An RFID based System for Monitoring Free Weight Exercises

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ABSTRACT
In this paper we present preliminary results and future directions of work for a project in which we are building an RFID based system to sense and monitor free weight exercises.

1. INTRODUCTION
The past years have witnessed significant advancement in integrating sensing capabilities into workout equipment and accessories. While most commercial products and research projects have focused on monitoring cardio activity, recent products now enable monitoring of strength training activities too [1]. A major part of strength training involves free weight exercises (dumbbells, barbells etc). However, to the best of our knowledge, currently there are no commercial products available to monitor free weight exercises. The only relevant work we are aware of in this area has been a recent work from Chang et al [2].

In this paper, we briefly discuss a project we are currently working on that enables sensing and monitoring of exercises involving free weights. While similar in some aspects to Chang et al's work, our system takes a different approach to address the problem. Specifically, our system is based on RFID infrastructure and uses the Wireless Identification and Sensing Platform (WISP) [3] for user and free weight identification and exercise identification.

In the sections below we present a high level description of the system and the long term vision for this project. We discuss some preliminary results and conclude with a discussion of future work.

2. VISION AND GOALS
Our goal is to build a system to sense, infer, and monitor exercises being done by users at a gym. Towards this, we have the following guiding principles in mind for the system:

- The system will be as non-intrusive as possible for users. Gym personnel will be responsible for system set up and maintenance.
- Initially the system will be a passive exercise monitoring system. Longer term, we envision that the system will actively guide users to workout more effectively and safely with free weights. Compared to controlled strength training equipment, getting the correct form factor for exercises is more difficult with free weights and the risk for self-injury is higher. With proper sensing capabilities and algorithms in place, our goal is to determine the ideal form factor for different exercises and guide users to perform exercises correctly.

3. SYSTEM DESCRIPTION
Our sensing system is based on RFID infrastructure. The core sensing elements in our system are Intel's WISP passive RFID tags [3]. WISP tags are enhanced RFID tags that incorporate motion sensing capability via a 3-Axis accelerometer that are compatible with standard RFID readers and protocols. When a WISP tag is read by a RFID reader, the reader sees a tag with the WISP's accelerometer readings encoded in part of the tag's unique identifier. On the infrastructure end, our application connects to the RFID reader over IP, collects the readings from the RFID reader, we then extract the unique ID of our WISP tag and retrieves the encoded accelerometer readings.

Free weights are instrumented with WISP tags and users wear a WISP tag on body parts involved in an exercise (e.g. on wrists). Figure 1, shows a dumbbell and wrist band with a WISP tag mounted on them. Tag ids are used to identify users and the weights being used. Accelerometer sensor readings from the tags are used to infer the exercise being done and to establish the association between the user and the particular weight(s) being used.

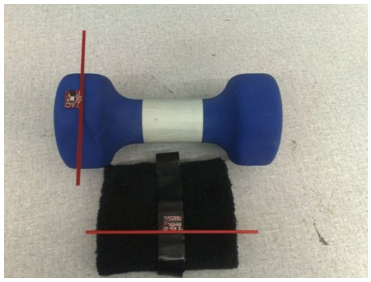
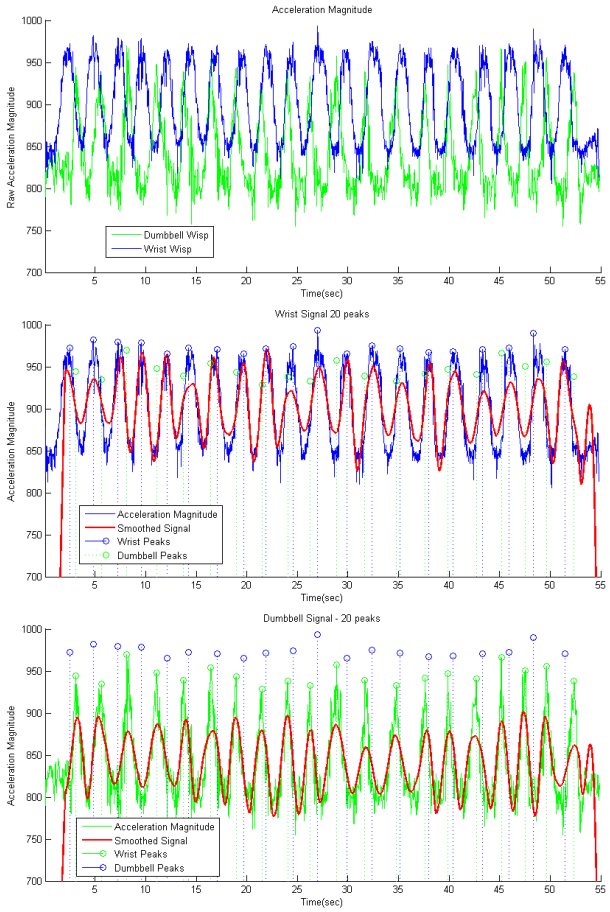


Figure 1 Wisp on Dumbbell and wristband



4. RESULTS

In this section we discuss some preliminary results from our work to date.

User-Free Weight association: Since the system will have multiple sensor streams active at any given time, an association needs to be established between a user performing an exercise and the weights they are using. Previous work from our group has shown positive results in correlating sensors carried by the same person [4]. We tried a similar approach and did a frequency domain analysis of the sensor signals to establish correlation between sensor streams. However, this did not give us sufficiently positive results. We have now switched to a time domain approach to establish the association. We detect the peaks from our accelerometer readings and examine the time intervals at which peaks occur to determine correlation between different signals. This analysis is still a work in progress.

Exercise repetition count detection: In addition to determining the exercise type being performed, the system also needs to determine the number of sets of each exercise and the number of repetitions in each set. Using the same signal peak detection mechanism as above, we were able to detect repetitions of an exercise with 95-100% accuracy.

Since orientation of the sensors keeps changing continuously while an exercise is being performed, we calculate the total magnitude of acceleration for analysis. Figure 2 shows graphs of the two sensor signals (one worn on the wrist and the other on the dumbbell) obtained from a session of the bicep curl exercise that was performed for 20 times. Magnitudes of the individual sensor signals are shown along with the peaks signal values.

5. CONCLUSION AND FUTURE WORK

In this paper we have presented some preliminary results from our project in which we are taking a new approach to sensing and monitoring exercises involving free weights. The project is in its early days and a lot of work still needs to be done. In particular we will be working on the following aspects of the system:

- Robust mechanism to establish association between users and the weights they are using.
- Mechanism to accurately infer the type of exercise being performed using free weights.
- Ability to be able to do the inferencing in real time.
- Once basic components of the system are in place we will look at the form-factor, effectiveness and correctness aspects of performing exercises.

6. REFERENCES

[1] FitLinxx. http://www.fitlinxx.com/brand.htm

[2] Chang, et al. *Tracking Free Weights*. UbiComp 2007.

[3] Smith, et al, *A Wirelessly powered platform for Sensing and Computation.* UbiComp 2006.

[4] Lester, et al, *Are You With Me? Using Accelerometers to Determine if two Devices are Carried by the same Person.* Pervasive Computing 2004