Karlsruhe Institute of Technology

Technology for Pervasive Computing

Energy-Efficient Activity Recognition using Prediction

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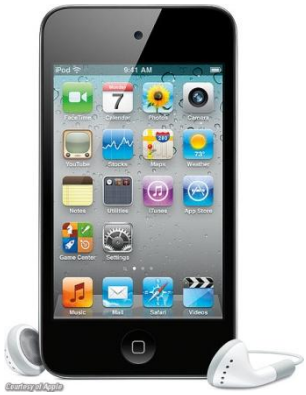
Motivation

- What happens as the number of devices increases?



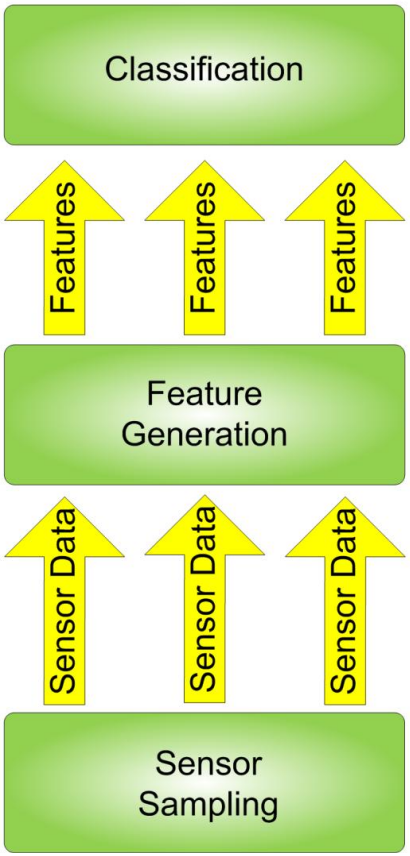



Use Prediction to Save Energy

Context prediction: forecast future contexts!

- Classify activity
- Predict probable future activities
- Identify sensor subset for differentiation
- Activate sensor set
- Repeat

- Save energy!!



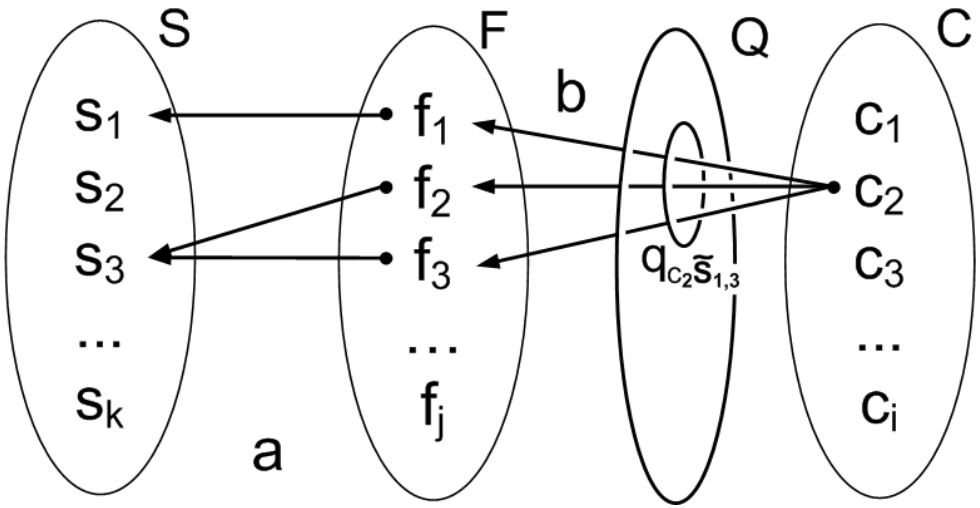
What is there to research?!

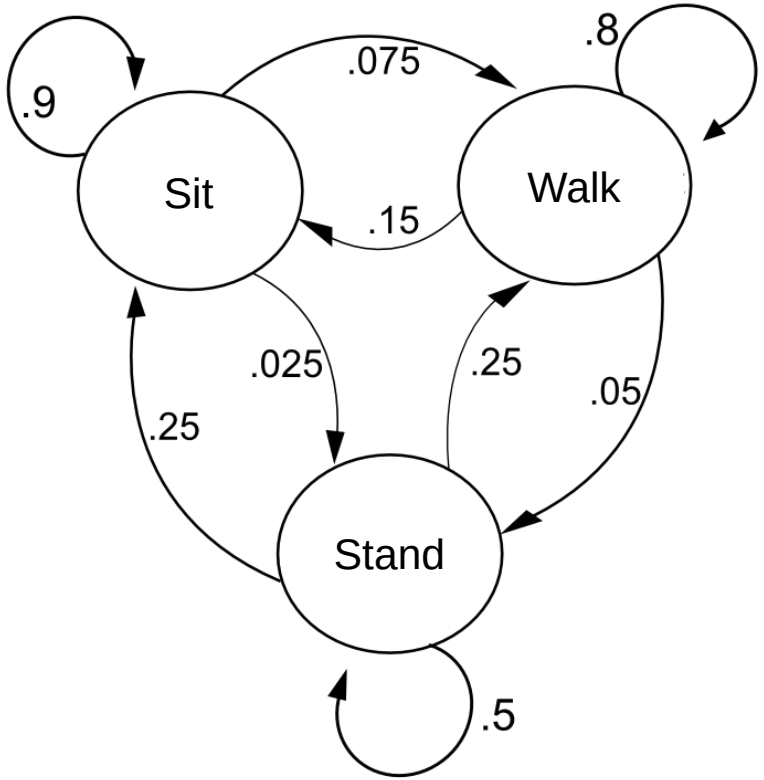
Research Issues

- How to select sensors for to be turned off?
  - How much information is delivered to
- How many classes to predict (ρ)?
  - 1 class prediction?
  - All class prediction?
- And what is the acceptable cost (λ)?
- How does performance depend on scenario?
  - How predictable is the subject (κ)?

System Description

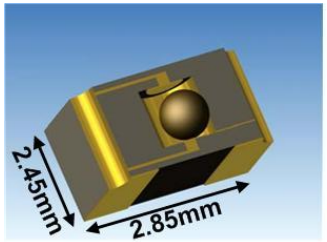
- Activity recognition algorithms
  - K-Nearest Neighbors
  - Hidden Markov Model
- Prediction algorithm
  - Markov chain
- Method for mapping activities to sensors
  - Selecting S without violating λ

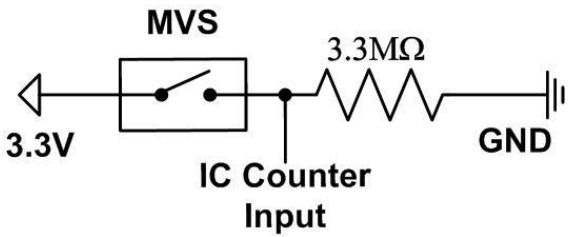


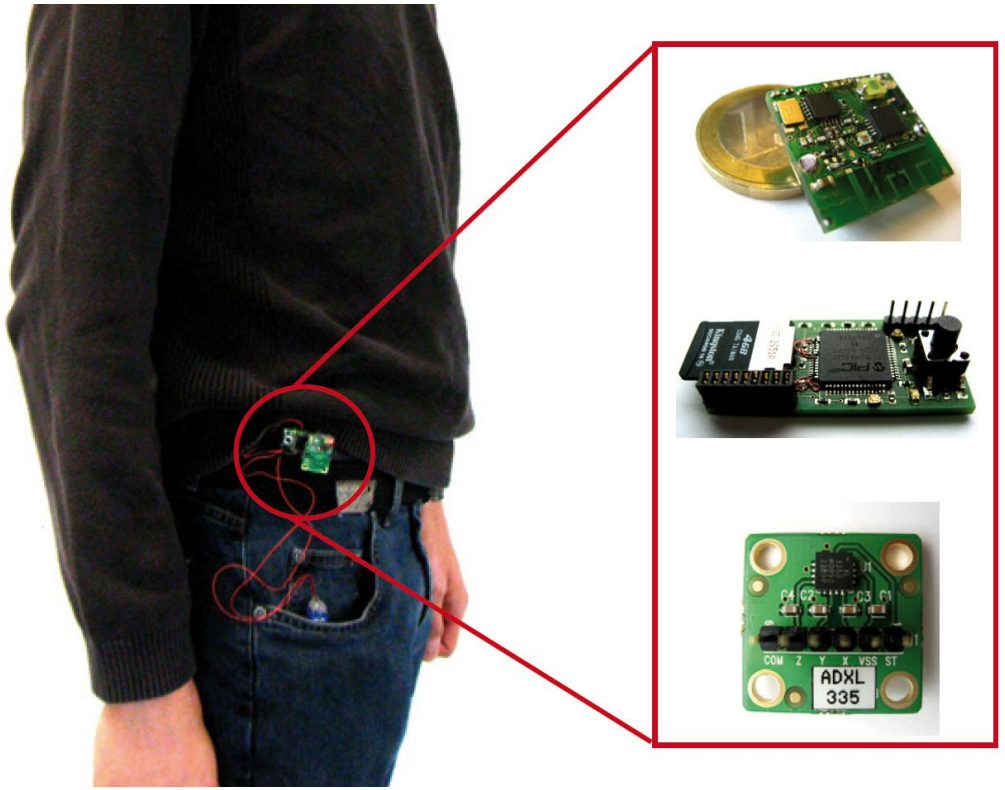


Activity Recognition Data Set

- 5 Subjects
- 8 Activities
- 60 Hz sampling
  - Vibration
  - Acceleration
  - Light
  - Temperature
- 142 Minutes of data
- Dataset available at: www.teco.kit.edu/~gordon/MVS/



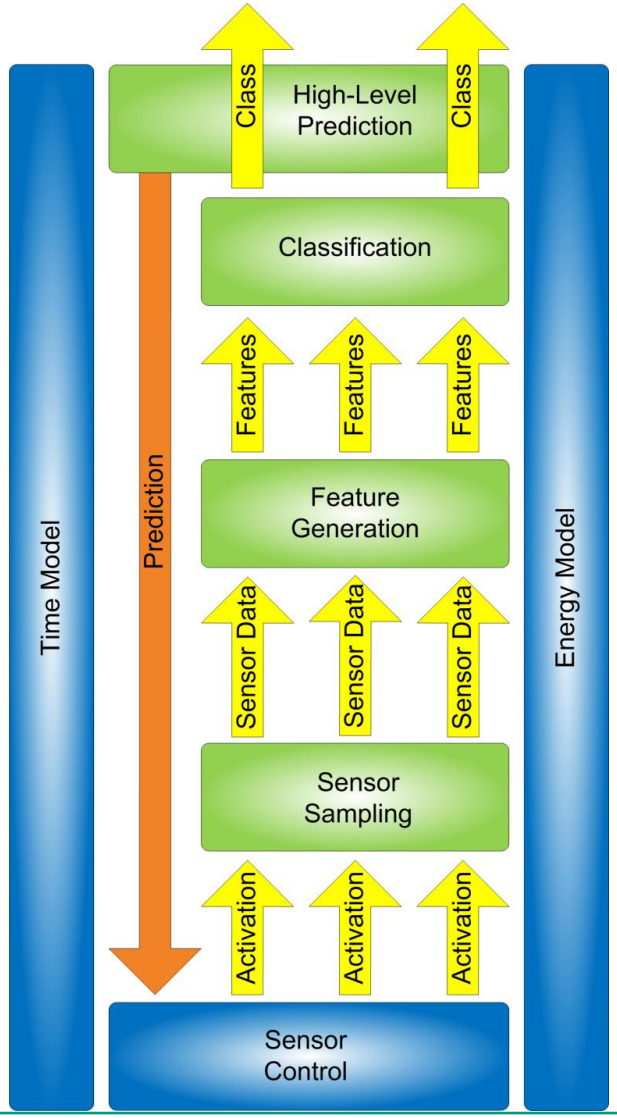




Gordon et al. A Novel Micro-Vibration Sensor for Activity Recognition: Potential and Limitations, ISWC'10

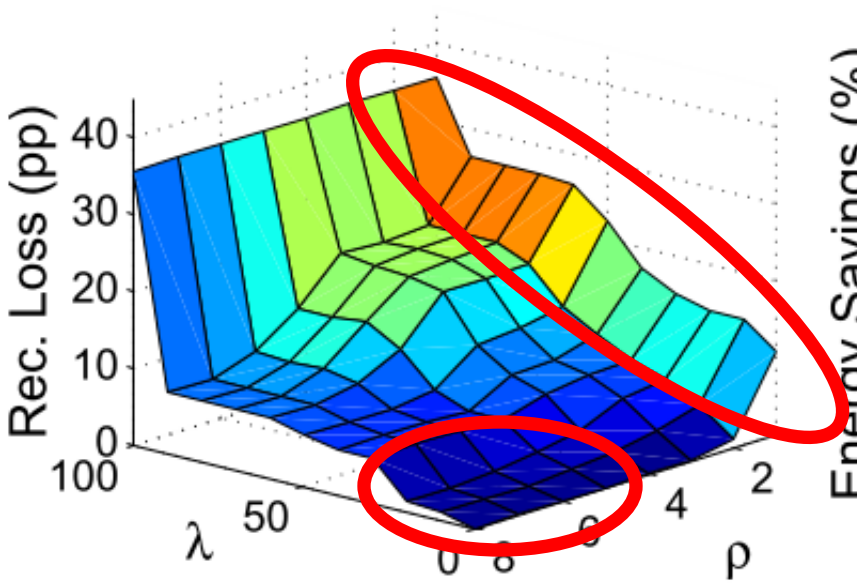
Simulation Environment

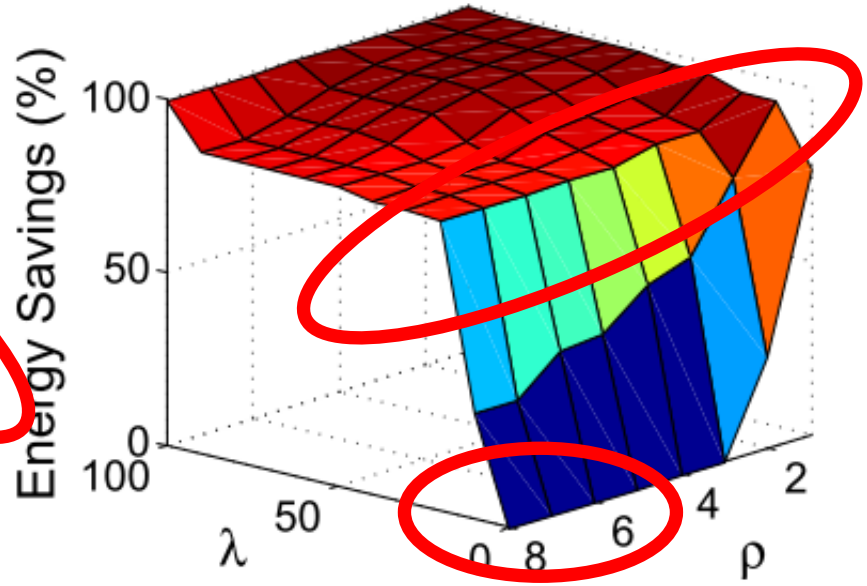
- Generate synthetic data sets using generative model (HMM)
  - Vary predictability (κ) (0.125:0.875 step 0.125)
  - Train: 2/5 train, 1/5 test, 2/5 eval
- Simulate performance
  - Loss parameter (λ) (0:100 step 10)
  - Predicted states (ρ) (1:8 step 1)
- Evaluate
  - Evaluate base case (ALL ON)
  - Classifier accuracy (loss)
  - Energy consumption (savings)



Lots of Results!

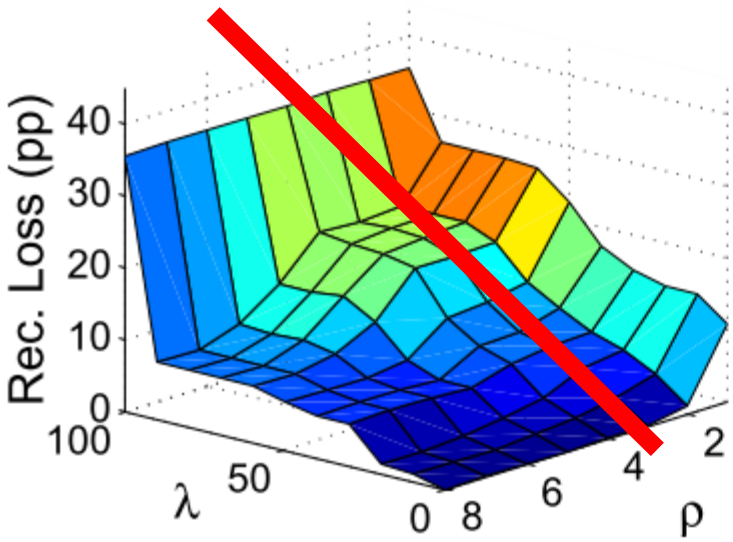
- Multi-dimensional results matrix!
  - [κ, λ, ρ, classifier]
  - A matrix for acc., prec., rec., f-meas., energy
  - Confusion matrix 2 more dimensions!
- This work:
  - Accuracy (loss) and energy (savings)

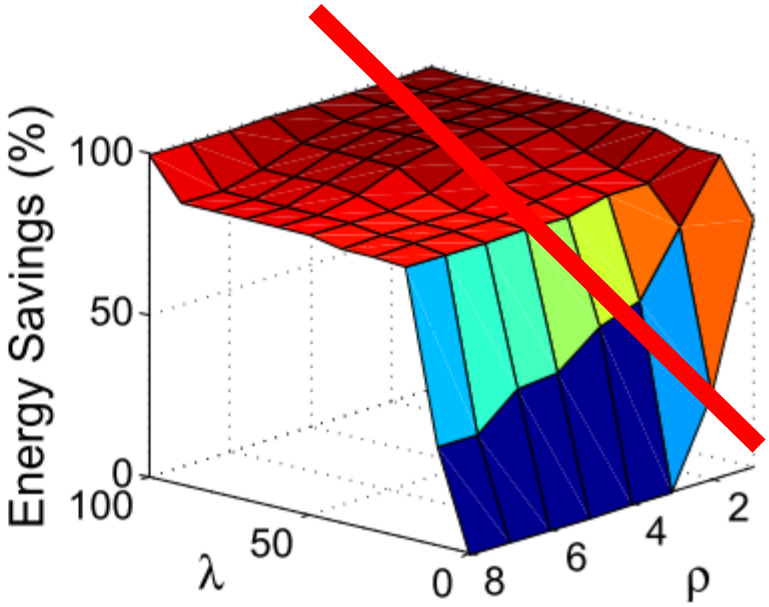




Loss Parameter λ

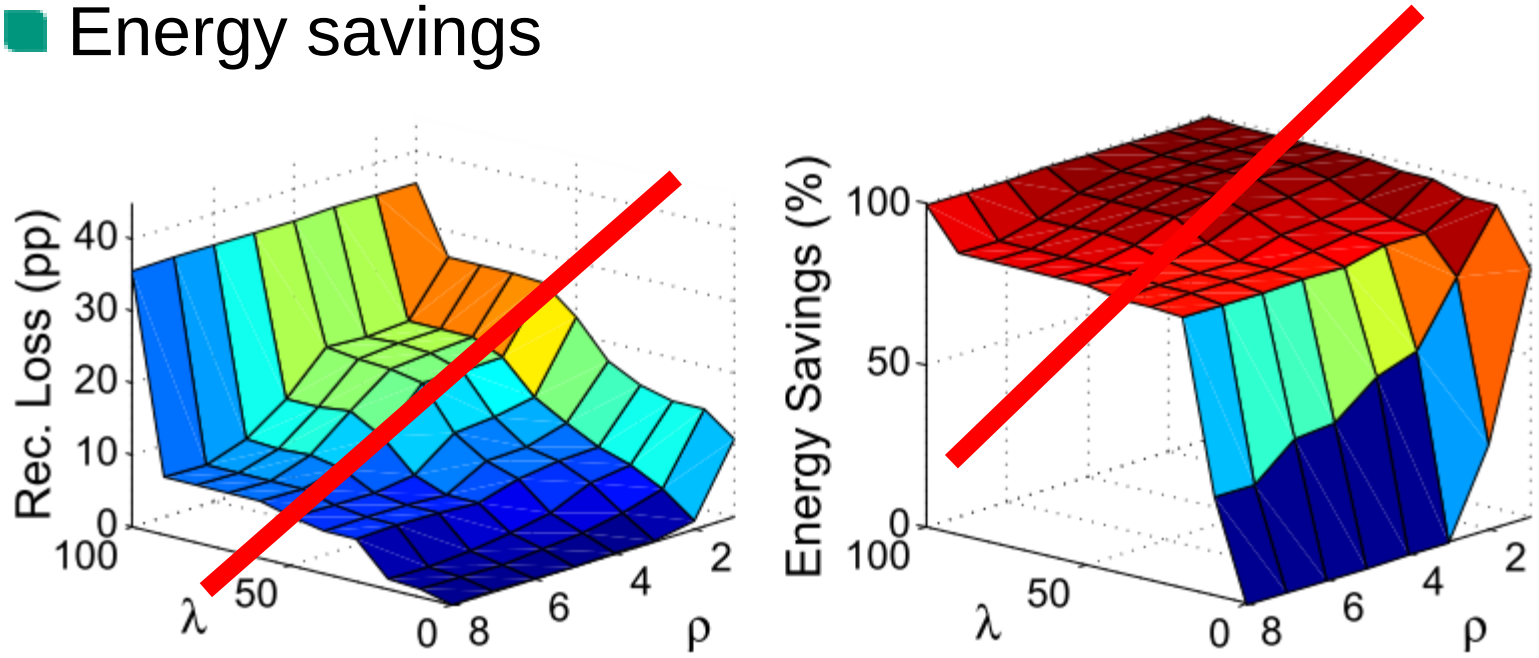
- Defines amount of recognition to trade for energy
- Like a **wager**!
- Monotonic increase in for fixed ρ, κ
  - Loss of recognition
  - Energy savings





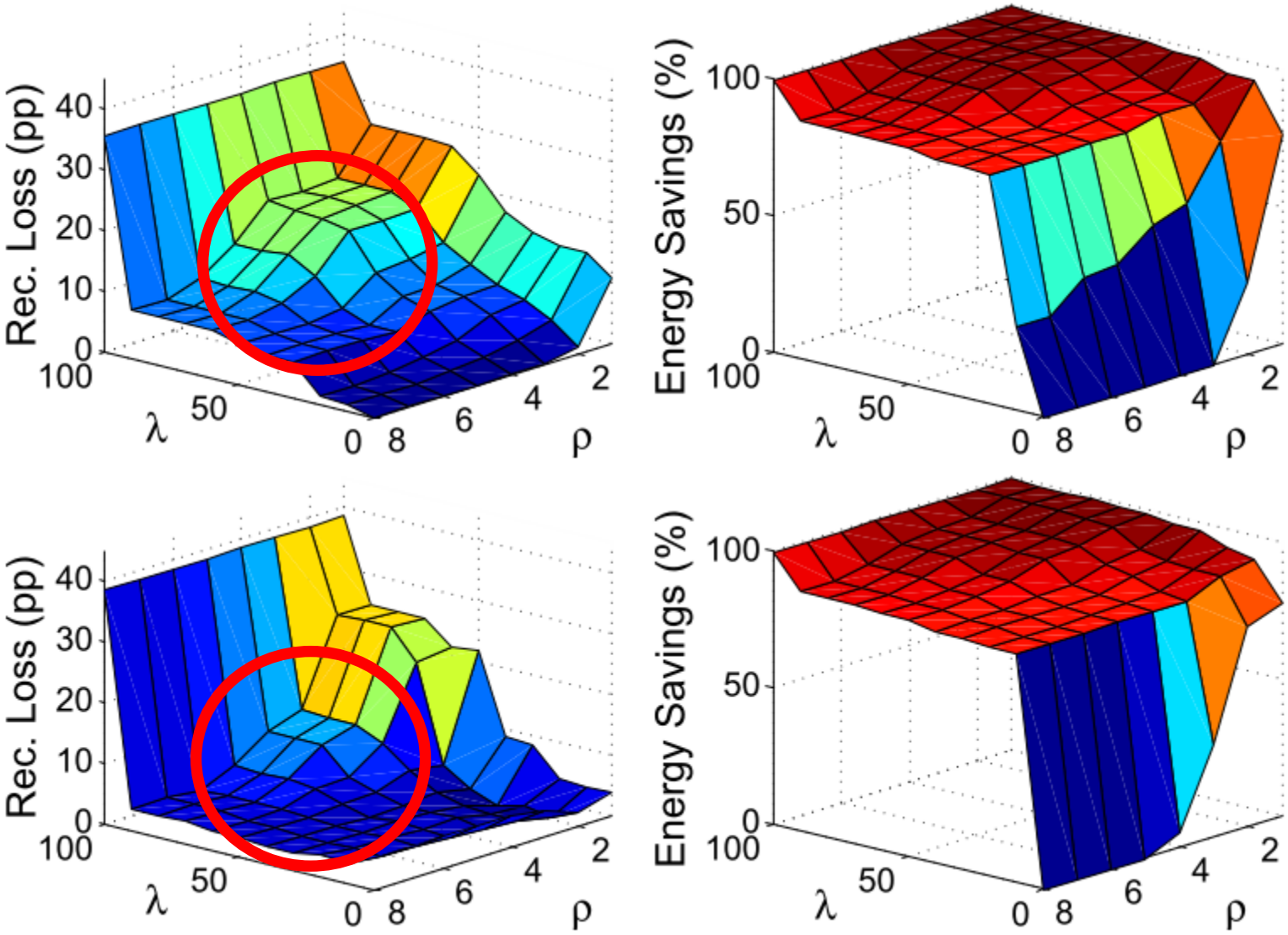
Number of Predicted States ρ

- Defines amount of risk!
- High risk – high payout
- Monotonic decrease in for fixed λ, κ
  - Loss of recognition
  - Energy savings



Effects of Predictability κ

- κ=.125
- κ=.875



Conclusion

- Novel approach using prediction
- Saves energy, e.g. 84% for 1.2pp
- Results heavily dependent on
  - Sensors used
  - Activities recognized
  - Predictability of scenario
- Tools for tuning desired trade-off supplied!
  - κ can be obtained with predictor and scenario
  - λ taken from the application
  - ρ adjusted to find the desired give and take

Thank you and Questions!

- So much more data!
- Effects of sensor control on prediction
- OPPORTUNITY data set

HELP: Special Issue CfP?!?