Identifying and modeling the patterns of human activity routines

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Overview

Hypothesis

Human behavior patterns is valuable in fields including sociology, psychology, anthropology, and human-aware technology design.

Modeling Human Daily Routine

- Collect behavior data from unobtrusive sensors.
- Design data mining methods.
- Propose a formal method for building models to understand the general principles behind human behaviors.

Datasets

Smart Home Dataset (99 smart homes)

- Four types of ambient sensors are installed in each home: motion, magnetic contact, light level, and temperature level.
- Automated activity recognition (AR) labels sensor data.
- Change Point Detection (CPD) indicates the start/end time of each activity.

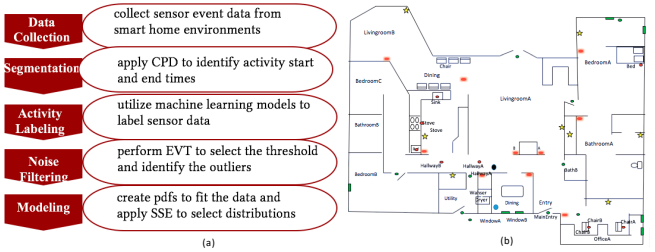


Figure 1. (a) the steps of population-based activity modeling; (b) the sensor layout in a smart home.

Residents' Information Dataset

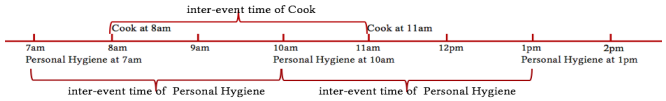
Table 2. Diversity analysis of the entire smart home dataset and the national population (national) by age(s) and education level (education), health information (health), and #residents.

	age(s)	education	health	#residents
smart homes	0.99	1.56	0.93	1.19
national	0.99	1.05	1.72	1.61

Data Mining

Inter-Event Times of Each Activity (in hours)

Defined as the time between two successive start times for an activity.



Noise Detection (Extreme Value Theory (EVT))

- Mean residual life plots evaluate alternative thresholds.
- Shape and modified scale parameter plots interpret thresholds.

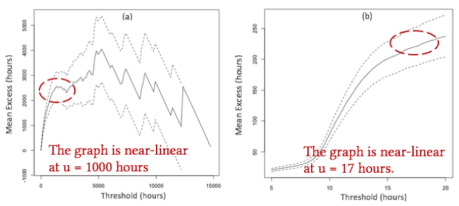


Figure 2. The mean residual life plots of Personal Hygiene inter-event times. The solid line plots the threshold value against the mean excess (outlier - threshold).

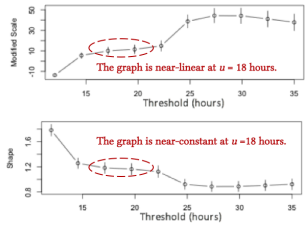


Figure 3. Parameter estimates against a range of from the Personal Hygiene inter-event times.

Modeling Fitting

Create 82 probability distributions

- Freedman–Diaconis rule decides a bin size.
- Sum of square error (SSE) represents a goodness of fit.
- A t-test validates the statistically

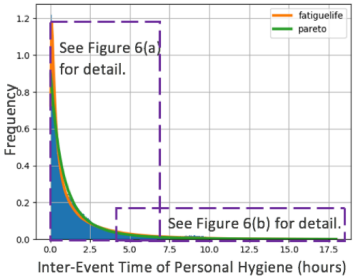


Figure 5. The Pareto Distribution Fitting.

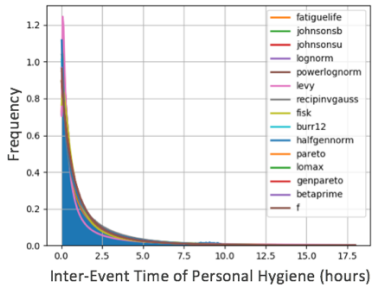


Figure 4. The top 15 fitted distributions among 82 distributions.

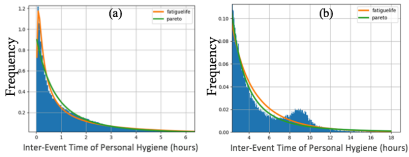


Figure 6. Details of the Pareto Distribution fitting for Personal Hygiene inter-event times.

Results

Table 2. Summarized results of seven activities. The two subgroups include single senior residents who are healthy (Subgroup H) and who have health ailments (Subgroup NH).

	Work	Wash Dishes	Personal Hygiene	Relax	Cook	Eat	Sleep
upper thresholds (hours)							
entire dataset	100	125	18	31	30	45	77
Subgroup H	60	65	15	60	52	70	45
Subgroup NH	30	75	15	27	30	55	32
SSE of the fitted Pareto distribution (SSEp)							
entire dataset	$5x10^{-2}$	$3x10^{-2}$	$3x10^{-1}$	$1x10^{-1}$	$3x10^{-1}$	$3x10^{-2}$	$1x10^{-2}$
Subgroup H	$4x10^{-3}$	$5x10^{-3}$	$7x10^{-2}$	$1x10^{-1}$	$7x10^{-2}$	$2x10^{-3}$	$1x10^{-2}$
Subgroup NH	$1x10^{-1}$	$3x10^{-3}$	$8x10^{-2}$	$8x10^{-2}$	$6x10^{-2}$	$3x10^{-3}$	$1x10^{-2}$
p value of the t-test between the top-fitted distribution and the Pareto distribution							
entire dataset	0.990	0.996	0.987	0.981	0.953	0.999	0.783
Subgroup H	0.976	0.863	0.931	0.977	0.989	0.977	0.638
Subgroup NH	0.985	0.905	0.912	0.950	0.957	0.839	0.700

Observations:

- The small thresholds of the inter-event times of Work, Relax, Cook, Eat, and Sleep in Subgroup NH indicate several problems:
  - Mobility limitations.
  - Cognitive limitations.
- The SSE shows that the Pareto fits well.
- The p value demonstrates that the Pareto fits as strong as the top-fitted distribution.

Conclusions

The behavior patterns and detection of deviations in our study may indicate potential health problems. The findings can also lead to more effective medical interventions and may benefit other fields.

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