Activity Tracking: Are We More Than The Sum of Our Programming?

Abstract
Standard activity trackers preprocess raw personal data from accelerometers and gyroscopes, to provide meaningful results in the form of step counts, calories burned, and progress over time. What happens though, when the built-in algorithms are not calibrated to an individual's physiological characteristics? Specifically, is 16 consecutive days of an activity rating at "-1" a meaningful diagnostic or a data disaster?

This paper highlights results from a preliminary study exploring the user experience of persons with chronic disease and/or cognitive disabilities with off-the-shelf wearable activity tracking devices. Results show that though these devices can be useful to determine baselines, trends and deviation in activity, their current one-size-fits-all analytics, coupled with their closed data policies, introduce a significant data disaster for this population.

Author Keywords
Activity tracking hardware and software, data analytics, open data.

ACM Classification Keywords
H.5.m. Information interfaces and presentation. J.3 Medical information systems. D.2.2 Evolutionary prototyping. Introduction
Wearables technologies are trending, emerging as the next big consumer electronics market category [4]. The 2014 Accenture Digital Consumer survey found that over half of the consumers polled were interested in ehealth management, using wearable devices such as fitness trackers [4]. Unlike many off-the-shelf devices that are easily customized, most activity trackers take the opposite approach. That is, though the hardware and mechanisms in each of the devices are highly similar, the software associated with each is highly customized for very active targeted market sectors – from recreational athletes, to high end users.

In the general sector of activity trackers, vendors work with standard raw personal data from simple sensors that report movement, preprocess it with their own proprietary algorithms, and return back (possibly incorrect) extrapolations of that data in terms of step counts, calories burned and activity levels achieved. Though these "impersonal informatics" work well the majority of this segment of the population, the question remains: what role can these low-cost devices play in the context of decision support for chronic diseases and cognitive disorders?

**Experiment**

Using low-cost sensors and tracking devices, researchers have begun to make important inroads into understanding complex symptomology associated with both physiological and neurological conditions [3, 5, 6, 7]. Specifically, we hope to build on results of studies focusing on geriatrics [2], vulnerable users [11], chronic disease management [8], and dementia [1, 9, 10] to aid individuals experiencing chronic illness.

Our pilot experiment with off-the-shelf activity trackers started with three popular commodity devices, all in the range of $50 to $150 dollars. These three devices were all worn on the non-dominant arm of an individual diagnosed with a chronic disease. In the case of one of these trackers, we could not download the individual’s data from the vendor’s site, so this study reports our findings for the two devices we did not have to manually transcribe the data from the vendor’s interface. The data set is a result of wearing the devices for 16 consecutive days, though the data reported in the collection contains gaps in several places, due to a variety of circumstances ranging from not downloading the data before it was deleted to forgetting to put the device on the wrist in the morning.

Though not tracked specifically by any of the commodity trackers, weather data was included in this experiment due to its impact on the symptoms of chronic illness and physical activity – particularly among individuals who are weather sensitive, who are negatively impacted by certain types of or changes in weather. For example, individuals affected by allergies, asthma, respiratory, and heart disease are adversely impacted by exposures to air pollutants and airborne allergens. Chronic respiratory and cardiovascular diseases can be aggravated by extreme heat or the short-term reductions in lung function attributed to increased particulates in the air.

**Results**

Over 16 days we took into account weather, step counts, reported inactivity levels, activity scores and calories burned. This pilot was a disaster in that the inter-device variation in step counts is significant, and the algorithms for inactivity ratings, activity scores, and calories burned (Figure 1) were meaningless. Ultimately, 16 consecutive days of negative activity levels was not a meaningful diagnostic. The diamond in the rough appears to be that the study reveals a potentially important trend between weather, an external environmental factor, and activity at the granularity of the step count trends.
Figure 1. (a) Tracker & Weather Comparison uses daily weather and temperature downloaded from the local forecast, compared to distances measured from trackers. (b) “Active Score” vs. Average Time Inactive shows inactivity ratings as a percentage of time outside of active zone, relative to the amount of time tracked overall. (c) Total Inactivity vs. Calories Burned scores both of which appear to be a data disaster in this context.
Lessons Learned
Though we believe commodity devices pose significant challenges in this domain with respect to their closed-data representations and algorithms for segments of the population, we plan to couple more critical context with quantification in the next version of our pilot study.

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References