Performance Evaluation of the Activity Analyzer

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Abstract – **The purpose of this study is to evaluate the performance of the Activity Analyzer used to monitor and encourage physical activities of older adults. The Activity Analyzer is a wearable device designed to monitor the daily activity and inactivity according to a pre-programmed time schedule. The device is also capable of playing back pre-recorded messages to encourage exercises if periods of inactivity are detected under predefined conditions. At the end of the day, the daily activity data with a time resolution of 5 minutes can be retrieved from the mobile unit via a docking station for further analysis. The study provided preliminary test results from human subjects to evaluate the performance and optimize parameters of the device. The result is useful as a guideline for a larger-scale human study to assess the effectiveness of the device in terms of improving the daily activities for older adults.**

I. INTRODUCTION

As baby boomers now represent nearly one-third of the total United States population, researchers are prompted to find new ways to encourage a healthy lifestyle through increased physical activity in older adults. Research has shown that older adults have the ability to adapt to exercise in much the same way as they did in their younger years, and a regular exercise program can often slow age-related declines in health by reducing the risk of heart disease, cancer, osteoporosis, bone fractures, high blood pressure, as well as help with arthritis and depression.

According to the Transtheoretical Model of Behavior Change (TTM) [1], helping relationships such as that of a family member, play an important role in supporting behavior change. The Activity Analyzer developed in this study uses family member participation to encourage older adults to stay active, through tracking of physical activity levels, positive reinforcement, and voice personalization.

The purpose of this study is to conduct a pilot test for performance evaluation and parameter optimization before the Activity Analyzer can be used in a larger-scale study involving older adults.

II. METHODS

A. Device Development

This device contains two main components – a mobile Activity Analyzer unit that is designed to be worn in a pouch around the individual's waist and a docking station. The mobile unit contains a microprocessor (PIC18F452, Microchip Technology, Chandler, AZ) used to store data and interface with all other major components including a voice recording integrated circuit chip (Winbond ISD1750) that can record and play back voice messages for a total of duration of 60-100 seconds. An accelerometer (STmicroelectronics lis302sg) is used to detect 3-dimensional motions (x, y, z directions). The x, y, and z signals are combined into one signal before it is acquired by the PIC processor. The mobile unit also contains an amplifier and speaker used to output pre-recorded messages, as well as a replay button in case the user needs to have a message repeated.

The second component, the docking station, contains a microphone that can be used by family members to record messages, as well as an LCD screen for displaying a manual that can be navigated using two pushbuttons. Using the LCD screen, caregivers can set the clock, record and erase messages, set the times at which these messages are to be displayed, and listen to previously recorded messages. Another important part to the docking station is the battery charger. This is used in combination with a series of switches to charge both the batteries for the mobile Activity Analyzer unit and the docking stations. This allows both components to run continuously without having to be turned off to charge. The docking station also contains a USB port that can be connected to a host computer. Through this USB port, the data from the accelerometer stored in the EEPROM of the PIC processor can be uploaded to the computer. The mobile Activity Analyzer unit and the docking station are connected through a 15-pin DB connector and must remain connected when using the push buttons and LCD display in the docking station to program the mobile unit [2].

B. Human Subject Testing

To develop an effective and ergonomic way for carrying the Activity Analyzer, we consulted faculty and students from the College of Nursing who have worked with the older adults. It was important to consider factors affecting functionality, convenience, appearance, comfort level, and user-friendliness for the older adult population. As shown in Fig. 1, the Activity Analyzer is worn around the waist in a custom pouch with a strap and clip to make it easy to be taken on and off. The design included durable fabric for the sides with a mesh material in the front for the speaker, as well as a metal ring on the top so the replay button would be easily accessible.

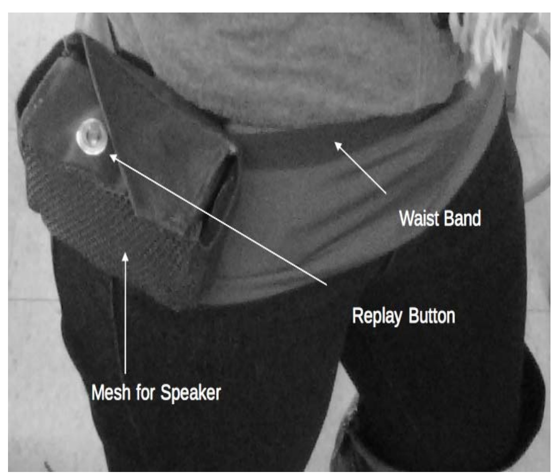

Fig. 1. The mobile unit of the Activity Analyzer in a carrying pouch strapped around the waist.

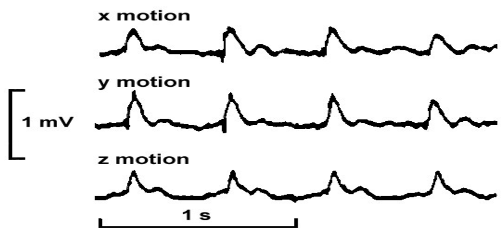

Fig. 2. Analog signals from the accelerometer showing motions in the x, y, and z axes before combining.

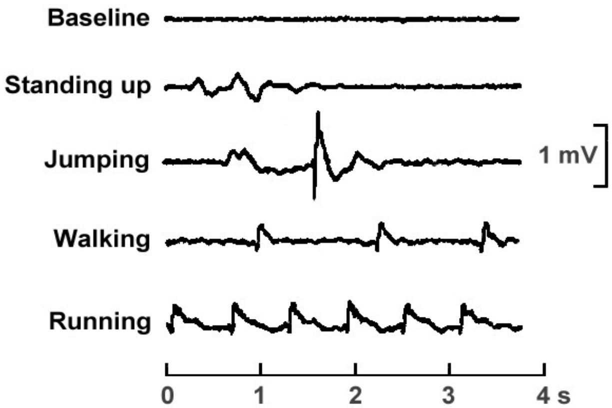

Fig. 3. The combined x-y-z motion signal shown for various types of activities.

Prior to the testing with human subjects, an approval from the Institutional Review Board (IRB) at the University of Rhode Island was obtained. The longer-term research objective is to test the hypothesis that the Activity Analyzer with voice messages recorded by loved ones can improve the activity level for community-dwelling older adults. The present study conducts a preliminary test on a small set of young, healthy subjects to determine if the basic function and comfort was sufficient before moving on to test older adults. The study also provides information about parameter settings such as the threshold for motion detection, which affects the sensitivity of the Activity Analyzer.

III. Results

Figure 2 shows the motion signals from the accelerometer in the x, y, and z directions. After summing up the three motions signals, the combined signal is acquired by the PIC processor to assess the activity level. Figure 3 shows the combined signal for various types of activities. The initial sampling rate is sufficiently high to reveal the shapes of the activity waveforms and to perform tasks such as the implementation of a pedometer, if needed. Then, the activity level is integrated at a 5-minute interval to produce an activity score, which is between 0 and 15. The data with the 5-minute temporal resolution are stored in the EEPROM, which can be retrieved later via the docking station. Figure 4 shows three sample data sets illustrating the typical data collected by the Activity Analyzer during activity testing. Data sets 1 and 2 display moderate household activity at two different sensitivity settings. A medium sensitivity setting results in an activity score of 1-2 for sitting, 3-12 for short periods of household activity, such as getting a glass of water or going to

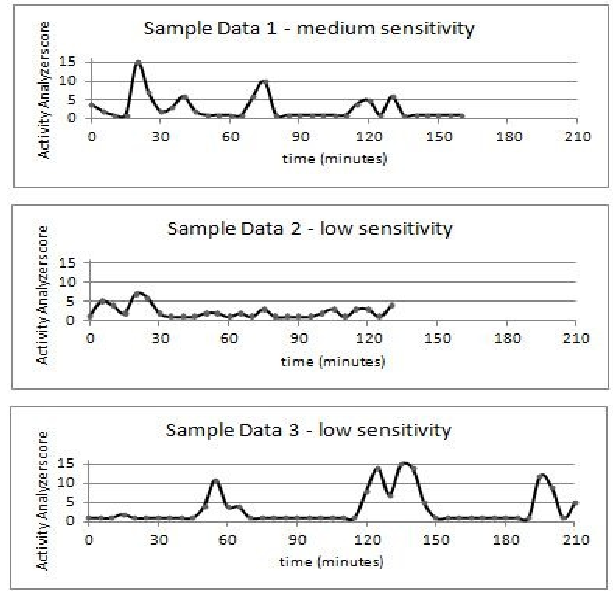

Fig. 4. Three samples of the activity data at the 5-minute temporal resolution retrieved from the Activity Analyzer.

the restroom, and a value of 13-15 for lengthier periods of activity, like preparing dinner or doing laundry. A low sensitivity setting results in scores of 1, 2-5, and 6-13 respectively for the same activities. Data set 3 describes longer periods of activity recorded at low sensitivity. The values for the peaks of 14 and 15 in the data set demonstrate sustained periods of higher activity, such as walking for five minutes.

IV. Discussion

The result of this study indicates that the performance of the Activity Analyzer is satisfactory and meets the original design goals. The activity data stored at the 5-minute temporal resolution are sufficiently sensitive to discern low, medium, and high levels of activities. Future work will include a larger scale study with an older adult population to assess the effectiveness of improving the daily activity level with voice messages recorded by the loved ones.

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