FREE-WEIGHT GYM EXERCISES: EARABLE & IOT DATASET

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ABSTRACT

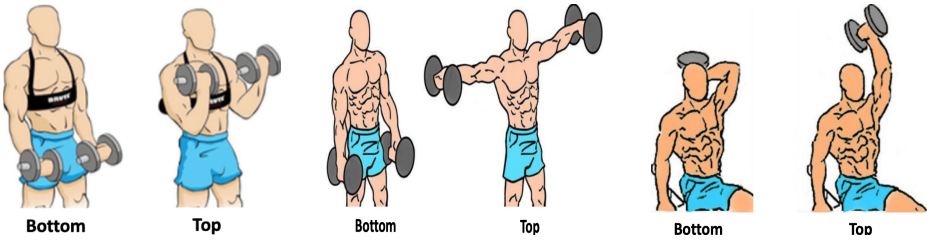
Wearable or infrastructure sensors have been widely proposed for automated tracking and analysis of individual-level exercise activities. This dataset is collected as part of building a pervasive, low-cost digital personal trainer system, that supports fine-grained tracking of an individual's free-weights exercises via a combination of (a) sensors on personal wireless ear-worn devices ('earables') and (b) inexpensive IoT sensors attached to exercise equipment (e.g., dumbbells). The dataset is comprised of sensor signals acquired from two 6-axis IMUs and contains a total of 324 samples for 3 different free-weight exercises performed by 27 individuals.

1 Introduction

We devised a low-cost system, called ERICA, that serves as a digital personal trainer for users performing free weights exercises with two key differentiators: (a) First, compared to prior works that either require multiple on-body wearables or specialized infrastructural sensing, ERICA uses a single in-ear "earable" device (piggybacking on a form factor routinely used by millions of gym-goers) a and a simple inertial sensor mounted on each weight equipment; (b) Second, unlike prior work that focuses primarily on quantifying a workout, ERICA additionally identifies a variety of fine-grained exercising mistakes and delivers real-time, in-situ corrective instructions. To assess the efficacy and effectiveness of our system, we conducted real-world user studies in which the participants exercised freely and naturally, and the system monitored their exercise dynamics to provide necessary corrective feedback in real-time. The value of this dataset for the research community working on wearable fitness-applications can be three-fold: (a) comparing the efficacy other approaches for quantifying free-weights exercises, (b) improving the algorithms on the association in a multi-user setting by differentiating the individual's earable and the gym equipment that the person is currently using, and (c) experimenting with new algorithms for exercise classification and fine-grained mistake detection.

The ERICA system employs two kinds of devices, namely, eSense Earable device [1] and an IoT device (DA14583 IoT Sensor) [2]. Both these devices comprise a 3-axis accelerometer and 3-axis gyroscope sensors. The earables can sense the individual's upper body/limb motion and the IoT sensors, attached to free-weights equipment, can sense the motion of the equipment. Figure 1 depicts the placement of the aforementioned sensors. The various algorithms (e.g., for exercise classification, mistakes recognition) employed by our system utilizes a fusion of the sensor data from these two devices to achieve better performance results.

Figure 1: Sensor Placement



(a) Biceps Curls (b) Lateral Raises (c) Triceps Extension

Figure 2: Bottom and top positions for free-weight exercises

We primarily focus on three free-weight exercises, namely, bicep-curls, lateral-raises, and triceps. Figure 2 demonstrates top and bottom positions of these exercises. In our user studies, each individual has performed four sets of each exercise and each set consists of ten repetitions.

2 Data Repository

The folder structure of the data repository is depicted in Figure 3. Each exercise has a separate folder that contains the data for 27 users. Each user has performed an exercise four times and therefore each user-folder is composed of four folders. A folder that contains the data of an exercise set has two other folders (which includes the data of IMUs) and a file containing the ground truth information. These files have records of the measurements for the 3-axis of accelerometer and gyroscope along with the timestamps. Figure 4 shows sample plots of raw signals captured by the accelerometer and gyroscope of two devices for bicep-curl exercise.

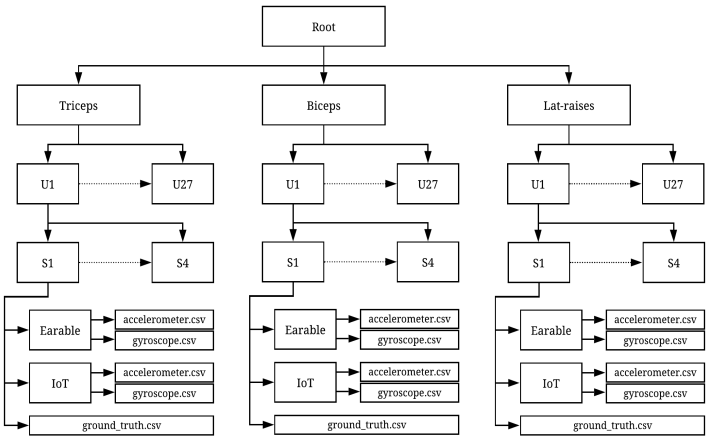


Figure 3: Folder structure of the data repository

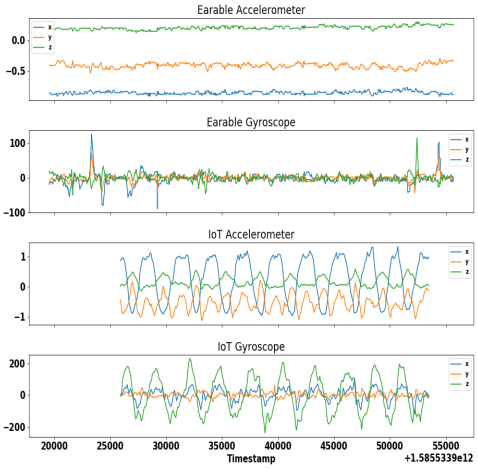


Figure 4: Plots of raw signals coming from two IMUs

The ground truth file has the information for each exercise set performed by the individuals who participated in the user study. At individual repetition-level of an exercise, it has the ground truth labels (obtained from manual labeling of video recordings of exercising individuals) for the mistakes made by each person. Table 1 summarizes the six labels that we used to annotate the various mistakes, elucidated by a Kinesiology expert as commonly occurring during these free-weight exercises.

Further details about our work, the dataset and the user-study experiments can be found in our publication [3].

Label	Description
NO_MISTAKE	No mistake observed in a repetition.
IC_ROM	Incorrect range of motion: the individual failed to maintain the full range of motion consistently.
WR_CURL	Mistakes known as wrist curls in kinesiology, that is specific to the Biceps Curls.
POSDRIFT	Position Drift: the starting/ending positions of the dumbbell change on each repetition.
ROMDRIFT	Range-of-Motion Drift: the range-of-motion progressively decreases across repetitions.
MOTION	Unwanted body motion: errors related to the upper body movement.

Table 1: Labels used to annotate the mistakes occurring in the exercises

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References

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