GRACE HOPPER CELEBRATION

ANITA B.ORG

Detecting Health and Behavior Change by Analyzing Smart Home Sensor Data

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Association for Computing Machinery

#GHC17

Health and Behavior Monitoring

Age, injury, or health-related impairments can impact health

Benefits of health and behavior monitoring

- Health insights
- Longitudinal tracking
- Aging in place

Preferably monitor 24/7

Objective data collection

CLINICAL STUDIES SUPPORT A RELATIONSHIP BETWEEN DAILY BEHAVIOR AND COGNITIVE AND PHYSICAL HEALTH

Technologies for Behavior Monitoring

Ambient sensors (installed in the environment)


Wearable sensors (inertial, vital sign, etc.)


Smartphone/tablet apps

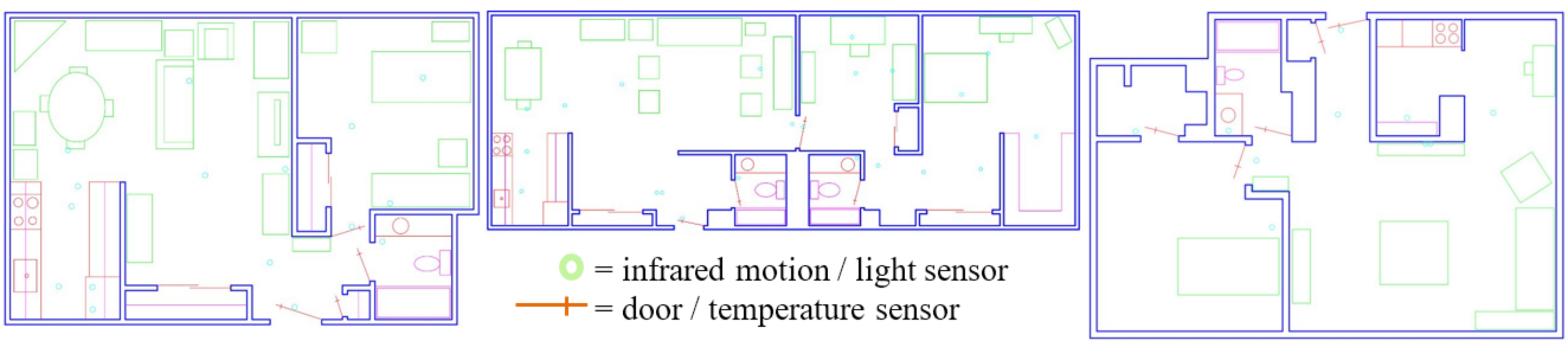

SELF-PERCEPTION OF BEHAVIOR OFTEN DOES NOT ALIGN WITH DIRECT MEASUREMENT

Smart Home Environments

Ambient sensors installed in the home

- Motion, door, temperature, etc.
- Fire event when state changes

WE COLLECTED DATA FROM SMART HOMES WITH OLDER ADULT RESIDENTS



Activity Recognition (AR)

CASAS-AR algorithm assigns activity labels

- Machine learning
- Cook, eat/drink, relax, sleep, enter/leave home, etc.

Timestamp/Identifier/Message	Sensor Location	Activity
2014-06-15 03:38:28.094897 M009 ON	BedroomMotion	Sleep
2014-06-15 03:38:29.213955 M009 OFF	BedroomMotion	Sleep
2014-06-15 03:38:17.814393 M015 ON	BathroomMotion	Bed-Toilet
2014-06-15 03:38:58.584179 M015 OFF	BathroomMotion	Bed-Toilet
2014-06-15 03:39:17.814393 M009 ON	BedroomMotion	Sleep

Tracking Behavior Changes

Analyze AR-labeled data to track resident behavior

Behavior Change Detection (BCD) framework

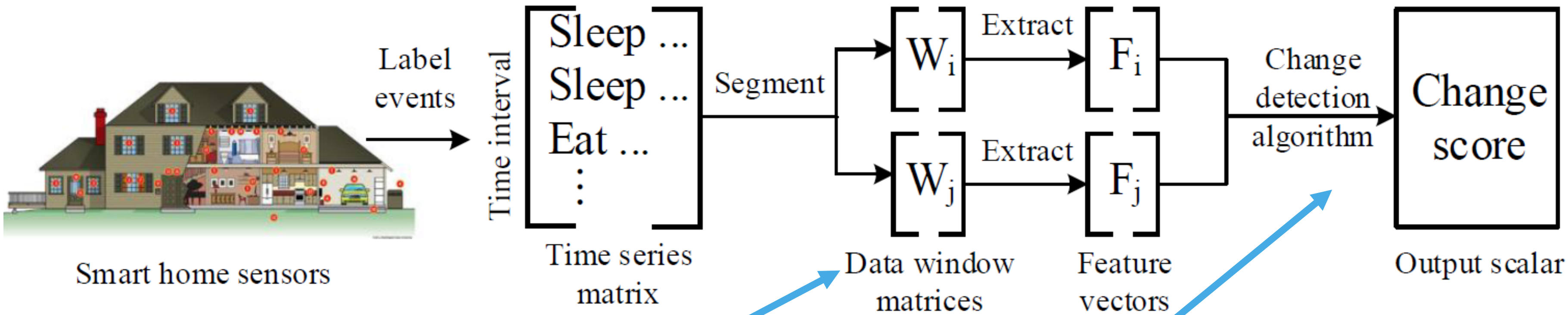
- Input: AR-labeled data
- Output: Quantification of change
- Output: Explanation of change

Focus on indicators of health events

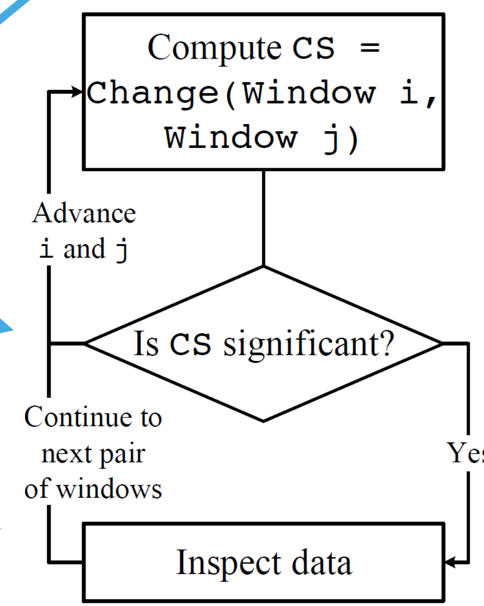
BCD IS A FRAMEWORK FOR INVESTIGATING BEHAVIOR CHANGE

Behavior Change Detection (BCD) Framework

BCD Framework



1. Window the data
2. Compute change score
3. Test significance of change
4. Analyze source of change



Change Detection Algorithm

A change detection algorithm

- Accepts two windows of data
- Quantifies the change
- double changeScore = computeChange($Window_i, Window_j$)

Different algorithms detect different change

- Virtual Classifier [Hido et al., 2008]
- RuLSIF [Liu et al, 2013]
- sw-PCAR [Sprint et al., 2016]

Focus on Virtual Classifier

WE INVESTIGATED 3 DIFFERENT CHANGE SCORE ALGORITHMS

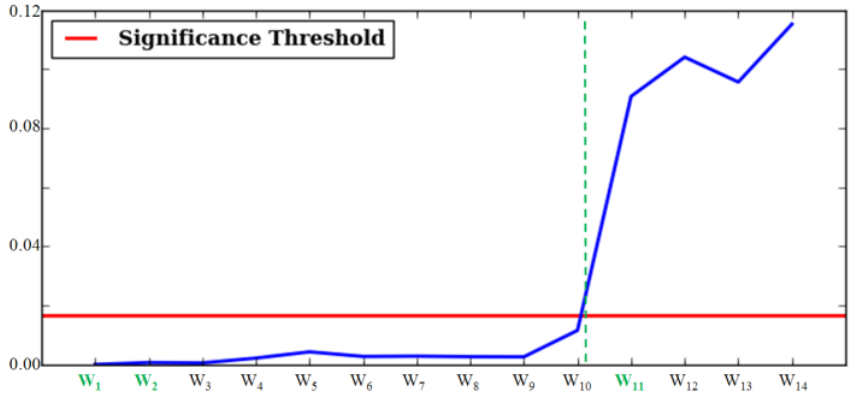
Results

Case Studies

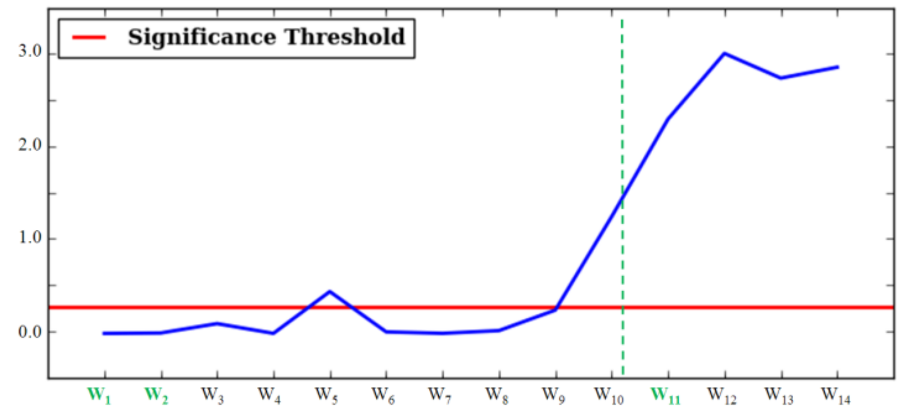
Smart home residents with health events

- SH1: 86 year old female
  - Diagnosed with lung cancer
  - Started radiation treatment during week 10
- SH2: 91 year old female
  - Diagnosed with insomnia during week 11

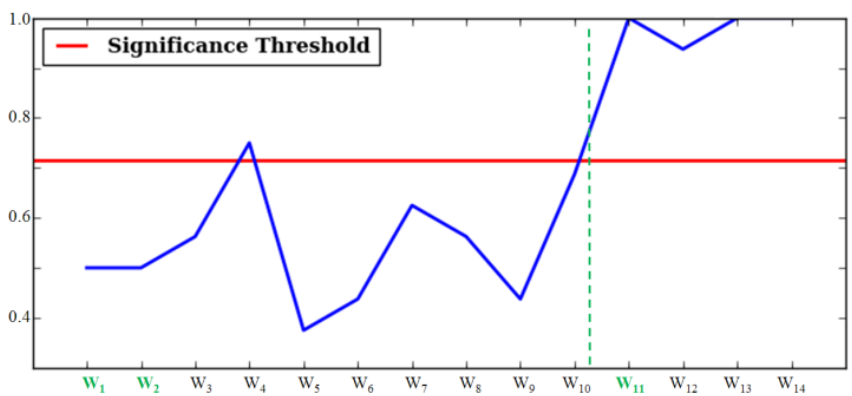
SH1 Health Event Results
(started radiation treatment during week 10)



sw-PCAR



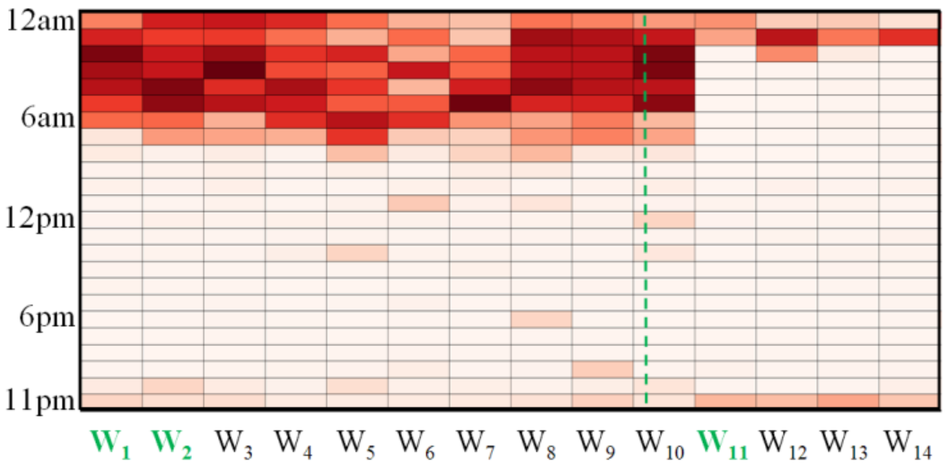
RuLSIF



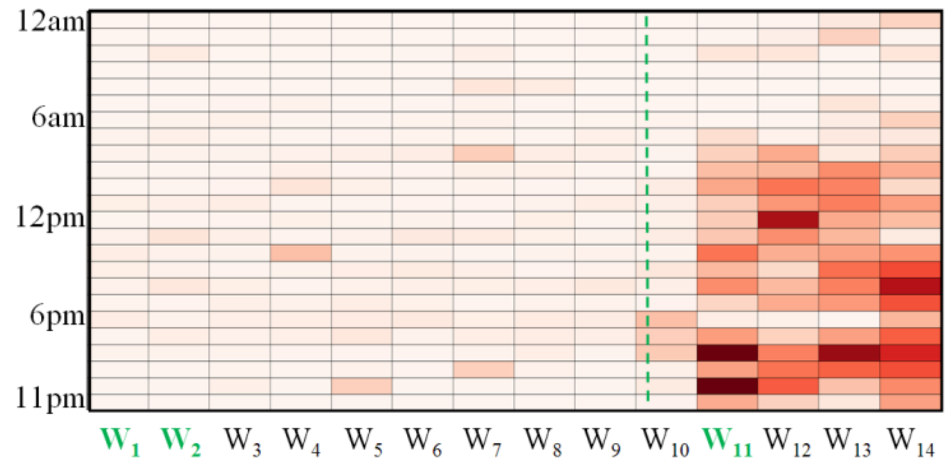
Virtual Classifier

BCD DETECTS SH1's HEALTH EVENT WHEN IT OCCURS

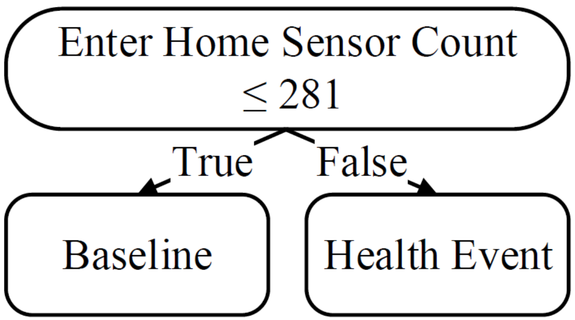
SH1 Explanation of Change
(started radiation treatment during week 10)



Sleep



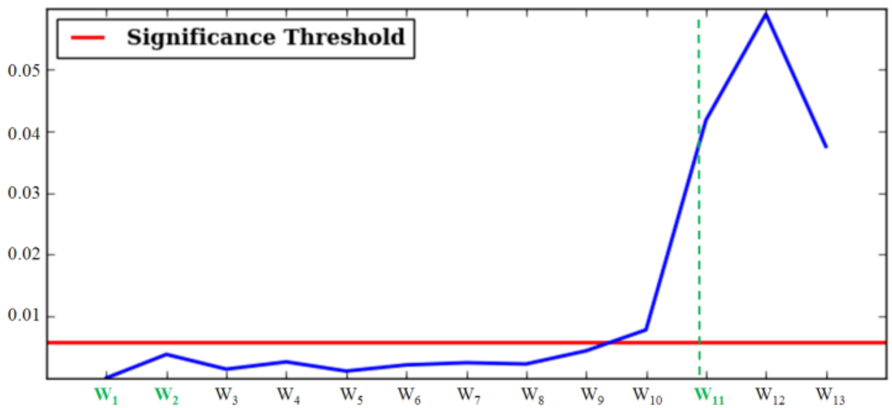
Enter Home



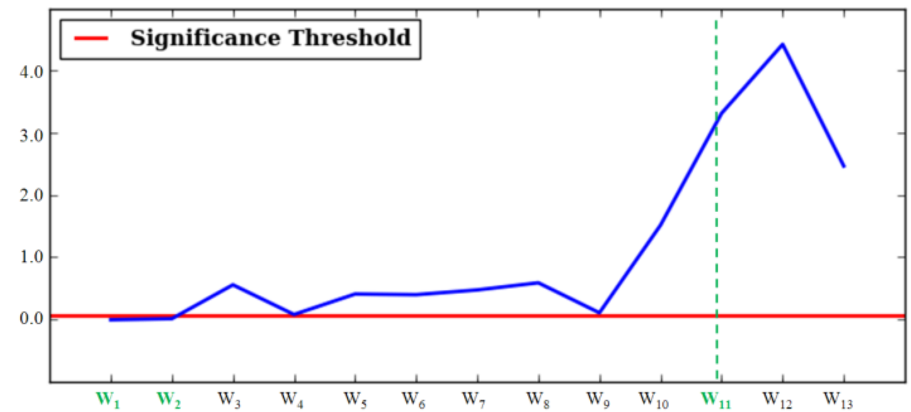
Top-level decision tree rule

SH2 Health Event Results

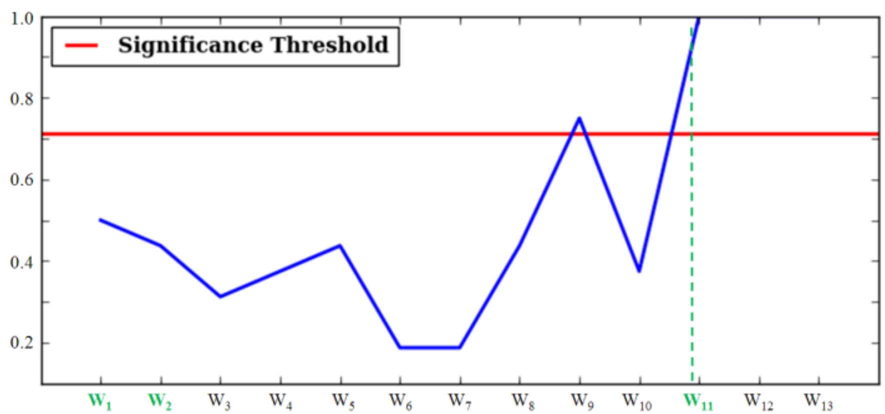
(diagnosed with insomnia during week 11)



sw-PCAR



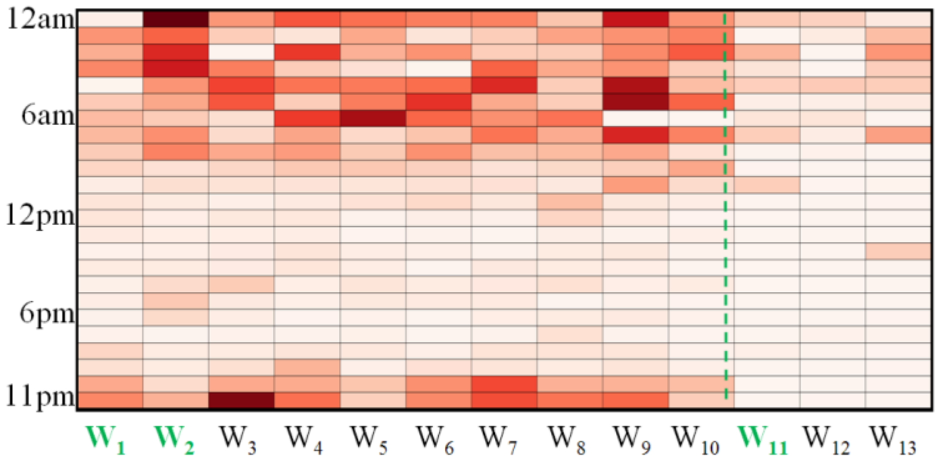
RuLSIF



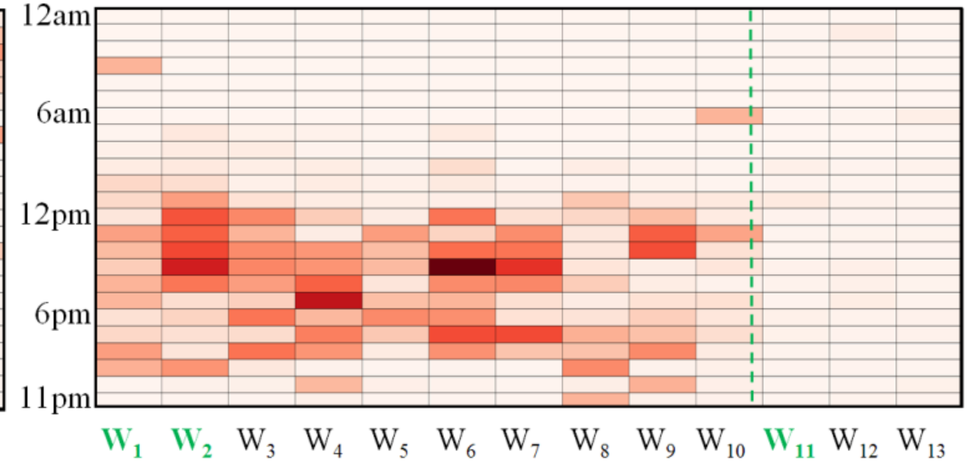
Virtual Classifier

BCD DETECTS SH2's HEALTH EVENT BEFORE DIAGNOSIS

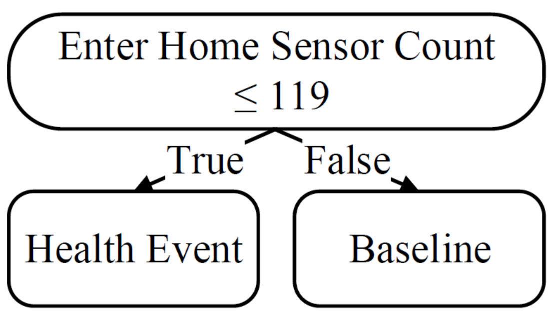
SH2 Explanation of Change
(diagnosed with insomnia during week 11)



Sleep



Enter Home



Top-level decision tree rule

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What's Next?

Impact

- Relationship between health and behavior
  - Over time
- Aging in place
- Motivation toward health goals

Future Work

- Different health events
- Vital sign data
- Interface caregivers

BCD IS OBJECTIVE, UNOBTRUSIVE, UNSUPERVISED

Thank You!

Connect with me

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Acknowledgments

- Co-authors: Diane Cook, Shelly Fritz, Maureen Schmitter-Edgecombe
- WSU CASAS-AR algorithm: [NC Krishnan and Diane Cook, 2014]

Related Publications

- G. Sprint, D. Cook, R. Fritz, and M. Schmitter-Edgecombe. *Using Smart Homes to Detect and Analyze Health Events*. IEEE Computer, 2016.
- G. Sprint and D. Cook. *Unsupervised Detection and Analysis of Changes in Everyday Physical Activity Data*. Journal of Biomedical Informatics, 2016.
- G. Sprint, D. Cook, R. Fritz, and M. Schmitter-Edgecombe. *Detecting Health Changes by Analyzing Smart Home Sensor Data*. IEEE SmartComp Conference, 2016

Thank you

FEEDBACK? RATE AND REVIEW THE SESSION ON OUR MOBILE APP

Download the GHC 17 app at http://bit.ly/ghc17app or search GHC 2017 in the app store

Virtual Classifier

Train a binary decision tree classifier

- Extract features
- Label feature vectors in $Window_i$ as positive class
- Label features vectors in $Window_j$ as negative class
- Average K-fold cross validation accuracy

Investigate source of change

- Accuracy significant?
- Investigate decision tree

WE TRAIN DECISION TREES TO LEARN THE DIFFERENCES BETWEEN TWO WINDOWS