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# Introduction

- The Smart Apartment is a network of motion sensors and cameras that is used to monitor the health and everyday functioning of older adults
- Estimotes are sensors that attach to objects (see Figures 1 & 2) and send radio signals to smart phones, indicating their motion along the X-Y-Z axis

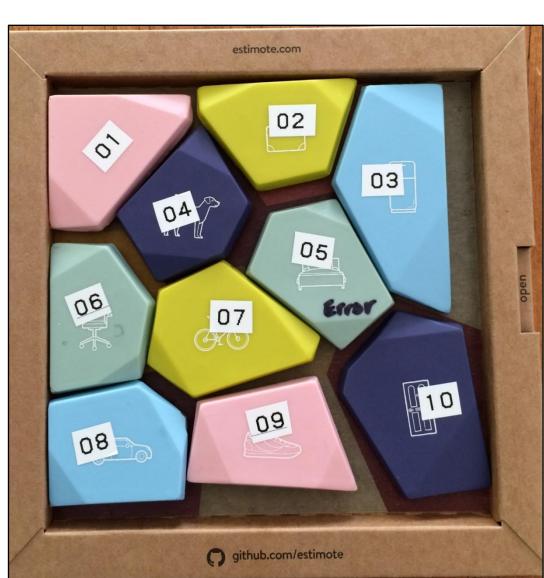
# Objectives

- Can estimote stickers accurately track motion of objects in use?
  - Compared sticker data collected through smartphones to the real time annotation tool (RAT)
- Test task recognition accuracy for a model trained with data from estimote stickers

# Methods

- Participant Demographics
  - 14 participants, 2 male and 12 female, between the ages of 20-44, obtained through university class and community outreach
- Materials
  - Estimote stickers placed on **broom, dish soap**, duster, dustpan, hand soap, medication dispenser, plastic soup bowl, watering can, and water filter
  - WSU Campus Smart Apartment (4 video cameras, RAT coding system, intercom)
  - 2 iPhones (iPhone 5 in living room downstairs, iPhone 6 in monitoring room upstairs)
- Procedure
  - Participants were instructed to complete 6 activities within the Smart Apartment: Water Plants, Fill a Medication Dispenser, Wash **Countertops, Sweep & Dust, Cooking,** and Hand Washing





**Figure 1:** Estimote sticker on water filter (left) Figure 2: Estimote stickers in package (right)

# Integration of Estimote Stickers into Smart Apartment Technology

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# Results

# **Table 1:** Number of inaccurate recordings for estimote stickers

Object	False Positive	False Negative	Accurate Fire %
Brita Filter	0	0	100%
Broom	0	0	100%
Dish Soap	1	0	100%
Duster	0	0	100%
Dustpan	0	0	100%
Hand Soap	1	10	15%
Medication Dispenser	0	1	93%
Plastic Soup Bowl	1	0	100%
Watering can	0	0	100%

- False negatives were more prevalent than false positives
  - Rate of true positives is **91.97%** [sensitivity]
  - Rate of true negatives (no data when there should not be) is **99.70%** [specificity]
- Average time difference between the RAT and estimotes was 9.57 seconds (M = 9.57,SD = 18.66)
- Activity recognition performance 10-fold cross-validation with
  - decision tree classifier on only
  - motion (M) sensor data yielded an
  - average of 94.17% ( $\kappa$ =0.93,  $\sigma$ =1.08)
  - recognition accuracy.
- Recognition accuracy on motion sensor data combined with estimote stickers data: **Receiving location**

Accuracy

- Downstairs (DS) Upstairs (US) 95.83% 95.76%  $(\kappa = 0.95, \sigma = 1.05)$  $(\kappa = 0.95, \sigma = 0.88)$
- p-values for 2-tailed t-test for accuracy values between the corresponding data: DS – US DS – M US – M 7.1x10<sup>-25</sup> 3.95x10<sup>-21</sup> 0.65 p-value



- testing
- activity recognition accuracy
- setup
- Confounds

  - prototype
  - particular object
  - used
  - have on stickers
- Future research
  - - receiver and stickers?

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# Discussion

• Estimote stickers show potential for tracking object use and being used in a smart home but require additional

High standard deviation means the time differences between the estimotes and the RAT are spread out • Addition of estimote stickers resulted in improvement in

While receiving location for estimote stickers had some effect on individual object movement detection, it didn't significantly affect the task recognition accuracy in our

> • Experimenter was in charge of marking tasks in the RAT, and humans are imperfect Cameras were on slight delay • App used on smartphones to collect and record data from the estimote stickers was a

RAT system was made to track a person's activities, not track when a person moved a Some items were not necessarily moved when

Hand soap had a pump in which participants pressed on, with the sensor on the back of the bottle Unsure of effects that heat, cold, and water

 How sensitive are estimote stickers? • Does the location of the estimote sticker affect estimote sensitivity? • Does different environmental conditions affect estimote sensitivity? What is the optimum distance between data

# Acknowledgment