Food Intake Monitoring System for Mobile Devices

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***Abstract*—In this paper, we introduce a real-time food intake monitoring system for mobile devices. The proposed system gets acceleration data from the sensor placed on the wrist of the user during a meal. The data is then sent to the mobile device via Bluetooth. The system analyses patterns between the motion profile and bite actions by first filtering the data to remove noise effects and then identifying the peaks. Based on detecting peaks, real-time feedback regarding eating trends such as total number of bites, bites-taken rate and eating speed is provided to the user. If the eating is too fast, the system warns the user in the form of both audio and text. The mobile application is implemented on the Android Platform and tested on a subject successfully. The proposed system offers an affordable quick solution that can be used in any place where eating happens. It can help people who are obese or with other eating disorders by monitoring consumption of food intake to control their eating rate in real-time.**

I. Introduction

Obesity is a medical condition in which excess body fat has accumulated to the extent that it may have an adverse effect on health, leading to reduced life expectancy and/or increased health problems [1]. Overweight is generally defined as having more body fat than is optimally healthy [2]. Obesity and overweight pose a major risk for serious diet-related chronic diseases, including type 2 diabetes, cardiovascular disease, hypertension and stroke, and certain forms of cancer. The health consequences range from increased risk of premature death, to serious chronic conditions that reduce the overall quality of life [3].

Obesity and overweight have been shown to increase the rate of several common adverse medical conditions, resulting in economic costs of $300 billion per year in the United States and Canada. These costs result from an increased need for medical care and the loss of economic productivity resulting from excess mortality and disability [4].

Results from the 2007-2008 National Health and Nutrition Examination Survey (NHANES) indicate that an estimated 34.2% of U.S. adults aged 20 years and over are overweight, 33.8% are obese, and 5.7% are extremely obese [5]. Globally, there are more than 1 billion overweight adults, at least 300 million of them obese. An estimated 17.6 million children under five are estimated to be overweight worldwide [6]. During past years, there has been a dramatic increase in obesity and overweight in the U.S. Between 1980 and 2000, obesity rates doubled among adults. About 60 million adults, or 30% of the adult population, are now obese. Similarly since 1980, overweight rates have doubled among children and tripled among adolescents - increasing the number of years they are exposed to the health risks of obesity [7].

In this paper, we present a food intake monitoring system for mobile devices. The system can monitor consumption of food intake during eating that can help to manage weight loss. Real-time feedback is provided to the user regarding eating trends such as bites-taken rate and eating speed. The proposed framework can help people with obesity, overweight or with other eating disorders to control their eating rate.

II. System Description

An overview of the proposed system is given in Figure 1. First, the system gets acceleration data from the sensor that user wears on the wrist during a meal. Then, the acceleration data is sent to the mobile phone via Bluetooth. Gaussian smoothing filter is applied to the noisy data in order to reduce the effects of noise. By detecting peaks in smoothed acceleration data, the system identifies the bite actions in which one peak represents a bite taken. Real-time information is provided to the user regarding eating trends. The system counts the total number of bites the user has taken, and provides the bites-taken rate. Finally, user is provided about his eating speed whether normal or fast. If the user is eating too fast, the system warns him to slow down.

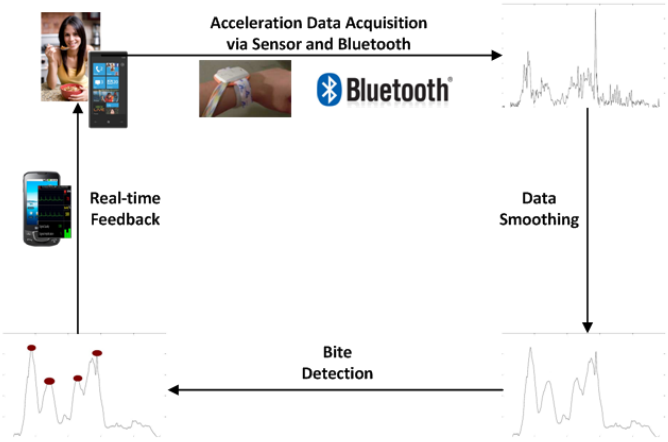

Fig. 1: System overview.

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A. Bluetooth Communication

The acceleration data of wrist motion of the user is transferred to the mobile phone via Bluetooth [8] wireless technology. Bluetooth is a short-range communications system intended to replace the cable connecting portable and/or fixed electronic devices [9]. The major features of Bluetooth wireless technology are robustness, low power consumption, and low cost. The Bluetooth protocol allows exchanging data from distances up to 10 meters [10]. Our system wirelessly connects to Bluetooth enabled sensor worn by the user on the wrist during the meal through the Android Bluetooth API [11]. Using the API, we then transfer the wrist motion data to the mobile phone.

B. Data Smoothing

To reduce the noise effects of the motion data received from sensor, a smoothing filter using Gaussian function is applied. The equation of a Gaussian function in two dimensions is:

$$G_\sigma = \frac{1}{2\pi\sigma^2} exp\left\{-\frac{x^2+y^2}{2\sigma^2}\right\} \quad (1)$$

where x and y are the distances from the origin in the vertical axis and horizontal axis, respectively, and sigma is the standard deviation of the distribution. Figure 2 shows a sample motion profile acquiesced from the sensor, and smoothed profile with Gaussian filter.

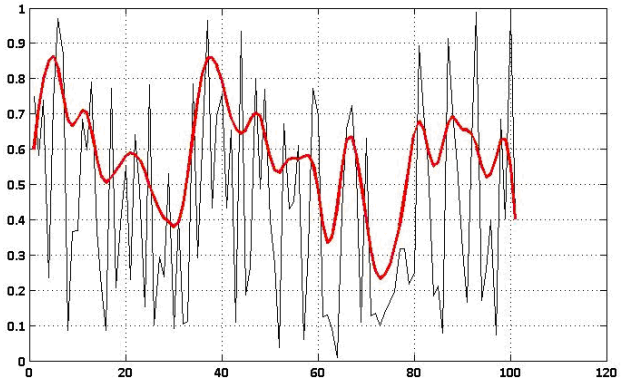

Fig. 2: Smoothing with Gaussian filter.

Data points at each sample time are replaced with the weighted average of surrounding data points. While the value of the original data point gets the highest Gaussian value, neighboring data points get smaller Gaussian value as their distance to the original data point increases.

C. Bite Detection

The proposed system detects and counts bites taken during the meal. Figure 3 shows a common wrist motion profile during a meal. Typically, raising food from the table towards mouth happens when the first derivative of the curve is positive. Similarly, when the first derivative is negative, the food is lowered from mouth to the table back. The bite action occurs on the peak point. The system identifies the food intake by finding maxima in the second derivative of the smoothed data.

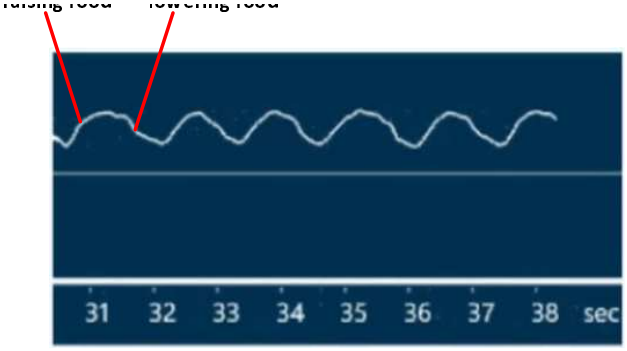

Fig. 3: A characteristic motion profile.

III. Application

The system was implemented on the Android Platform [12]. The illustration of the application on the Android emulator is depicted in Figure 4. The system acquiesces acceleration data via sensor worn by the user on the wrist. Then, the data is sent to the mobile device via Bluetooth. Acceleration data is then smoothed to remove noise effects. From the motion profile, bite actions are identified based on detecting peaks on smoothed data. Finally, real-time feedback such as total number of bites, bites-taken rate and eating speed is presented to the user during the meal. The user is warned by the system if he is eating too fast. If the speed of eating exceeds a predefined threshold (i.e. 5 bites/minute), the system gives the user a warning message *"Slow down. You are eating too fast"* in both audio and text form. So the user is able to control his eating speed.

IV. Conclusion

We presented a mobile based consumption of food intake monitoring system that can help to manage weight loss. Our system process acceleration data received from the sensor that user wears on the wrist during eating and sent to the mobile device via Bluetooth. The data is smoothed to reduce noise and examined to detect peaks representing bite actions. The information of total number of bites, bites-taken rate and eating speed is provided to the user in real-time. The system is developed on the Android Platform and successfully experimented on a subject. The proposed solution could be used for helping people with obesity, overweight and other eating disorders to promote healthy lives.

Acknowledgment

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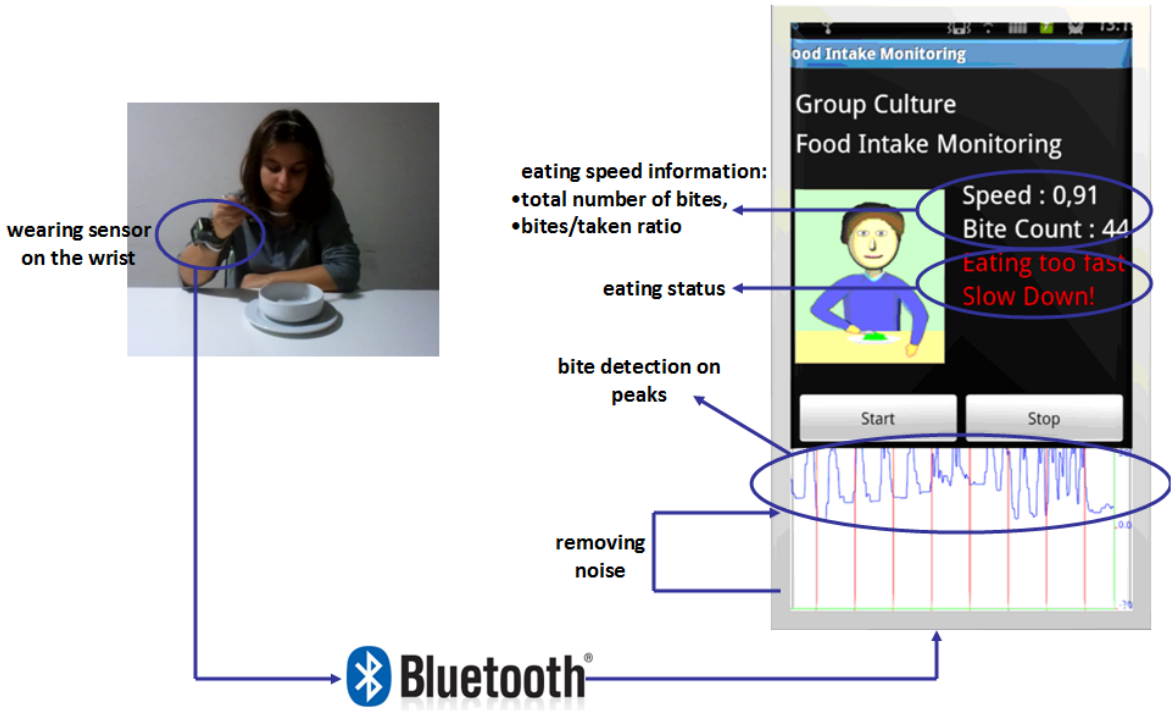

Fig. 4: The illustration of the application.

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