Understanding Household Priorities when Scheduling Activities

Robert Regue, Mahdieh Allahviranloo & Will Recker

Institute of Transportation Studies. University of California, Irvine

University *of* California Irvine

INTRODUCTION

The idea of understanding activity patterns of individuals and how activities are scheduled during any given day has been the focus of the travel demand studies for decades and has resulted in various lines of research in the field. One particular line of the research is using **constrained optimization frameworks** to analyze activity-scheduling behavior, such as **Household Activity Pattern Problem (HAPP)** *(1)*, an activity-based travel demand model posed as a multi-objective optimization model that optimally schedules household activities throughout the day. However, there are at least **2 major confounding issues** with these types of models:

1. **Specification of the objective function(s)**
2. **Specification of time window constraints**

Need CALIBRATION

Calibration Challenges *(2)*:

- Infinite set of alternatives
- Non interpretable utility coefficients
- Household Specific methodologies

OBJECTIVES

Reformulate and Calibrate the **Household Activity Pattern Problem**

Address following questions :

- What do individuals and households value the most when they schedule their activities?
- Is there any similarities in the way individuals - belonging to the same cluster of patterns - value different utilities?
- What is the proper metric to measure and compare the utility terms of an activity pattern?
- How to account for the utility of different activity types and household characteristics in activity scheduling?

DATA DESCRIPTION

Data:

- California Household Travel Survey Data, 2000-2001 *(4)*

Sample size:

- 8684 activity patterns, generated by segmenting the length of day, starting from 5:00 to 23:00, into 10-minute intervals, clustered into 8 distinct groups *(3)*.

Activity categories :

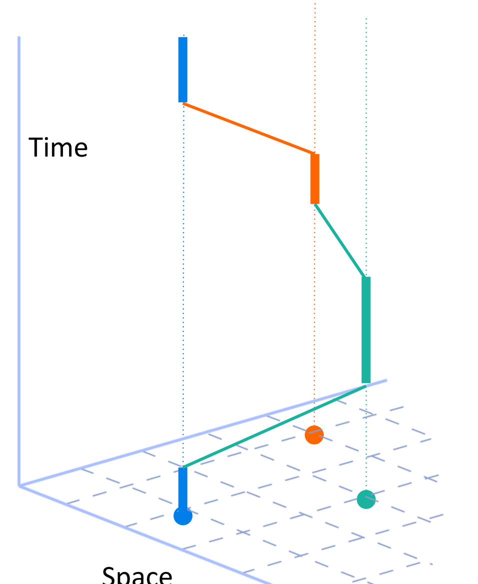
- In home (H), Work (W), School (S), Maintenance (M), Recreational/Socializing (R), Personal (P), Pick-up/Drop-off (K) and Other (O) activities.

Data sampling criteria for calibration (**50 individuals** from **each of the 8 clusters**) :

- Out-of-home activities between 2 and 5
- Activity duration larger than 10 minutes
- Travel time shorter than 60 minutes

Input parameters for each individual:

- Cluster membership
- Activity duration
- Estimated travel time matrices



METHODOLOGY

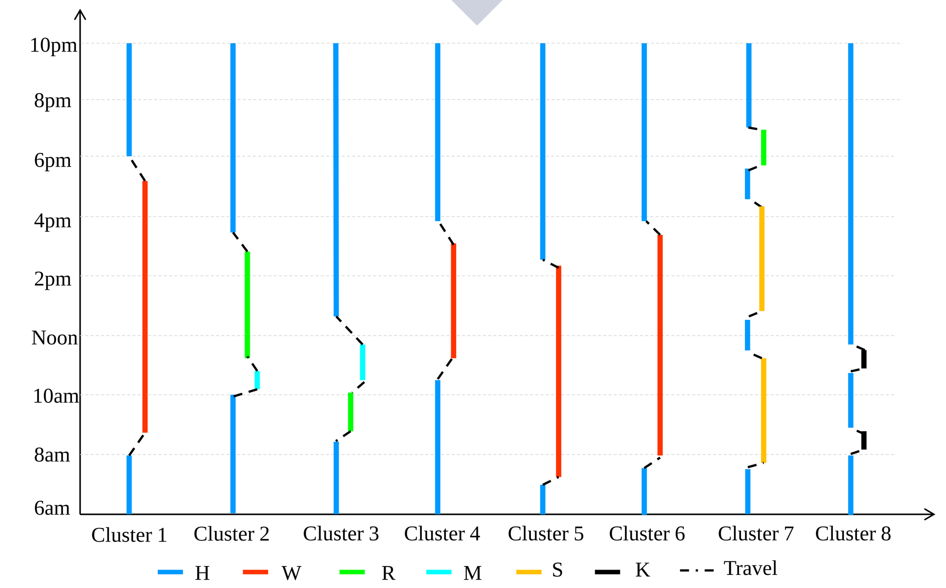
Original HAPP as PDPTW

$$\min\ Z = \sum_{i=1}^{m} \omega_i \cdot U_i(X,T)$$

st.

$$A(X,T,a,b,s,t) \le 0$$
$$X = \{0,1\}, T \ge 0$$

Cluster Households



Goal Programming

$$\min\ Z = \sum_{i=1}^{m} \omega_i \cdot \left(d_i^+ + d_i^-\right)$$

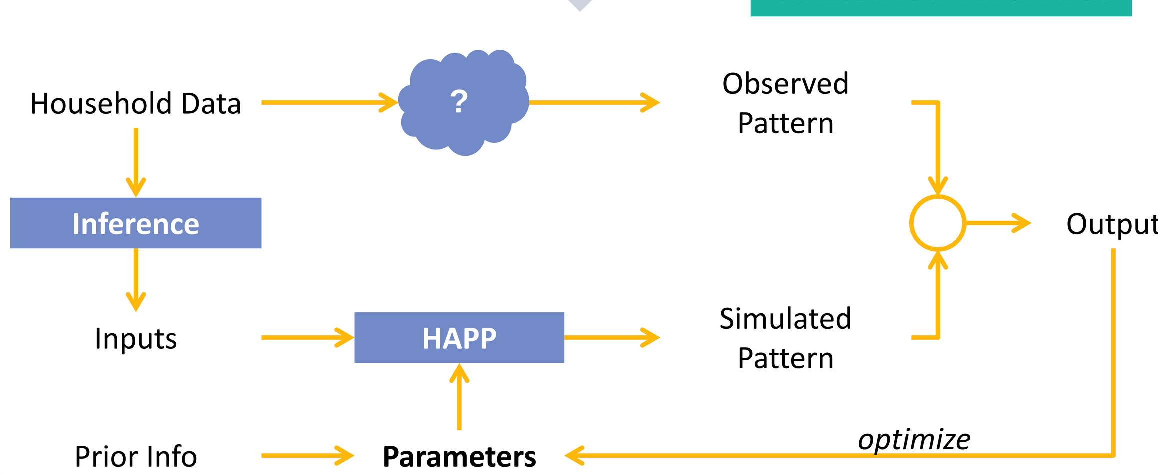
All objectives have same Units & Scale: COMAPARABLE

st.

$$U_i(X,T) + d_i^- - d_i^+ = \tau_i \quad i = 1,2,\dots,m$$
$$d_i^+, d_i^- \ge 0 \quad i = 1,2,\dots,m$$
$$A(X,T,a,b,s,t) \le 0$$
$$X = \{0,1\}, T \ge 0$$

Calibration: Differential Evolution

Calibrated Priorities



UTILITIES $U_i(X,T)$

1) **Arrival time** deviation from the cluster mean per **mandatory** activities

$$U_1 = \sum_{u \in \mathbf{M}} \left| T_u - \bar{T}_u^c \right|$$

2) **Arrival time** deviation from the cluster mean per **flexible** activities

$$U_2 = \sum_{u \in \mathbf{F}} \left| T_u - \bar{T}_u^c \right|$$

3) **Arrival time** deviation from the cluster mean per **pick up** activities

$$U_3 = \sum_{u \in \mathbf{K}} \left| T_u - \bar{T}_u^c \right|$$

4) **Travel time** budget deviation from cluster mean

$$U_4 = \left| \sum_{v \in \mathbf{V}} \sum_{u \in \mathbf{N}} \sum_{w \in \mathbf{N}} t_{uw}^v X_{uw}^v - \bar{t}^c \right|$$

5) **Out-of-home time** spent deviation

$$U_5 = \left| \sum_{v \in \mathbf{V}} \left(T_{2n+1}^v - T_0^v \right) - \bar{T}_{out}^c \right|$$

6) **Waiting time** disutility before starting an activity

$$U_6 = \left| \sum_{u \in \mathbf{P}^+} \left(T_u - \sum_{v \in \mathbf{V}} \sum_{w \in \mathbf{N}} \left(T_w + S_w + t_{wu}^v \right) X_{wu}^v \right) - 0 \right|$$

T_u: arrival time to activity u, X_{wu}^v: vehicle v travels from activity w to u, n: number of out-of-home activities, c: cluster, t: travel time

$\mathbf{P}^+ = \{1,2,\dots,i,\dots,n\}$

$\mathbf{P}^- = \{n+1, n+2, \dots, n+i, \dots, 2n\}$

$N = \{0, \mathbf{P}^+, \mathbf{P}^-, 2n+1\}$

- Utilities 1-3 capture the utility of performing different activities throughout the day: Mandatory (**M**), Flexible (**F**) or Pickup (**K**) activities
- All the targets are cluster dependent. They capture differences among different behaviors and potentially different household socioeconomics.
- Time windows are different for each cluster and activity type. They are drawn from the arrival time distribution to activities for that cluster and activity type.

RESULTS

We compare the calibrated and non calibrated approach using **edit distance** as an error measure, 1 edit distance unit is equivalent to 10 minutes.

- Overall improvement in the sample using calibration : **7.4%**
- Clusters with the **largest improvement: cluster 1 and 8**
- Clusters with the **lowest improvement: cluster 7**
- Low importance is observed for the waiting time and the travel time budget goals.
- Clusters with maximum priority for waiting: cluster 1, (waiting time before performing is not important in scheduling unless it is a mandatory activity- cluster 1, cluster 5 and cluster 7).

Comparing the results of the model for two cases: 'Equal Priorities' and 'Calibrated Priorities'

Cluster	Equal Priorities		Calibrated Priorities								%
	Total Error	Mean Error	w_1	w_2	w_3	w_4	w_5	w_6	Total Error	Mean Error	
1	1535	32.7	5	3	3	6	3	4	1383	29.4	9.9
2	2264	48.2	1	3	-	-	2	-	2087	44.4	7.8
3	1988	42.3	3	1	3	-	5	-	1831	39.0	7.9
4	1809	38.5	5	3	4	-	5	-	1663	35.4	8.1
5	1726	36.7	2	5	2	-	5	2	1617	34.4	6.3
6	1687	35.9	3	1	-	5	4	-	1601	34.1	5.1
7	2749	58.5	6	2	4	3	1	1	2674	56.9	2.7
8	2003	42.6	3	5	3	2	-	-	1771	37.7	11.6
	15,761								14,627		7.4

CONCLUSIONS

- Under the goal programming approach comparisons among priorities can be made.
- Different utilities were associated to activities based on their type.
- Individuals in different clusters set different priorities for different goals.
- The travel time and the waiting time goals are higher in clusters where a long work activity is present in the representative pattern of the cluster.
- The solutions obtained are sensitive to the priorities.
- Individuals do tend to behave as other do given the differences in cluster behavior and the sensitivity of the priorities.

FUTURE WORK

- Introduce new goals that can better capture the utility of performing an activity depending on the time of day, activity type and the sequence.
- Accommodate bimodal distributions when defining time windows to perform activities.
- Test the methodology on new datasets.

SELECTED REFERENCES

1) Recker, W. The Household Activity Pattern Problem: General Formulation and Solution. *Transportation Research B*, Vol. 298, Jan. 1995, pp. 61–77.
2) Chow, J. Y. J., and W. W. Recker. Inverse optimization with endogenous arrival time constraints to calibrate the household activity pattern problem. *Transportation Research B*, Vol. 46, 2012, pp. 463–479.
3) Allahviranloo, M., R. Regué, and W. Recker. Pattern Clustering and Activity Inference. Presented at the 93rd Transportation Research Board, 2014.
4) Caltrans. *2000-2001 California Statewide Household Travel Survey*. California Department of Transportation, Jun. 2002.

AKNOWLEDGEMENTS

This research was supported, in part, by grants from the University of California ITS Multi-Campus Research Program and Initiative on Sustainable Transportation, the *Balsells-Generalitat de Catalunya Fellowship* and the *Fundación Caja Madrid Fellowship*. Their support is gratefully acknowledged.

15-2992