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SAS4P: Providing automatic smoking detection for a persuasive smoking cessation application

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Abstract

Smoking is the biggest avoidable health risk, causing millions of deaths per year worldwide. Persuasive applications are those designed to change a person's behavior, usually in a specific way. Several mobile phone applications and messaging systems have been used to promote smoking cessation. However, most interventions use participants' self-reports to track cigarette consumption and avoidance, which may not be accurate or objective. Previous proposals have used sensors to track hand movements and other contextual data to detect smoking or have used devices to detect smoke or breath carbon monoxide. This article proposes a low-cost wearable device that may be worn in a front shirt pocket or clipped to clothing to detect smoke and secondhand smoke. Furthermore, the device is integrated into a persuasive application to promote smoking cessation. The device was evaluated through an experiment to detect whether it may detect direct, passive, and no smoking conditions. The results are promising and may help improve tracking of cigarettes in persuasive applications.

Keywords

Health and wellbeing, persuasive technology, Arduino, smoking detection, wearable sensors

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Introduction

In the United States, approximately 15.5% of adults are smokers.[1] Smoking is the biggest avoidable health risk,[2] and it is related to a number of diseases, for example, cancer, cardiovascular diseases, and pulmonary diseases, with serious deleterious effects, and it is estimated that worldwide, direct smoking and secondhand smoking caused over seven million deaths in 2016[3] and are responsible for billions of dollars in healthcare costs every year.[4] In some countries such as Chile, more than 33% of adults are smokers,[5] and although some public health policies have been introduced (e.g. a ban on smoking in enclosed public spaces,[6] graphic warnings on cigarette packages),[7] there is a level of complacency that has hindered efforts to reduce smoking in children and adults in Chile.[7]

Even though no amount of cigarette smoking is considered to be safe, lowering consumption decreases

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cardiovascular disease risk.[8] There is a wealth of research about smoking cessation programs and initiatives: for example, picture warnings, ad bans, and increased taxes have been shown to reduce tobacco use.[9] However, smokers tend to overestimate how likely they are to quit smoking.[10] Studies have reported that 68% of current smokers intend to stop smoking—however, only a third of those who try to stop smoking use evidence-based cessation methods and less than 10% of smokers are actually successful.[11]

Persuasive applications are those designed to change a person's behavior, usually in a specific way.[12] Persuasive technologies may impact health care and can be thought of in terms of the involved technologies, persuasive strategies, and healthcare subdomains—for example, weight loss, nutrition, physical activity, addiction, aging, risky behaviors, and smoking cessation.[13]

Mobile phone applications and messaging have been used to promote smoking cessation, finding long-term benefits in using these interventions, although the existing studies have been conducted in high-income countries with tobacco control policies, and may therefore not be applicable in other contexts.[14] A review of available applications in app stores found that, although some applications based on scientific evidence currently exist, they are difficult to find for consumers[15] and that most applications focus on ease of use rather than implementing evidence-based behavior change techniques.[16] Another review of smoking cessation applications found that existing applications do not sufficiently stimulate autonomous motivation.[17]

Several interventions for smoking cessation currently use self-report through questionnaires, which may be distributed in person or via post, telephone, or the Internet[18] to track smoking. Some proposals to automatically detect smoking have been proposed, with some tracking hand movements[19] along with other data (e.g. heart rate sensors,[20] lighter sensors)[21] to improve detection accuracy. These proposals are discussed in the next section.

This article aims to answer the following research question: is a low-cost smoke sensor able to differentiate between no smoking, secondhand smoking, and direct smoking? To answer this question, we developed an Arduino-based low-cost smoke sensor that is paired with a persuasive application to automatically track how many cigarettes a person has smoked.

This article is organized as follows. First, we discuss related work in persuasive smoking detection applications and automated smoking detection. Then, we present Evitapp, the persuasive application with which the device is paired. The next section introduces SAS4P (smoking automated sensor for persuasive applications), our sensor-based approach to smoking detection. We evaluate the effectiveness of the sensor by differentiating direct and secondhand smoking. Then, we present a discussion of our results and our conclusions.

Related work

Persuasive smoking cessation applications

Computer-based interventions are an effective alternative to in-person interventions for drug misuse;[22] they provide features such as self-monitoring, progress tracking, and daily reminders.[15]

Google Play store (as of August 2019) displays hundreds of applications when searched by the keywords "quit smoking," for example, Flamy, Quit Tracker, Stop Smoking, QuitNow!, myQuitTime, etc. A 2017 review found a few evidence-based applications in both the Google Play and Apple application stores,[15] which are still available as of 2019: Craving To Quit!, 2Morrow's Tobacco Cessation program, also known as SmartQuit (https://www.2morrowinc.com/smoking-cessation), and SF28, or SmokeFree28) (http://www.sf28.co.uk/). SmartQuit aims to provide users with techniques that help them not act on the urge to smoke, by recording urges and completing daily exercises.[23] SmartQuit has been found to have promising rates of quitting,[24] also finding in a small study that smoking was reduced in the short term and in the medium term for a few participants.[23] SF28 is an application that encourages users to become smoke-free for 28 days, providing users with evidence-based behavior change techniques. Abstinence rates from 28 days of use of SF28 suggest that it may be helpful for some smokers.[25]

Many smoking cessation applications send reminders to users in the form of messages—for example, SMS and MMS.[26,27] Users would like text messaging smoking cessation programs to allow them to feel involved with the program, communicate their feelings, and visualize their progress.[28] Anti-smoking messages stressing gains (over losses) and short-term (over long term) consequences have been found to have more effect on smoker attitudes.[29]

Several other applications have been proposed and studied in academic research. A smoking cessation application called Quit Smoking, based on persuasive design theory, highlighted how much users had saved by not smoking (in terms of money and life regained). To report cigarette consumption, the application allowed users to choose whether they had resisted or submitted to their cravings to smoke.[30] A similar approach for an application called SmokefreeNZ asked for users to track each cigarette they smoked or resisted.[31] Most assessments currently use self-report to track smoking.[19] Even though self-tracking offers the possibility of tracking both the effective number of cigarettes smoked and the number of times a user