

# Wearable System Solution for Medical Adherence and Dietary Monitoring

## Introduction

Study shows that increased adherence to recommended medication regimens would make substantial improvements in public health. Also, medical institute need to monitor the medical adherence of their patients to decrease readmission rate and consequently avoid unnecessary fines. Recent technology enables the wearable device system to contribute to the medical adherence and dietary monitoring tasks. This paper reviews several methods to detect human dietary behaviors based on wearable systems. Since currently there are little research focusing on medical adherence only, a broader topic, which is dietary monitoring, is being focused. Also, since this review focuses mainly on research papers and articles, system costs are not being fully examined.

## Sensing Locations

Sensing location is critical to the sensing quality and stability of the wearable device systems. For dietary monitoring, several on-body locations are considered [2]. First, the sensors could be mounted in the mouth and in the ear, which enables high quality acquisition of audio and mouth motion data. But these sensor locations are invasive to the user's body and expensive because of the need of implant surgery. Second, the sensors could be positioned near the ear or jaw. This can keep a relative high-quality sensing over the jaw motion without being invasive to human body. However sensing devices could be hard to mount in such locations because of the adhesion-to-skin requirement. Third, the sensors could be mounted over the neck. Such sensors could detect the chewing and swallowing acoustics. Also, since the neck is on the axial skeleton of human body, the sensors can monitor other physiological events [1]. But these sensor locations require close sensor contact with user's neck, which can lead to some discomfort. Fourth, the sensor can be located over the wrist. It the most common wearable devices location. Hand-to-mouth gestures and hand motion could be monitored. But such data are less useful than the more direct data, such as body emitted food intake sounds and jaw motion.

## Sensing Methods

Besides the placement of the sensors, different methodologies behind the dietary monitoring are being reviewed. Currently there are acoustic-based, image-based, motion-based and the combination of these methods.

### Acoustic-Based

This method is based on audio processing technology. Sensors attached to human body detect the audio data from the user's body and ambient sound. Then an audio signal processing algorithm is commonly implemented to analysis and classify the dietary behavior. BodyScope [3], a wearable acoustic sensor solution, uses several acoustic sensors over the user's throat/neck to acquire audio data of the user's chewing and swallowing activities. Then relevant audio features are extracted and fed into a SVM(Support Vector Machine) for further activity classification. The real-world activity classification

accuracy is 71.5%. Another example [4] uses the ambient sound sensor over user's wrist followed by similar feature extraction and classification process. It can detect meal-eating behavior with an accuracy of 79.8%. Note that if the BodyScope choose to detect only one eating/drinking behavior, the accuracy is as high as 87.5%. Therefor mounting sensors to detect more direct body emitted sound could raise the detection accuracy.

### Image-Based

A camera can be embedded in a wearable system to capture images or videos of relevant events. With combination of other detecting methods, like chewing as in [5], the camera method can accurately capture and monitor the dietary activities with an accuracy of 82.51%. But these image-based methods would raise potential privacy concerns.

### Motion-Based

Accelerometer, gyroscope and piezoelectric sensors can be used to detect body movement and thus provide information to monitor the dietary activities. As mentioned before, these sensors are mounted on different body locations including inside the mouth, near the ear, on the wrist and on the neck. Since the first two locations are invasive and hard to mount, sensors located on the neck and wrist are being focused. Some piezoelectric sensors are attached on the neck [6] and near the ear(jaw) [7] to detect chewing and swallowing movements. But user's feedbacks show that these methods may not be comfortable to wear and may cause skin-irritation. Others use wrist-based accelerometer and gyroscope to detect and capture the unique linear and rotational motion when users use their hands to transfer food or pills [8]. Such method has an accuracy of 81%, which is not as high as the acoustic or image based sensing methods.

## Conclusion and Future Development

Despite of different sensors and sensing locations, current dietary monitoring shares a common overall procedure. First, the sensors get relevant data. Second, proper analysis is being done over the data, such as feature extraction. Third, a machine learning classification system is used to make final detection. To apply these technologies to a narrower task, medical adherence, few accomplished related works can be found. However, this research [9] proposes a method of combining the smart pill tray solution with the wearable device chewing detection together to make an accurate monitor over medical intake.

## Reference

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