brainwave instrument. Linking a phone to brainwaves, it can detect and transfer brainwaves through a conversion function. As a result, it will calculate a number based on attention and meditation (Rebolledo-Mendez et al., 2009, 2010; Hsu, 2013a, 2017b). When you want to take pictures with a crowd of people, you can put your phone at a distance, concentrate for seconds at a specific level and blink. A nice picture is taken. Take pictures at any time; you don't need to rely on others. Similarly, you can use it the same way to change songs when you listen to music that you just don't like. You don't need to directly touch the phone, you can still change the songs even when it is inconvenient, for example, while driving; this is a safer way to protect life (Yasui, 2009; Hsu et al., 2012; Hsu, 2015b, 2017a). The function of monitored attention can be used not only in the monitoring of fatigue driving, but also in situations of study or work; in other words, where there is a need to focus in daily life. If the user appears in a trance or at inattention, or even falls asleep, it sends an alert to help reduce the risk of accident due to fatigued driving. This feature can help build a safer road environment, and improve our reading and work productivity in daily life, by preventing excessive distractions that lead to time waste and by improving upon poor concentration.

1.1. Contributions

In this study, we propose an innovative app for the smartphone, to take pictures, switch songs, and provide focus reminders using a brainwave instrument. In our app, the brainwave instrument, through conversion functions, will transmit brainwave data to a smartphone so that shutter snaps and songs changes don't require the use of hands. Just focus, reach the threshold, then blink, and the app easily triggers automatic execution. In setting the threshold, the first thing we look for is the best value by experiment. Secondly, we verify the difference between a normal blink and self-blink by blink experimentation. Brainwave amplitude can also vary by user. So we will record brainwaves at the same time, to determine whether the threshold needs to be amended, a small fine-tuning in order to enhance the user's experience. Additionally, focusing reminders can be used in both driving and reading and for various other circumstances where focus is needed. This provides monitoring to increase reading efficiency and reduce driving risk.

2. Literature reviews

2.1. Brainwaves and EEG

The brain has been the most mysterious area of the body in the past, but with advances in brain science the activity of cranial nerves can be obtained by using electrophysiological methods to detect brainwaves (Hsu, 2011, 2013b, 2016; Rose and Abi-Rached,