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Automatic Food Intake Frequency Detection Method

Jinwoo Jo[1)], Ahyoung Choi[1) *]

[1)] Department of Software, Gachon University, Seongnam, South Korea

Abstract. Recently many products or services are being introduced to monitor calories through analyzing user's food intake behavior. However, it provided low usability that users should write dietary information manually and some cannot be used in a normal daily life. In this work, we proposed automatic food intake frequency detection method based on accelerometer and gyroscope sensors of smart watches. This system detected wrist motion of eating activity and recognized food intake frequency in real time. For this particular application, we selected two dominant features such as an average sum of accelerometer data and a yaw value of gyroscope data and developed algorithm to count eating behavior. We evaluated this method in a pilot study and we found that accuracy of this method was about 90 % with 20 subjects' data in an experimental setting.

Keywords; activity recognition; accelerometer and gyroscope sensors; obesity management

1. Introduction

Recently, people's interests in health care have been increased. With this trend many eating monitoring products and devices to monitor the calories and ingredients of the food are released. Jawbone, LifeSum, and MyFitnessPal are smartphone applications that provide users to search and to record their food intake items. However, these manual input application has limitations because users should record food intake item and its amount manually for every meal. If some records are missing and there are no appropriate food database, accuracy of food intake record is not guaranteed. To overcome the limitations, many companies have been researched automatic food intake monitoring system. Google is developing an application called 'Image2Calorie' that measures the calories of foods by analyzing a photo taken by user. However,

[*] Corresponding author: aychoi@gachon.ac.kr
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image-based food recognition has difficulties in understanding the directions, angles, and distances of photographs which makes it difficult to analyze the amount of food. Healbe's Gobe provides automatic calculation of the total calories of the food based on the impedance sensors. Impedance-based calorie recognition method supports high usability that the device automatically measure their total food calories when users wearing a wrist type smart watch. However, it has low accuracy especially to detect the amount of fat and protein because of limitation of impedance sensors.

In addition, many researchers has been proposed automatic eating monitoring technologies. Haik Kalantarian and his colleagues proposed an audio-based food intake recognition method using a microphone of a smartphone. This method can distinguish the sound of chewing and swallowing and classify the type and quantity of food. However, it is vulnerable to environmental noises thus it is limited to be used in outdoor environment [1]. Engin Mendi and colleagues conducted a study to recognize the food intake behavior by the movement of the arm using the acceleration sensor of the wearable device. However, it did not consider the different speed and the moving patterns of individual users [2]. Yujie Dong and his colleagues proposed a method for recognize food intake based on an accelerometer sensor and a gyroscope sensor of a wearable device. To analyze arm movement, they selected some features empirically. In this result, they observed that the accuracy of recognition is in between 60% to 80% that indicated large variations depending on users. And the collected data were processed by post processing not in real-time processing [3].

2. Food intake behavior recognition

In this paper, we propose a method to monitor food intake and pattern automatically in real time on the basis of data acquired by accelerometer sensors and gyroscope sensors of wearable devices. This allows the user to recognize patterns of food intake automatically without recording the type and the amount of the food. We used 3-axis accelerometer and gyro sensor values as input signals. The sampling rate was set to 100 Hz which was the maximum output of the smart watch devices that we used. The data received in real time analyzed repeatedly every 50 size windows data. Then we applied low pass filters to remove high frequency noises. For the acceleration, a weighted moving average filter was used with the smoothing factor α value, 0.99 as a low pass filter. For the gyroscope, the moving average filter was applied without smoothing factors. To obtain the rotation angle through the gyroscope, the Euler angle was obtained after the conversion from the gyroscope value to the quaternion form in order to solve the gimbal lock problem [4].

In feature extraction step, we selected two dominant features such as a length of the accelerometer vector data and yaw value of gyroscope data. We empirically observed these features because behaviors of taking the spoon up and down based on the extracted features were recognized with a high accuracy. Thus, these features used as an input of food intake frequency detection algorithm to count eating behavior. To recognize food intake frequency we computed the slope of features and counted the time if the SVM and Yaw values were exceed a certain threshold. Two kinds of slopes were occurred when users (1) move their hand from the table to the mouth and (2) move their hand from the mouth to the table. The algorithm counted eating frequencies if the peak values of SVM were exceeded threshold and the positive and negative peak values of the Yaw were observed. To determine the threshold value, we used initial value for threshold and updated based on initial averaged value.

3. Implementation Result and Summary

To implement this method, 3-axis values of an accelerometer sensor and a gyroscope sensor were used and the data were transmitted to mobile device through UDP communication. The input signals were acquired through LG WATCH URBANE (API 20: Android 4.4W, KitKat Wear) and Samsung Galaxy Note4 was used for data acquisition and processing. Matlab was used for data analysis and verification. To verify the proposed method, we collected the data for 20 participants during 40 to 60 seconds. The SVM and Yaw feature-based method showed 90.9% accuracy as shown in Table 1. We evaluated the proposed method using 539 eating behavior data and found 490 data were recognized correctly and 49 data detected incorrectly. Figure 1 and Figure 2 showed implementation results and we used these application for the evaluation.

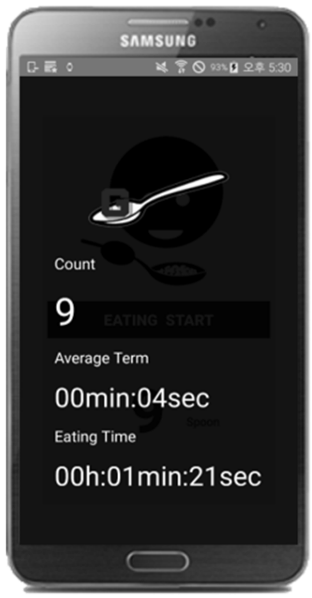

Figure 1. Implementation result of mobile application

In summary, we proposed a method to recognize user's eating behavior by using sensor data. We tried to overcome limitations of real-time measurement and accuracy compared to previous researches. To measure the accuracy of the proposed method, data of 20 users were collected and analyzed. More data collection and analysis for various scenarios will be carried out to distinguish dietary behaviors in everyday life. In order to increase the accuracy, we will also improve the algorithm to adapt individual users' different eating pattern.

Table 1. Experimental Result

		Predicted	
		Positive	***Negative***
Detected	***Positive***	490	49
	Negative	0	0

Figure 2. Implementation result of wrist watch

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