OVERVIEW ON SNIFFPHONE: A PORTABLE DEVICE FOR DISEASE DIAGNOSIS

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ABSTRACT

We present SNIFFPHONE, a handy and easy-to-use device that allows the non-invasive detection of gastric diseases. It analyzes the user's exhaled breath using specifically developed gas sensors. The device is coupled to a smartphone, which governs the breath analysis process, sends the data measurements to an external data analysis server, and finally gives feedback to the user. In this work, we describe the SNIFFPHONE device and the general platform under development.

Index Terms— breath analysis, SNIFFPHONE, gas sensor, gastrointestinal cancer

1. INTRODUCTION

Analysis of exhaled breath is increasingly gaining attention in medical diagnostics for early disease detection and therapy progress monitoring.[1-4] This is mainly due to the great advantage of being non-invasive, which facilitates the patients' diagnosis process, and of being fast, which allows for easy disease screening over the population.

Detection of diseases from exhaled breath, via volatile organic compounds (VOCs) linked with the disease conditions, has been demonstrated in different fields of medicine, particularly in infectiology, respiratory medicine and oncology using heavy and expensive mass spectrometry techniques and/or array of sensors in conjugation with algorithms for pattern recognition [1]. Nevertheless, all previous and currently available breath studies/projects were unable to develop a screening approach through exhaled breath [1,5]. The insufficient portability and insufficient autonomy of the device, and the lack of an ICT approach for the ethical and security aspects of the disease detection were the major reasons for this obstruction. As a matter of fact, an ideal screening tool is expected not only to identify cancer at an early stage, but also to reveal the presence of benign pre-cancerous conditions so that these can be followed up and/or managed prior to the development of cancer.

In this paper, we present an approach to tackle these requirements by integrating heterogeneous micro- and nano-technologies into autonomous smart system that can be coupled to a mobile phone and analyze disease markers from exhaled breath. We term this approach, SNIFFPHONE. Section 2 explains the SNIFFPHONE concept and method of use of the SNIFFPHONE device, while Section 3 focuses on the device design and working principle. Finally, Section 4 summarizes discussion and conclusions.

2. SNIFFPHONE

2.1 Overall Concept of SNIFFPHONE

Figure 1 shows a scheme of the SNIFFPHONE concept. The SNIFFPHONE sensors response resulting from the breath measurements along with other relevant user information (A) is transferred wirelessly via the phone's internet (B) to an external server for a remote analysis of the collected signals (C). Pattern recognition and statistical methods are then applied on the received data, while considering other clinical information of the same patient. Upon completion of the analysis, a clinical report including the diagnosis results is sent back to clinical doctor for diagnosis and tracking (D) along with a brief feedback to the user (E).

For the sake of demonstrating the viability of the developed technology, we focus our presentation on the detection and classification of gastric cancer and related diseases.

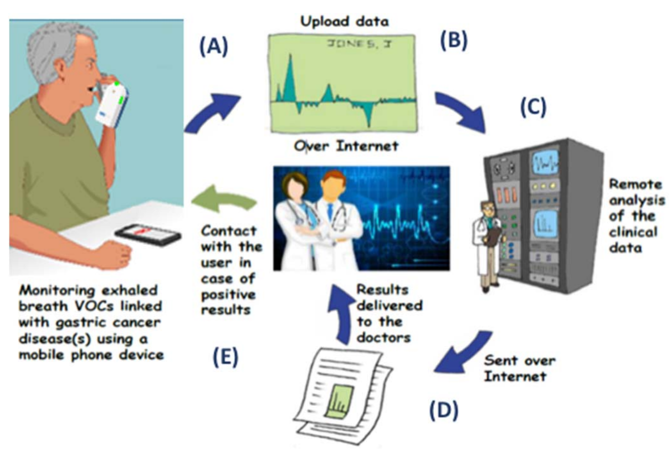

Figure 1. *Illustration of the SNIFFPHONE concept.*

2.2 Using SNIFFPHONE

SNIFFPHONE is easy-to-use for doctors and patients. The usage method is the following. First, the user wishing to

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analyze his/her exhaled breath creates an account on the SNIFFPHONE server, with login and password along with some personal information, such as gender and age. For the breath analysis, the user logs into his/her account using his/her smartphone, fills a brief questionnaire regarding his/her life style at the time of the measurement and triggers the measurement process. The user is guided through all the measurement process with instructions displayed in the smartphone app (Figure 2a and b). Once the measurement is finished, the SNIFFPHONE device sends the measurement data to the smartphone, which in turn sends it to the data analysis server along with the given questionnaire information. Finally, the user receives a feedback message in his/her smartphone related to the result of the data analysis.

3. MATERIALS AND METHODS

The SNIFFPHONE device is coupled to a smartphone via Bluetooth (Figure 1A) through which the measurement data is transferred to the cloud server (Data Analysis Server) for analysis (Figure 1). The device consists of several units; microfluidics, pumps, collection chamber, gas sensor array, auxiliary environmental sensors, breath detectors, electronic unit, all integrated in a case, as shown in Figure 2c. The SNIFFPHONE device operates in two steps; first the ambient air is measured for reference and then the user exhales at a short distance from the inlet of the device. When the user exhales, the beginning and end of his/her breath is detected by a breath detector sensor (NV sensors by Nanovation). Then, the microfluidic system directs the breath sample to the sensors chamber, where the gas sensor array is located.

The breath sampling protocol is designed to sample the deep alveolar end-tidal part of the breath. Thus, the first part of the exhaled breath is discarded by pumping the sample during the first few seconds, determined by the NV sensors. Then, two valves enclose the target part of the breath sample in the sensors chamber, where the sensors are measuring during few seconds until they reach stability. Finally, the sample is pumped out and the chamber is cleaned.

The sensor array contains a chip with eight Gold Nanoparticles (GNP) gas sensors developed at the Technion Institute [6-9] and specifically designed for detecting gastrointestinal diseases and cancer. The GNP sensor technology is an advanced approach for detecting volatile organic compound (VOC) profiles present in breath, which in this application are the VOC biomarker profiles of gastrointestinal diseases with risk of developing cancer [8-9]. Other environmental sensors monitor the measurement conditions, and their responses can also be considered in the posterior data analysis.

4. CONCLUSION

The presented device is a user-friendly, fast and highly portable breath analysis instrument, aimed to be used for non-invasive diagnosis of gastrointestinal cancer. Currently, clinical studies are being conducted in hospitals in Latvia with individuals that has been pre-examined by the conventional clinical system. Results will be analyzed by our partners at VTT Technical Research Centre of Finland Ltd. The results of these studies will be thoroughly discussed in another article, which will be published in the near future.

An additional advantage of this device is that the whole SNIFFPHONE concept can be extended to other diseases, which would be extremely helpful in improving the general health of the population. If successful, SNIFFPHONE will play a key role in the generalization of the VOC analysis for disease diagnostic in clinical practice. Indeed, SNIFFPHONE has been awarded with the 2018 European Commission Innovation Award and the Smart Systems Auction at ICT 2018 in Vienna.

Figure 2. *Screenshots on iPhoneX of smartphone application; sign up for an account (a), breath measurement instructions (b) and SNIFFPHONE device (c).*

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