Routine Change Detection Using Estimotes

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INTRODUCTION

- Programs to promote brain health behaviors have emerged as an important public health initiative.
- Such programs encourage change in behaviors such as physical activity and cognitive engagement.
- Traditional methods of measuring behavior change including self-report, neuropsychological assessments, and physiological measurements have limitations such as unreliability, high cost, and time-burden for both researchers and participants.
- Small, battery-powered binary state-change sensors called Estimotes may provide a reliable, unobtrusive, cost-effective, and time-efficient way to measure behavior change in free-living conditions.

OBJECTIVES

- Determine if estimote data can capture changes in routine after starting a behavior change intervention.
- Examine patterns of routine behaviors between the first three weeks (i.e., week prior to goal setting, cognitive engagement and physical activity goal weeks) and subsequent weeks.

METHODS

Study Design

- Participants
  - Selected from a larger intervention
  - Exclusion criteria: a known medical, neurological, or psychiatric cause of cognitive dysfunction.
- Estimote Deployment:
  - Participants interviewed about their daily routine to identify objects that could serve as proxy measures for routine

Figure 1. Participant sample flow diagram

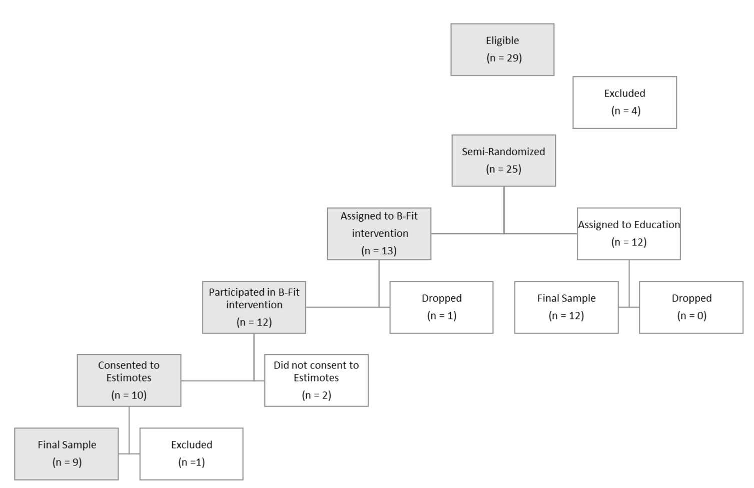
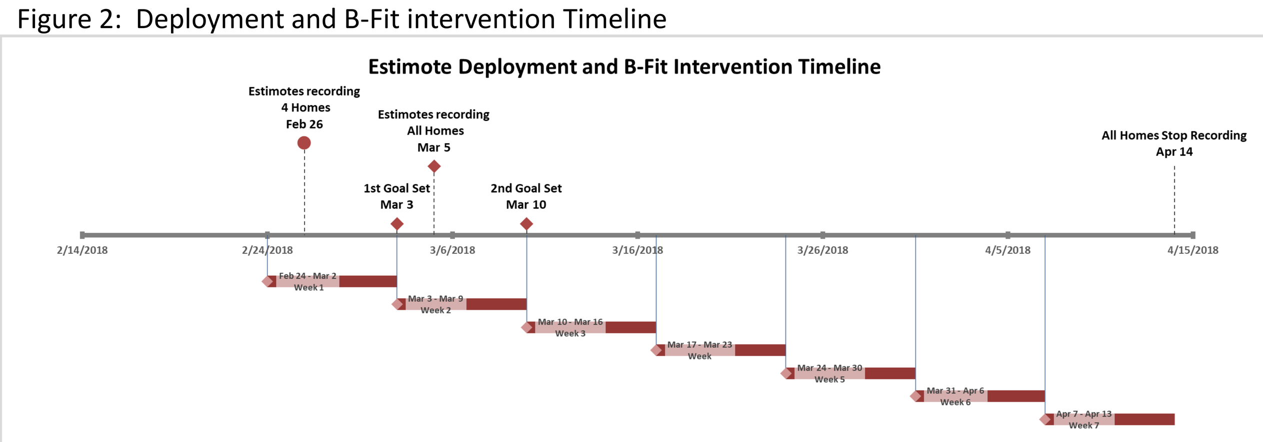


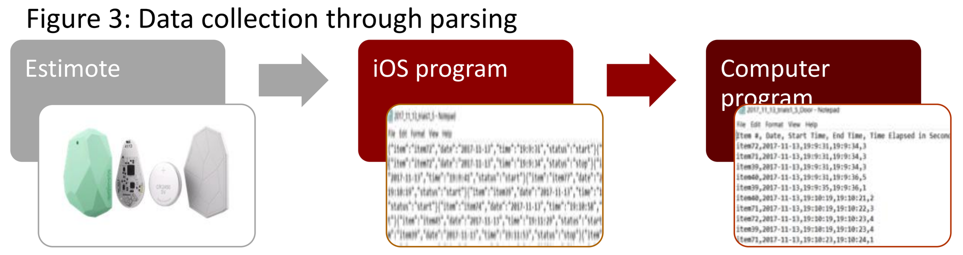
Figure 2: Deployment and B-Fit intervention Timeline



Hardware and Software

- Estimotes
  - Contains accelerometer and temperature sensors
  - Transmits data through radio signals
- iOS App: receives and exports sensor data in a text file
- Data Parsing Application
  - Developed to parse and select data
  - Exported the organized data to a CSV file

Figure 3: Data collection through parsing



- Estimote Inclusion:
  - Estimote stickers selected due to their size and ability to broadcast data via Bluetooth
  - Two types of estimote stickers included– stickers with and without a silicon casing

DATA

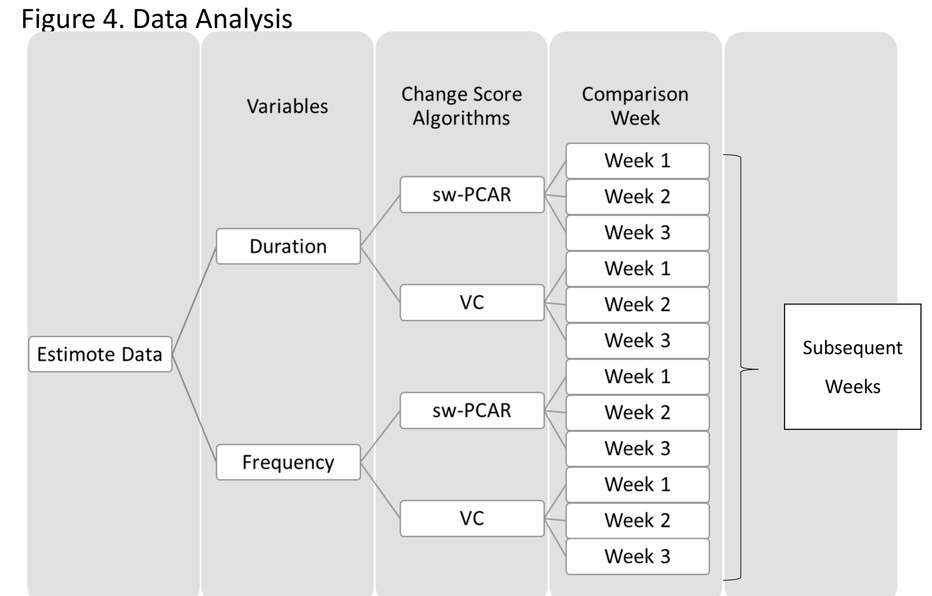
Pre-Processing

- Selection
  - Only used data from tracking routine (e.g. toilet, sleep, cooking).
  - Duration = the amount of time from the initial "start" time to the next recorded "stop" time.
  - Discrete = amount of times estimotes started moving.
- Missing data
  - Fist day of data collection removed
  - 1 participant removed due to missing data
- Week intervals
  - Data was sectioned off into weekly intervals corresponding to the intervention (see Figure X).
  - First week: missing days were prepending by simulated days
  - Last week: truncating the end of the dataset

Data Analysis: Physical Activity Change Detection (PACD; Sprint, 2017)

- PACD used to detect and analyze changes for each house from the estimote data, but modified for weeks.
- Three sets of comparisons with the 1st, 2nd, & 3rd weeks serving as the "baseline" and compared to subsequent weeks.
- Used 2 change scores: permutation-based change detection in activity routine algorithms (sw-PCAR) and virtual classifier (VC).

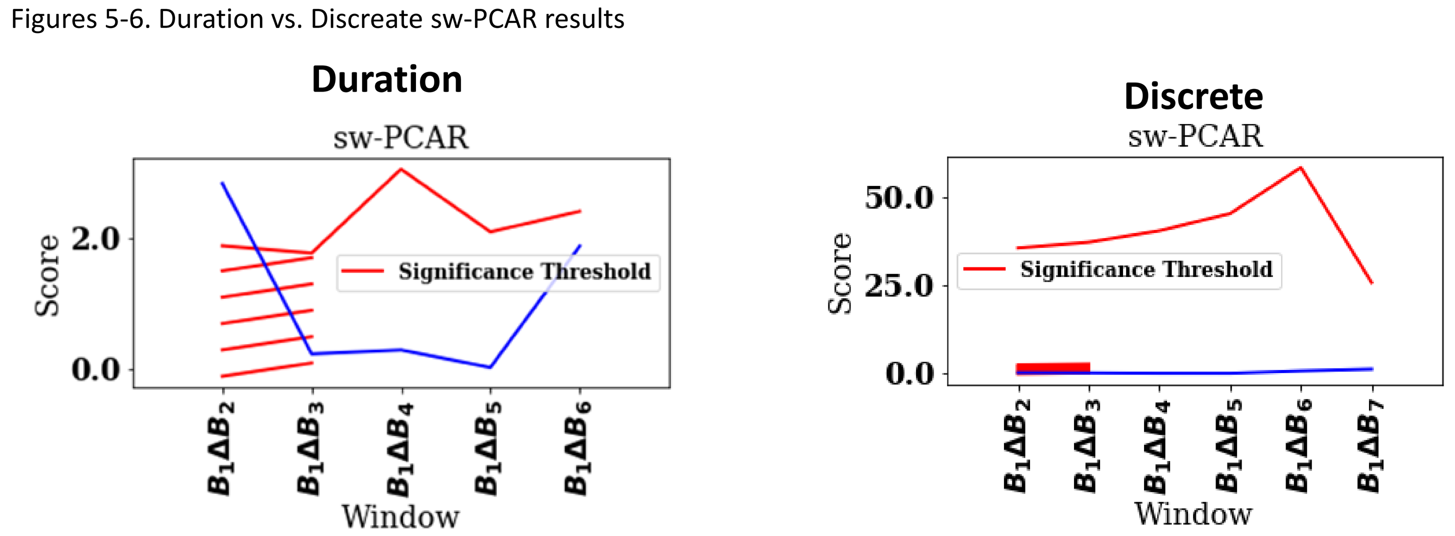
Figure 4. Data Analysis



RESULTS

Duration vs. Discrete change scores
- Results suggest that there were no similarities between the different weeks.
- Due to missing start or stop signals caused large activity changes in the data.

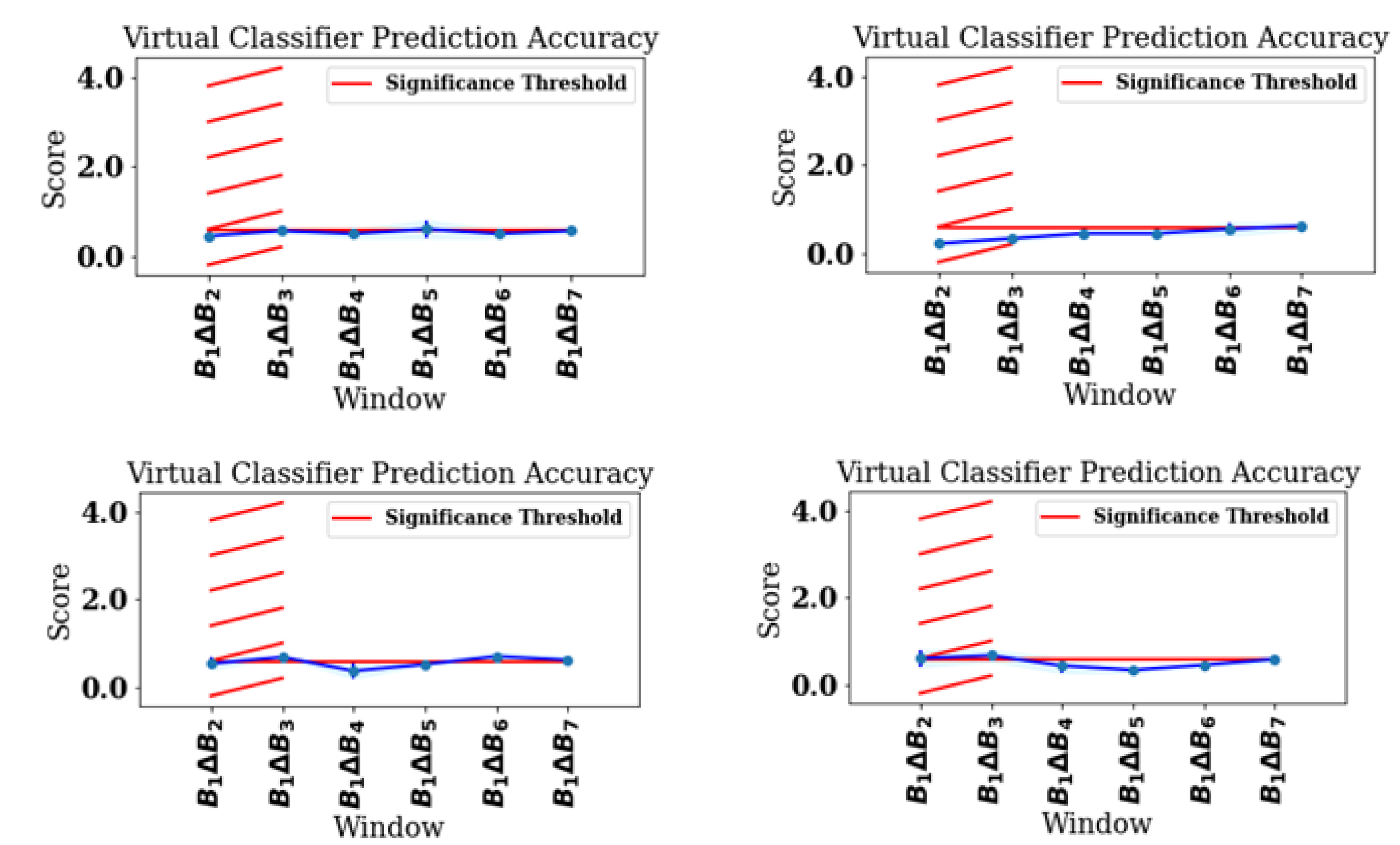
Figures 5-6. Duration vs. Discreate sw-PCAR results



RESULTS

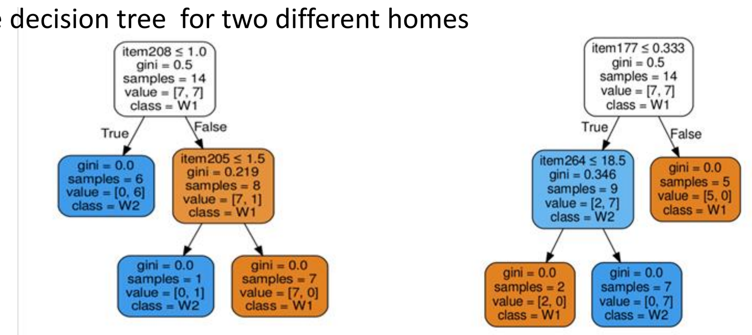
Discrete change scores
- Change scores more consistent and accurate representations of movement across houses.
- Across homes, there was a change– scores began to rise above the significance threshold.
- Whole this change was slight, there is a definite trend of statistical significance between the 5th through 7th week.

Figures 7-10. Discreate virtual classifier for four different homes



- Examination of the decision tree demonstrates a reduction in the number of features in a given sensor set.

Figures 11-12. Discreate decision tree for two different homes



DISCUSSION

- The discrete data is more reliable and can be more effectively parsed for trends in the user's activities. Although duration data poses some issues, future research could focus on identifying when there are missing "start" and "stop" times.
- Compared to the first week, objects with estimotes were moved (i.e., discrete movement) significantly less at the end of the intervention. These results could potentially suggest
  - Estimotes made participants more cognizant of moving routine objects at beginning of intervention and then became less aware over time.
  - Intervention initially increased routine activity at beginning of intervention due to new behavior changes, but planning and developed routine improved efficiency of routine behaviors.

Future directions
- Comparisons may be biased since the study did not monitor routine behavior prior to the intervention starting.
- Therefore, future studies should include a real baseline with more weeks to be compared to long-term health related behavior changes.
- Moreover, since homes varied in size, analyze the accuracy of using estimotes to detect routine in multi-person homes.

SUPPORT

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