Demo Abstract: AsthmaGuide: An Ecosystem for Asthma Monitoring and Advice

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ABSTRACT

AsthmaGuide is a smartphone and cloud based asthma system in which a smart phone is used as a hub for collecting a comprehensive collection of information. The data, including data over time, is then displayed in a cloud web application for both patients and healthcare providers to view. AsthmaGuide also provides an advice and alarm infrastructure based on the collected data and parameters set by healthcare providers. With these components, AsthmaGuide provides a comprehensive ecosystem that allows patients to be involved in their own health and also allows doctors to provide more effective day to day care. Using real asthma patient wheezing sounds we develop a new combination of classifiers that is 96% accurate at automatically detecting wheezing. This abstract provides an overview of the design and implementation of AsthmaGuide and provides empirical evidence that AsthmaGuide is 3% – 11% more accurate in detecting wheezing sounds than standard techniques.

Categories and Subject Descriptors

H.3.4 [**Systems and Software**]: User Profiles and Alert

General Terms

Algorithm, Design, Experimentation

Keywords

Asthma Ecosystem, Environment, Advice

1. INTRODUCTION

With the integration of wireless sensor networks in hospitals and homes, healthcare providers are able to provide more accurate and personalized patient care. One group of patients that should greatly benefit from intensified daily monitoring is asthma patients. In the latest surveys by the Centers for Disease Control and Prevention, about 25 million people in the United States have asthma [2]. As of 2011, of these 25 million, 53% of these people suffered from acute asthma attacks [2]. Because there is currently no cure for asthma, the NIH states that the priority for doctors is to assess and monitor these patients as there are usually clear symptoms that indicate an oncoming asthma attack [6]. While it is obviously essential to monitor patients' lung health, per se, environmental factors can also trigger and exacerbate asthma symptoms. These environmental factors include extreme temperatures, extreme humidity or dryness, pollen, smoke, and mold [3]. The actual effect of these environmental factors differs from patient to patient.

Currently, there is no effective way for doctors to monitor asthma patients at home on a day to day basis. Most patients visit their doctors monthly, but once they go home there is a lack of communication between the two parties. Because the course of asthma is dependent on dynamic factors, this loss of daily information is potentially costly. There have been attempts to detect wheezing via machine learning or to make peak-flow measurements convenient [1, 7, 4, 5]. But none of these systems analyzes these factors in an integrated fashion, and they do not consider environmental factors in conjunction with lung health. Also, there are a number of asthma diary systems based on smartphones, but users typically must input all the information with little, if any, data automatically input from sensors.

In this abstract, we provide an overview of AsthmaGuide which is an asthma ecosystem that monitors asthma patients comprehensively. A smart phone is used as a hub for collecting physiological, environmental, human input, and video information. Physiological information includes lung sounds, peak flow values, and blood oxygen level. This information is then pushed to the cloud where doctors and patients can interact with this information. One feature of the cloud web application is the automatic analysis of lung sounds: they are further analyzed and classified as either normal or wheezing. Subsequently, this lung health "diary", as well as the captured environmental information, is available in essentially real time to the health care providers and patients in the form of a web application. Beyond the display of information, AsthmaGuide uses the data to provide specific patient advice. Although there are many potential asthma triggers, they are not applicable to all patients. Thus AsthmaGuide can use the data to act as a personalized coach for the patient. This system in no way replaces the doctor and we are actively working with doctors to better understand the kinds of advice that are appropriate. But this automated advice can help improve patient outcomes

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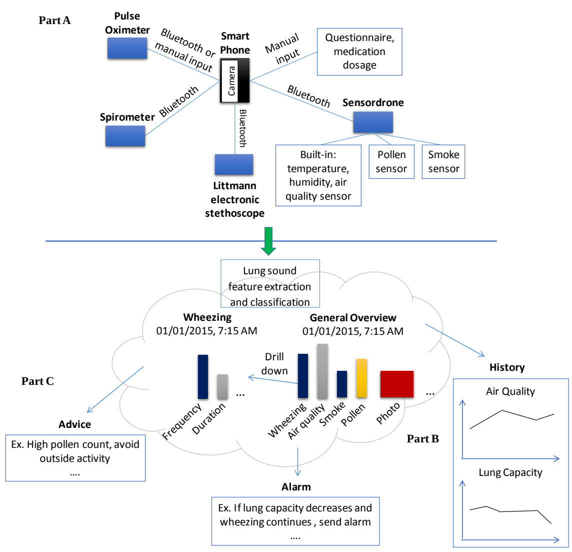

Figure 1: AsthmaGuide overview.

while reducing the workload of the healthcare providers.

The contributions of this system are the following:

- AsthmaGuide which is the first comprehensive monitoring and advice system for asthma patients.
- The development of the wheezing lung sound classifier. Our classifier also uses a combination of support vector machine (SVM) and random forest classifiers, which leads to a more robust system than previous models.

2. OVERVIEW OF ASTHMAGUIDE

AsthmaGuide consists of four main components: an extensive sensor suite, the smart phone hub, the cloud web application, and the advice infrastructure. The sensor suite is where data collection occurs (Figure 1 - Part A). This data is then sent to a smart phone via a physical connection or wirelessly via Bluetooth. There are multiple sensors which can connect and transmit data to a smart phone via Bluetooth or physical connection. Patients can also take photos and/or videos of themselves with the in-phone camera, which can help healthcare providers understand their health via this built-in telemedicine modality. Some data cannot be obtained via sensors, so patients will be able to enter this information manually into the phone. Lastly, we provide a way to record patient lung sounds using a Littmann 3200 electronic stethoscope.

Once all of this data is collected, it is then pushed to the cloud where the data is stored and further analyzed (Figure 1 - Part B). The last part of our system is the advice (Figure 1 - Part C), which is based on the collected data and parameters set by healthcare providers. For example, if a patient's lung capacity decreases as dust increases, AsthmaGuide can recommend that the patient vacuum more often.

3. EVALUATION ON WHEEZE DETECTION

In order to develop an accurate classifier, we focused on three types of models: C4.5 Decision Trees, Random Forest models with C4.5 trees, and SVM. The first three rows of Figure 2 show the results when using all of the features for the three types of models. The results show that of the three models, the random forest classifier performed the best

Classifier	Sensitivity (Wheezing Accuracy)	Specificity (Normal Accuracy)	Overall Accuracy
SVM	58/63 (92%)	15/21 (71%)	73/84 (87%)
Decision Tree (C4.5)	58/63 (90%)	18/21 (62%)	71/84 (85%)
Random Forest Classifier	60/63 (95%)	18/21 (86%)	78/84 (93%)
Combination	62/63 (94%)	19/21 (95%)	81/84 (96%)

Figure 2: Using a combination of classifiers is 3% – 11% more accurate than standard techniques.

with an accuracy of 93%. In order to build a more accurate classifier, next we combined the results of all three classifiers in order to take advantage of their strengths. It achieves the best result for sensitivity and specificity with a best overall accuracy of 96%.

4. DEMO SCRIPT

The objective is to demonstrate how AsthmaGuide operates and how it can allow patients to become involved in their own health and healthcare professionals to provide up-to-date care. In this demo, the user will be using a smart tablet, the AsthmaGuide sensor suite, and a Littmann electronic stethoscope. The user opens the AsthmaGuide application which prompts the user to collect lung sounds and measure lung capacity; takes a 'selfie' type picture of the user; and allows entry of his administered medication dosage from the previous day. At the same time, the sensor suite is collecting environmental data and sending it to the smart tablet. At the end of the process, the user will click on a button which sends the lung and environmental data to the cloud. Once in the cloud, the lung sounds are classified as normal or wheezing. AsthmaGuide will display the user's lung and environmental information visually on a screen.

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