



On Using Existing Time - Use Study Data for Ubiquitous Computing Applications

Kurt Partridge, Philippe Golle

Presented by: Minh Huynh

**CS525m – Mobile and
Ubiquitous Computing**





Introduction

- **Time-use studies have been conducted by government and commercial institutions for several decades**
- **Participants of the studies give detailed records of their activities, locations, and any other data imaginable**
- **Data can be collected over a day, week, or longer period of time**
- **Large studies contain hundreds of thousands of participants and can cost millions of dollars to conduct. Some datasets are available to the public for free.**
- **Provides cheap and comprehensive activity classifiers for ubicomp developers.**



Uses in Ubicomp Systems and Applications

1. Construct Activity Classifiers

- Activity data in time-use studies are linked to variables. These variables are treated as features that make up the activity classifier.
- Usually sensor data is used in ubicomp applications. Combining sensor data with time-use data can create better activity classifiers.

2. Estimate Which Features Predict Best

- Time-use data can help determine the value of features such as demographics, location, time, and previous activity.

3. Inform Understanding about Simultaneous Activities

- Can be used to confirm which activities tend to occur simultaneously.

4. Identify Circumstances for Rare Activities

- Can be used to determine when a rare activity is most likely to occur. For example, a system that uses cameras may not always need to be powered on throughout the entire day. They can be adjusted to power on during certain times and conditions.



Uses in Ubicomp Systems and Applications (cont)

5. Validate Study Sites

- Time-use data can generalize a study's findings since time-use data illustrate population norms. Therefore, multiple study sites would not be required to validate the same findings.

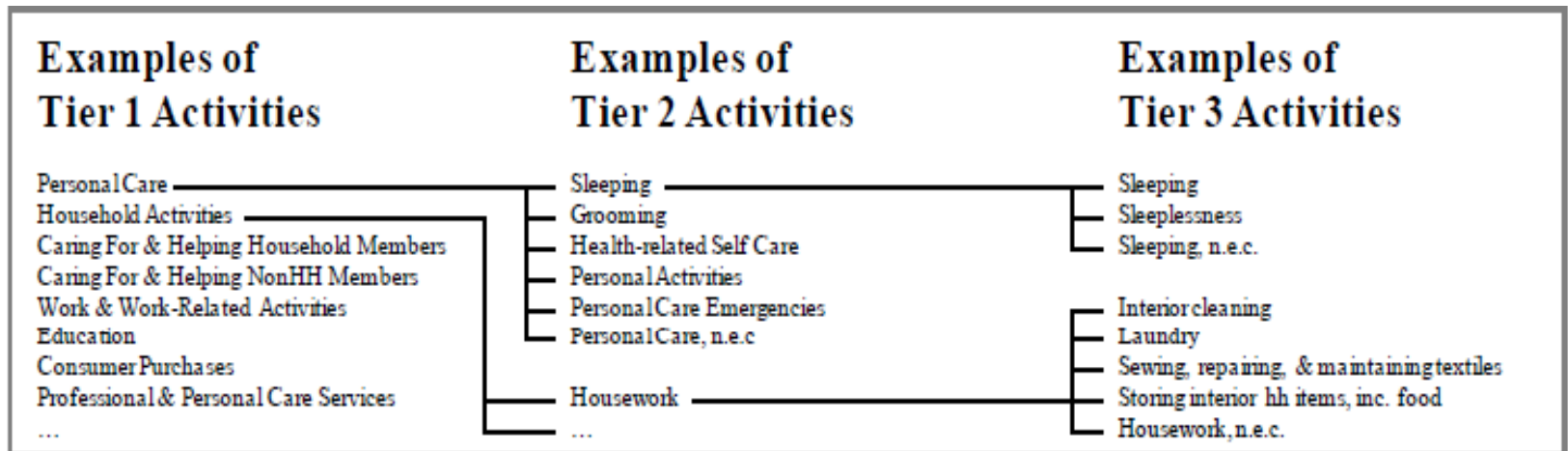
6. Provide Field-Tested Activity and Location Classifiers

- Longer running studies are more likely to have better and more accurate classifiers than new classifiers.
- Saves time and cost by not having to create a new classifier.

This study focuses on the first 3 uses of time-use data in ubiquitous computing

- Construct Activity Classifiers
- Estimate Which Features Predict Best
- Inform Understanding about Simultaneous Activities

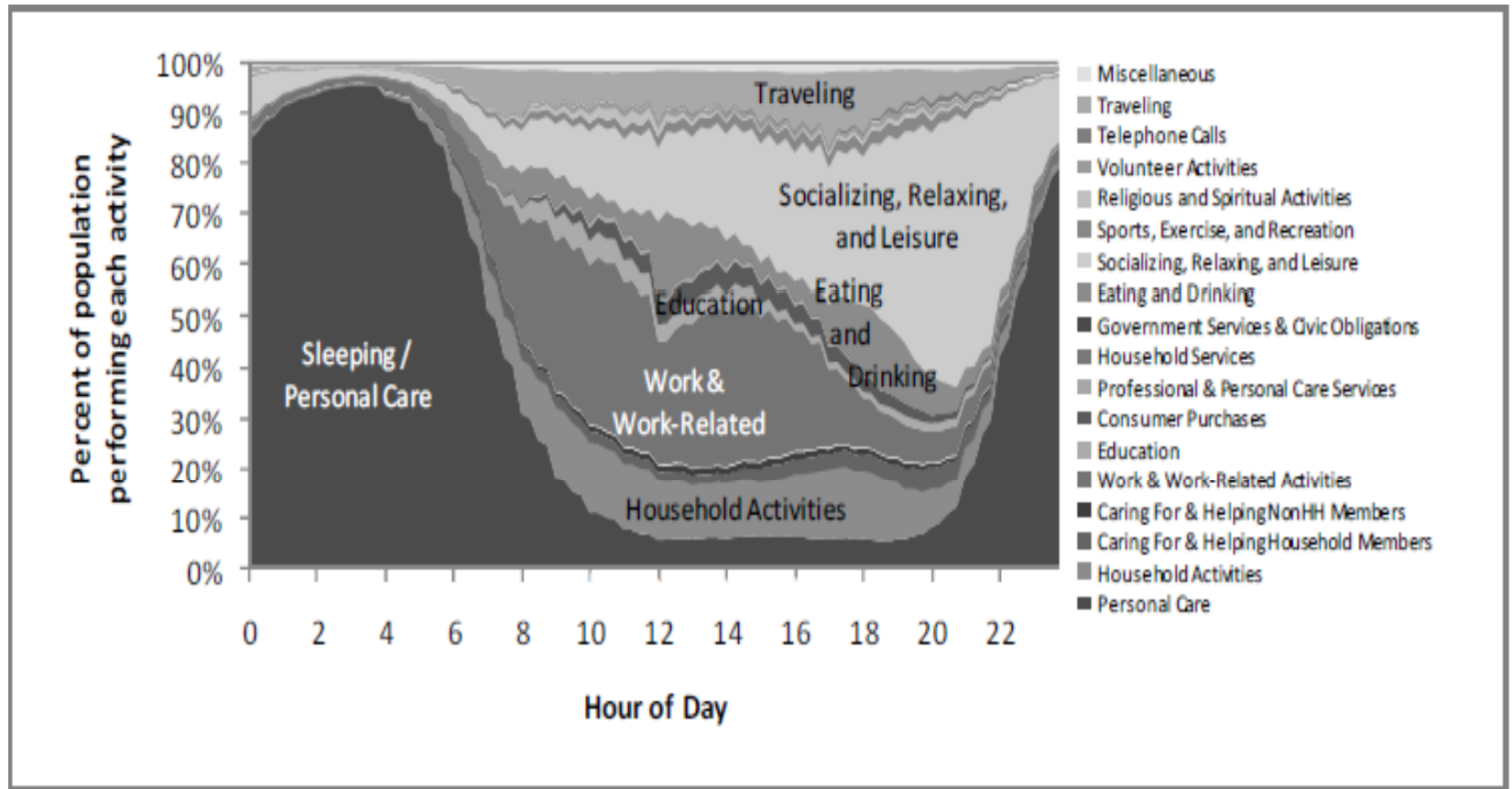
Activity Classification



- American Time-Use Survey (ATUS) is the largest time-use study in the US. It's purpose is to estimate work that is not included in economics measure. Such as childcare.
- The ATUS study uses 3 tiers of activity codes that differ in granularity. Tier 1 activities are more general and Tier 3 activities are more specific. This study has 18 Tier 1 activities, 110 Tier 2 activities and 462 Tier 3 activities. Location has 27 different variables.



Activity Classification (cont)





Differences in Time-Use Studies and Ubiquitous Computing Studies

1. **Duration Difference** – Activities in time-use studies may last a couple of hours. Activities in ubiquitous computing may last between an instant to tens of minutes.
2. **Domain Specificity Difference** – Time-use studies usually cover ALL activities in an entire day. Ubiquitous computing studies may only cover a limited domain. Example: ElectriSense system.
3. **Cognitive Interpretation Difference** – Data in time-use studies need to be recalled and interpreted by the participant. Data in ubiquitous studies generally come from sensors.

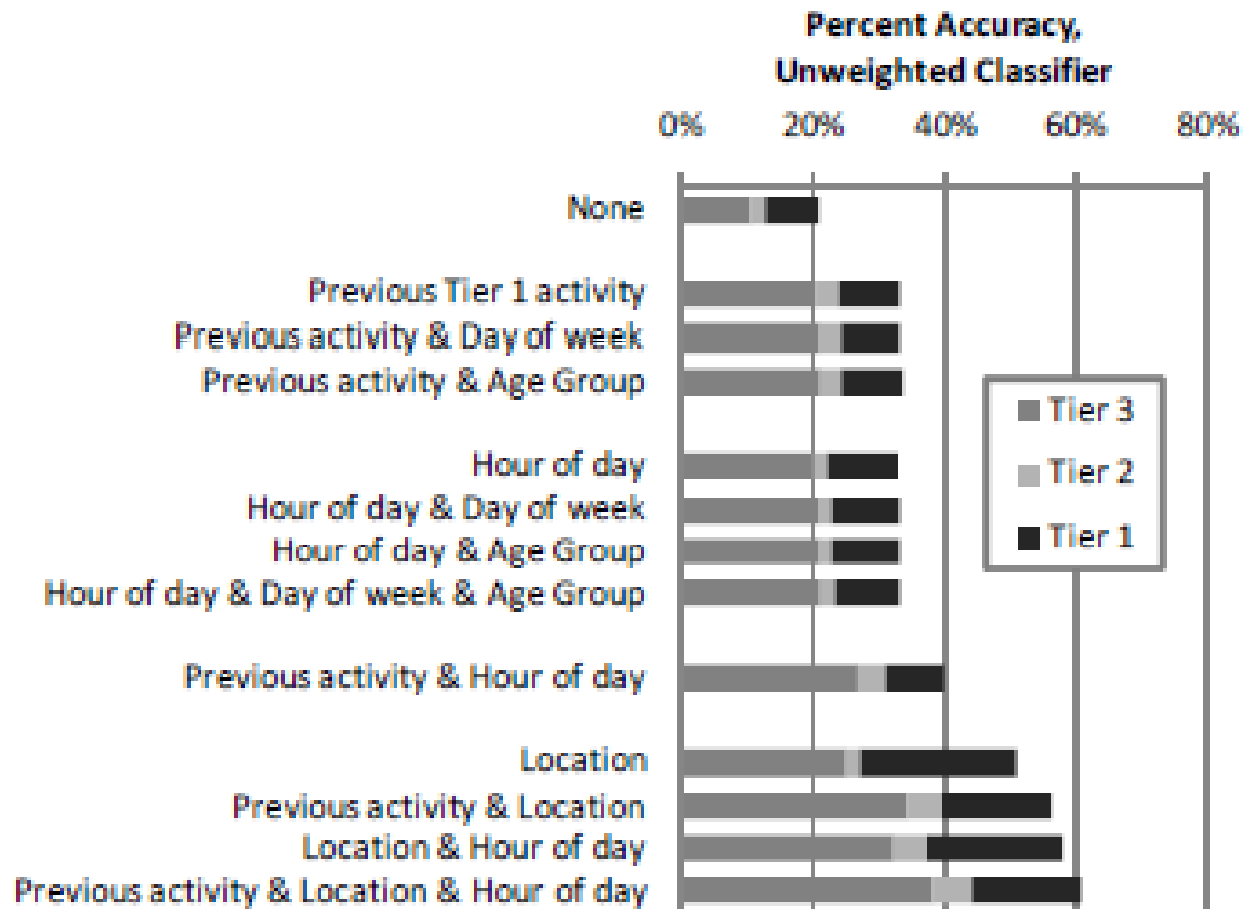


Unweighted and Duration-Weighted Classifiers

- **Unweighted Classifier – Shorter activities that happen more often.**
 - Example: Telephone calls
- **Duration-Weighted Classifier – Longer activities that happen less often.**
 - Example: Sleeping

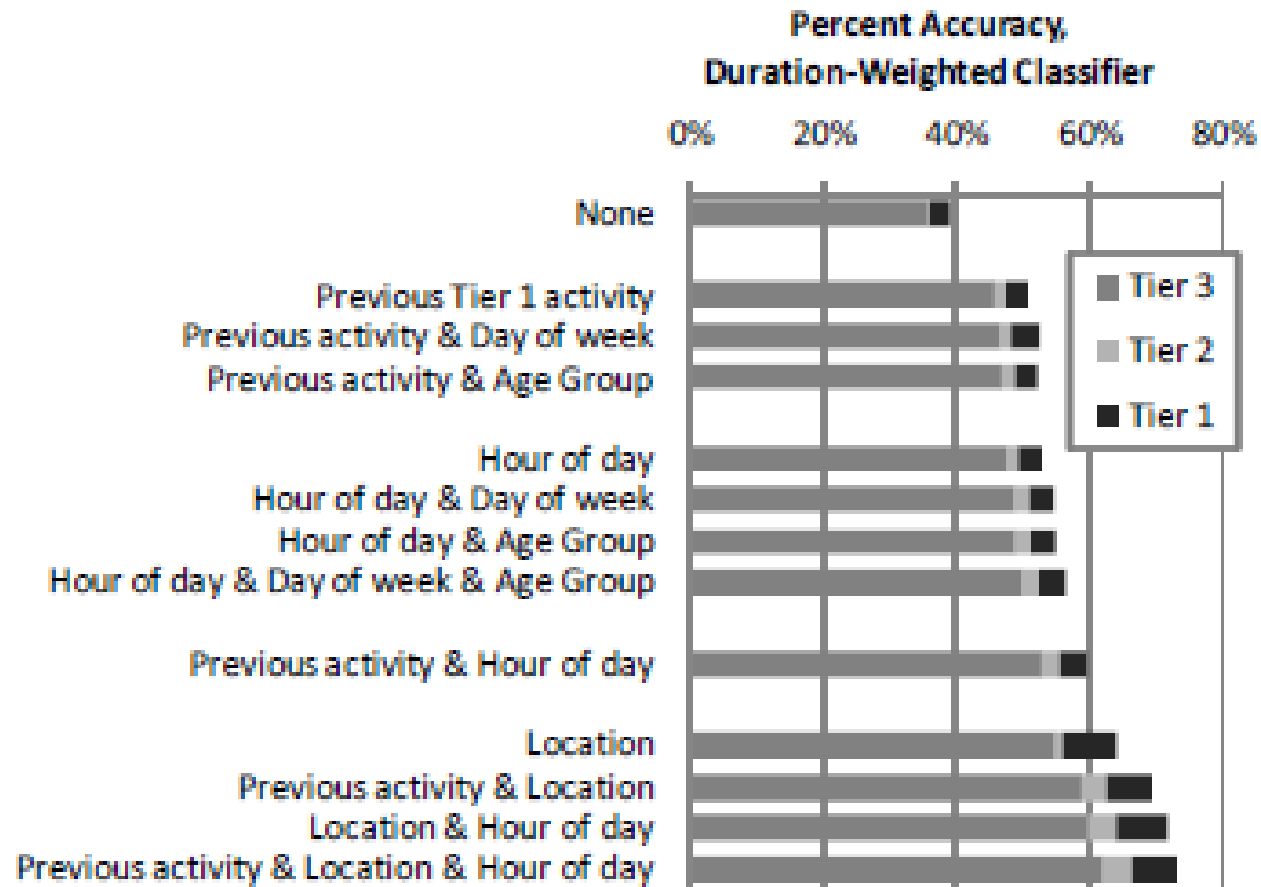


Overall Accuracy of Unweighted Classifier





Overall Accuracy of Duration-Weighted Classifier





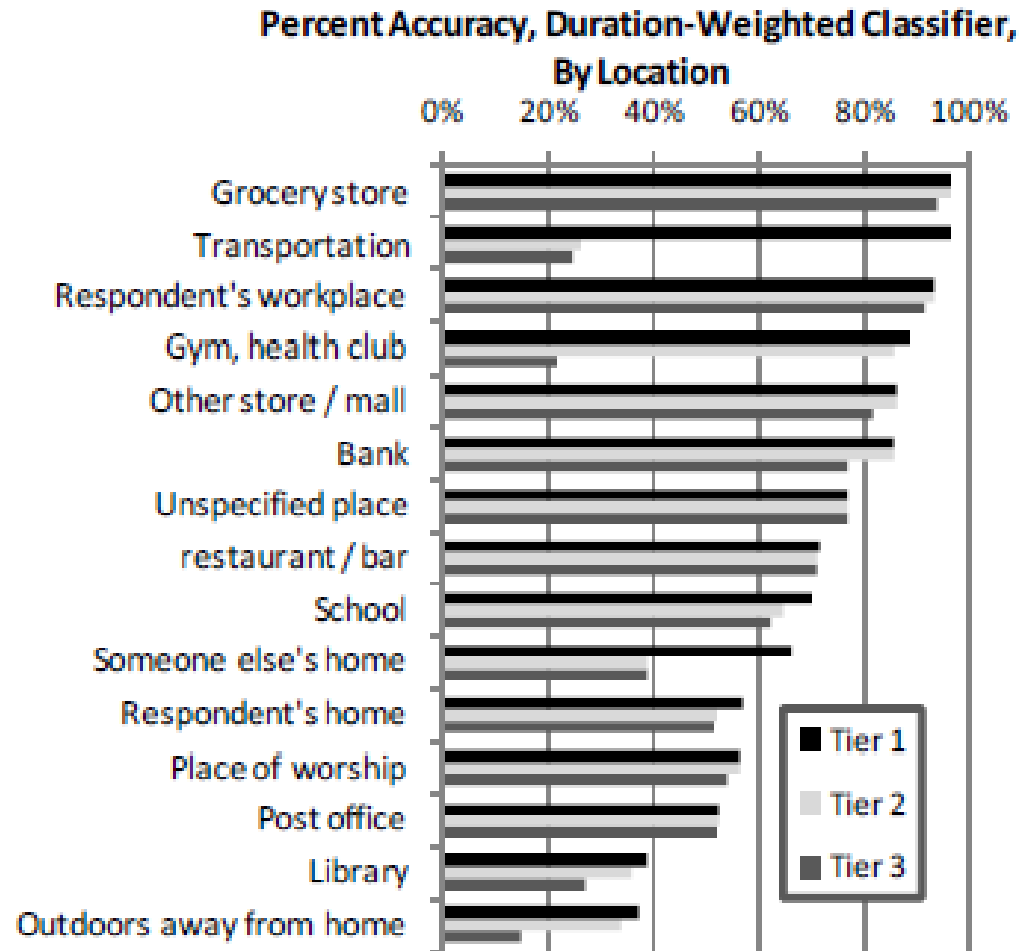
Accuracy Inference using Location

- Locations designed for commercial transactions, employment, or transportation have a higher accuracy for predicting activity
- Locations that are public facilities, churches, and homes have lower activity inference accuracy
- In some cases, improving location taxonomy may provide better prediction results.

Example: Home, watching television and eating. (Instead of home, we can have living room and kitchen) – Gathering this type of data set is very time consuming. Much faster to reuse a large already collected dataset like studies from ATUS.



Accuracy Inference using Location (cont)





Activity Inference Accuracy for Different Activities

- Activities are measured using recall and precision measurements
- Some activities increase in recall/precision when adding extra features.
 - Example: Household Activities.
- Some activities decrease in recall/precision when adding extra features.
 - Example: Personal Care Activities.

Accuracy Inference for Different Activities (cont)

Activity	Avg hh:mm per day	Accuracy of Tier 1 Activity Classification (in percent)											
		Hour of day		Hour of day & Age Group		Prev Acty & Hour of day		Location		Location & Hour of day		Location & Prev Acty & Hour of day	
		Rec	Pre	Rec	Pre	Rec	Pre	Rec	Pre	Rec	Pre	Rec	Pre
Personal care (inc. sleep)	9:23	87.2	74.5	85.8	77.5	88.2	84.0	100	56.8	89.0	82.3	89.1	86.6
Socializing, relaxing, and leisure	4:31	52.1	39.3	57.5	39.8	61.0	41.6	14.3	47.8	71.2	47.1	73.8	49.0
Work & work-related activities	3:27	61.3	30.2	68.5	36.7	73.5	44.8	87.9	93.7	87.9	93.6	87.6	95.0
Household activities	1:49	-	-	1.0	21.8	11.6	28.6	0.1	52.3	14.2	31.5	22.2	34.0
Telephone calls	1:14	-	-	-	-	-	-	-	-	-	-	0.0	0.0
Eating and drinking	1:06	-	-	-	-	8.6	51.9	20.2	71.6	19.5	73.2	29.1	65.2
Education	0:27	-	-	39.0	32.9	4.4	44.1	64.7	69.9	64.3	69.6	59.8	72.2
Caring for household members	0:26	-	-	-	-	1.4	27.7	-	-	0.0	1.5	2.4	35.7
Consumer purchases	0:24	-	-	-	-	-	-	89.2	88.9	89.2	88.9	88.2	89.9
Sports, exercise, and recreation	0:18	-	-	-	-	0.4	16.8	36.4	48.5	35.5	47.2	31.3	48.8
Traveling	0:11	-	-	-	-	31.8	49.4	96.0	97.0	95.9	96.8	94.8	96.1
Caring for non household members	0:08	-	-	-	-	0.1	11.9	-	-	0.0	24.6	3.8	25.4
Religious / spiritual activities	0:07	-	-	-	-	2.6	17.7	80.7	56.4	80.0	56.4	75.8	60.1
Volunteer activities	0:07	-	-	-	-	0.8	15.7	-	-	0.0	2.9	2.9	24.7
Prof & personal care services	0:05	-	-	-	-	3.5	34.6	5.1	85.7	24.5	22.0	40.0	32.5
Household services	0:01	-	-	-	-	0.0	0.0	-	-	-	-	0.0	0.0
Government and civic services	0:00	-	-	-	-	3.0	22.3	-	-	-	-	4.0	67.9



Simultaneous Activities

- American's Use of Time Study (AUT) shows 45% of all activities were accompanied by secondary activities.
- Activities that are secondary activities or accompanied by a secondary activity:
 1. Conversation, phone, texting
 2. Watch television, video
 3. Wash, dress, personal care
 4. Other meals and snacks (excluding work or in a restaurant)
 5. Listen to radio



Simultaneous Activities (cont)

- National Human Activity Pattern Survey (NHAPS) results for top 5 locations for eating:

1. Home, Kitchen (47%)
2. Home, Living Room, Family Room, Den (14%)
3. Home, Dining Room (12%)
4. Indoors, Restaurant (11%)
5. Home, Bedroom (2%)

- A study showed that the frequency of eating out is roughly the same frequency of eating in different rooms. Data had to be collected from a single individual for several weeks.

- AUT and NHAPS combine to show that these eating activity patterns of the individual in the above study is consistent with the thousands of people from the two survey results.

- Although the analysis draws from old data, multiple studies, and different years, it only took a couple hours to perform and it did not cost anything to carry out.



Future Work

- How much do time-use activity and location taxonomies vary?
 - What aspects of activity and location are universally agreed on?
 - How much do classification differences contribute to inaccuracies?
- What issues arise when adopting an activity classifier for a ubicomp application?
 - Creating a standard classification would be beneficial, less likely to leave out important activities, and more likely to interoperate with other systems.
- What methodologies used by time-use studies can be adopted in ubicomp systems?
 - Recruitment, collecting and coding data, treatment of simultaneous activities
- How can ubicomp contribute to time-use study research?
 - Offer automated and pervasive tools to help collect time-use data
 - Provide more accurate results
 - Reduce cost



Related Works

- **Predestination** – Uses land use data from the US Geological Survey and National Household Transportation Survey to better predict destination places of people. Time-use studies covers the entire day and not just transportation activity, potentially benefits a broader range of applications.
- **Recent studies involving sensors to infer activity** – More detailed than using time-use studies. However, time-use studies have more participants so they are less biased and they cover rare activities much better.
- **LifeNet** – Most similar to time-use studies. Uses large data set to study how contextual variables (location, gender, emotion, ect) influence activity.

Questions?

