

Classification of User Activity Energy Efficiency Analysis

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Introduction: Comparison of Sampling Strategies in order to Conserve Energy

The sensor platform has a limited battery life

- With continuous sampling, the sensor platform will run out of battery power in a few hours.

In order to determine which sensors use the most battery power, 15 separate sensors were tested at two minute intervals, ten times each.

- In order to conserve battery life, samples are taken at specific intervals

Four different techniques were used: **Uniform Sampling**, **Random Sampling**, **Exponential Sampling**, and **Markov Chain Sampling**.

Each sampling technique was run with 24 hours of data, recorded at 1 Hz

- Each test was run in order to determine the least number of samples that can be used while still conserving accuracy. Five characteristics are outputted for each test:
 - Percent of samples used** – the amount of samples used during this test
 - Overall accuracy** – the correct samples divided by the incorrect samples
 - Individual accuracy** – the average of the accuracies of each activity
 - Confusion Matrix** – the number of transitions between activities
 - Percentage Confusion Matrix** – the probability of activity changes

Problem Description: Continuous activity classification poses a large energy burden

In order to determine which sensors are the most energy draining, 15 separate tests were performed on various sensors. Each test was performed ten times for two minutes each.



The Nokia N95, The Sensor Platform

The analysis determined that some of the most commonly used sensors for activity classification, the accelerometer and GPS, are the most battery-draining.

	NOKIA N95 BATTERY CONSUMPTION ANALYSIS				All Values in Watts				2 MINUTE TESTS											
	ACCEL	RT SENSOR	CELL	GPS	WLAN	GPS+ACCEL	SOUND	CONTROL	WHELLO	GPS+UO	BT/UO	CAMERA	GPS+NO SGNL	WEL+GPS	WEL+GPS+ACCEL					
T1 Average:	0.64	0.34	0.13	0.43	0.33	0.69	0.52	0.12	1.55	0.48	0.46	1.28	0.6	0.54	0.59					
T2 Average:	0.59	0.34	0.12	0.41	0.25	0.82	0.5	0.14	1.43	0.26	0.47	1.26	0.43	0.58	0.6					
T3 Average:	0.47	0.34	0.15	0.42	0.36	0.81	0.37	0.17	1.15	0.35	0.48	1.41	1.12	0.56	0.6					
T4 Average:	0.46	0.3	0.12	0.43	0.2	0.82	0.37	0.13	1.51	0.09	0.44	1.2	0.47	0.56	0.59					
T5 Average:	0.48	0.37	0.12	0.43	0.42	0.8	0.37	0.11	1.33	0.37	0.44	1.21	0.98	0.56	0.59					
T6 Average:	0.63	0.33	0.12	0.42	0.35	0.82	0.39	0.36	1.45	0.16	0.57	1.21	0.52	0.54	0.59					
T7 Average:	0.61	0.33	0.11	0.44	0.31	0.83	0.42	0.11	1.39	0.17	0.64	1.2	0.97	0.37	0.58					
T8 Average:	0.48	0.25	0.38	0.41	0.21	0.81	0.37	0.17	1.41	0.22	0.58	1.2	0.48	0.57	0.59					
T9 Average:	0.45	0.33	0.13	0.43	0.21	0.8	0.37	0.31	1.56	0.13	0.64	1.2	1.15	0.57	0.6					
T10 Average:	0.48	0.31	0.12	0.43	0.4	0.82	0.43	0.11	1.46	0.14	0.72	1.19	0.74	0.57	0.58					
Mean:	0.529	0.324	0.15	0.428	0.304	0.802	0.411	0.173	1.423	0.237	0.544	1.238	0.748	0.562	0.591					
Max % Deviation:	20.98%	22.84%	153.83%	4.21%	38.16%	13.97%	26.52%	108.09%	19.18%	102.53%	32.95%	14.08%	54.16%	3.91%	1.86%					

Proposed Solution: Decreasing the sampling rate leads to a prolonged battery life

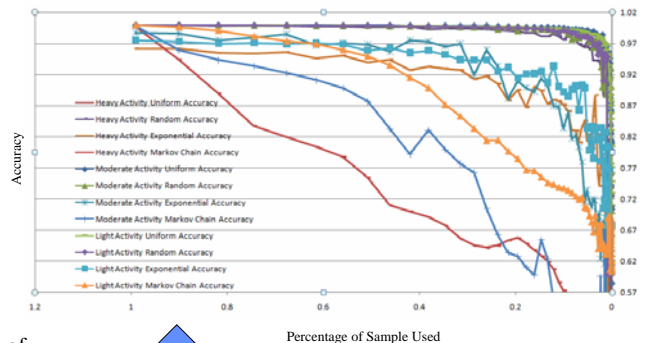
We analyze a set number of samples and use the last confirmed activity to fill in the "blank spots"



User generated data is saved into a CSV file, to be used to test sampling algorithms

21	Stationary Outdoors	1216832188
22	Stationary Outdoors	1216832189
23	Stationary Outdoors	1216832190
24	Stationary Outdoors	1216832191
25	Running	1216832192
26	Running	1216832193
27	Running	1216832194

The 24 hours of data is processed using each of the four algorithms



Four Sampling Techniques Tested:

- Uniform Sampling** – Sample sensors at a regular interval
- Random Sampling** – Sample a given percentage of samples at random intervals
- Exponential Sampling** – Humans have a tendency to continue their current task, so if the current sample is identical to the previous sample, increase the time in between sampling
- Markov Chain Sampling** – By multiplying probability matrices with the current activity, an accurate prediction of the next activity can be determined.

Individual Accuracy

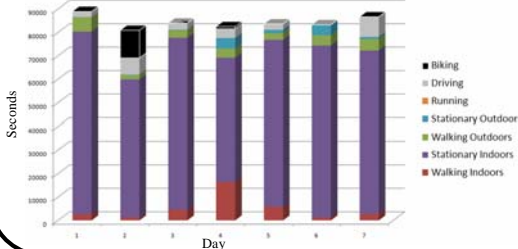
Overall Accuracy: 0.912800753828192, 0.5999999999999999, 0.912800753828192, 0.5999999999999999, 0.912800753828192, 0.5999999999999999, 0.912800753828192, 0.5999999999999999

Confusion Matrix

Probability Confusion Matrix

The processed data is graphed in order to determine the most accurate sampling technique.

Indoor Activities tend to be much more prevalent than Outdoor Activities



Sample Confusion Matrix:				
•PREDICTED OUTCOME:				
ACTUAL OUTCOME:	X	Stationary	Walking	Driving
	Stationary	3045	23	18
	Walking	4	653	3
	Driving	7	0	248