NILM2016
3rd International Workshop on Non-Intrusive Load Monitoring
May 14 - 15 | Vancouver, Canada

Non-Intrusive Appliance Load Identification with the Ensemble of Classifiers

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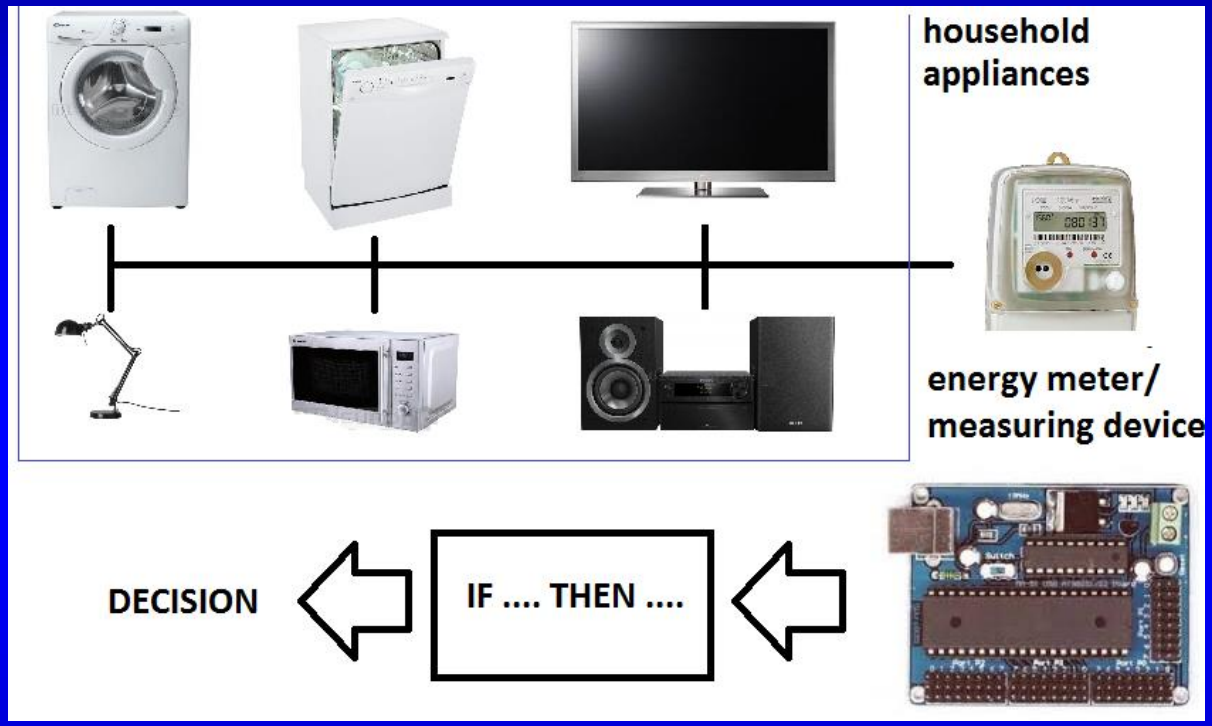
14-15.05.2016, Vancouver, Canada

Presentation Outline

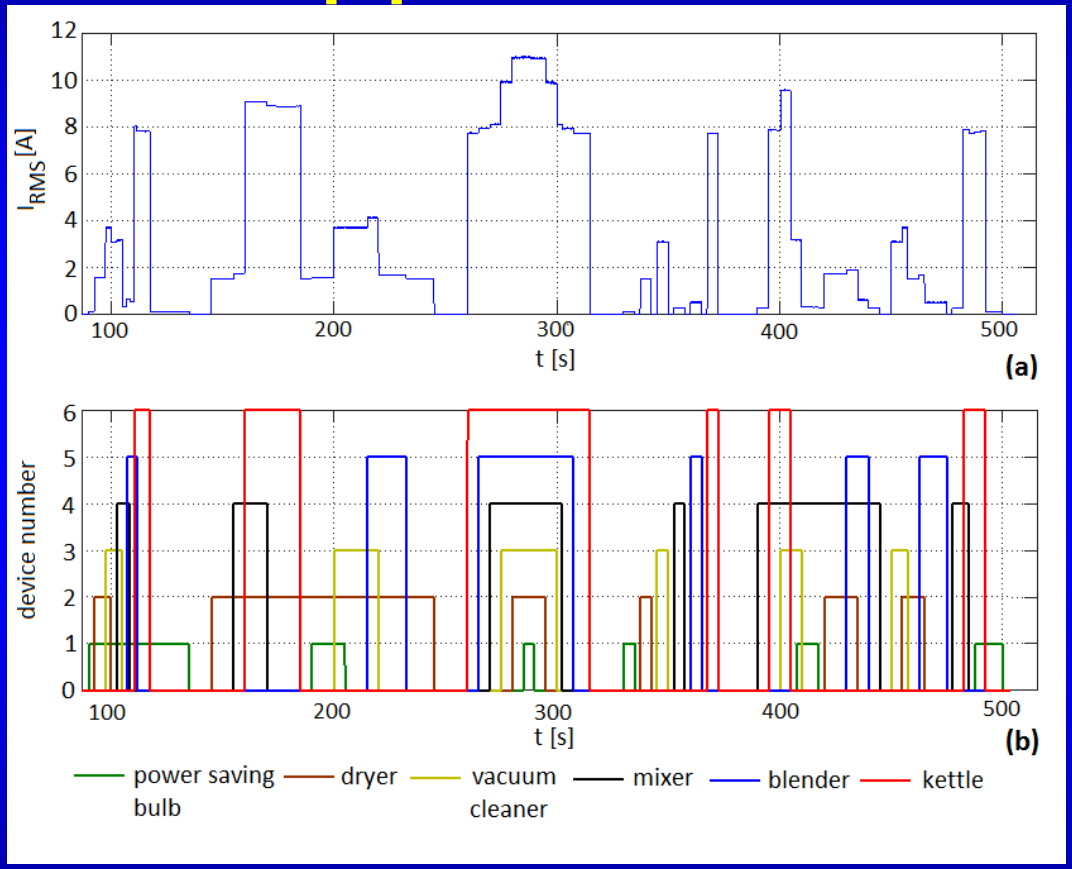
- The problem statement
- Introduction of the identification system
- Architecture of the ensemble of classifiers
- Processed data
- Experimental results
- Conclusions

System architecture (NIALM)



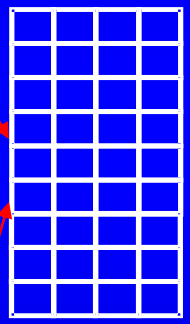
- Single DAQ node outside of the apartment
- Software responsible for the event detection and appliance identification

Current waveform for selected appliances



- Multiple devices working simultaneously!

The proposed ensemble approach

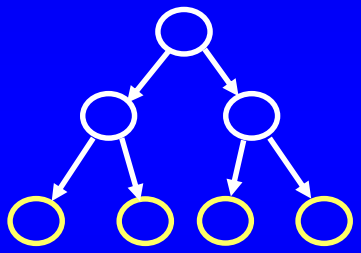


ensemble

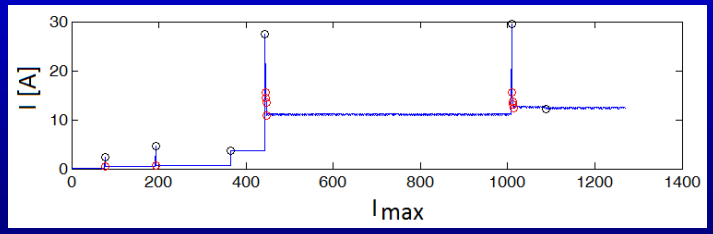
IF $U_1 > 1.23V$ AND $U_3 < 4.56V$ THEN FS=21

…

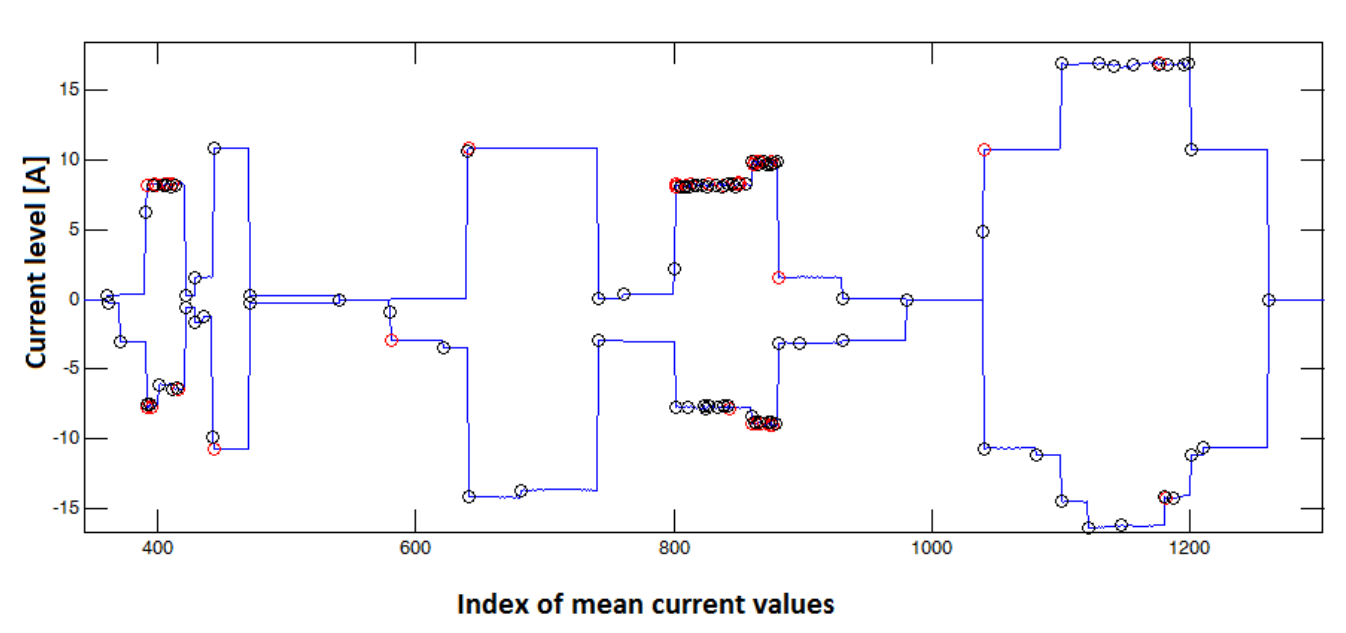
IF $U_2 > 5.32V$ AND $U_3 > 1.17V$ THEN FS=32



decision



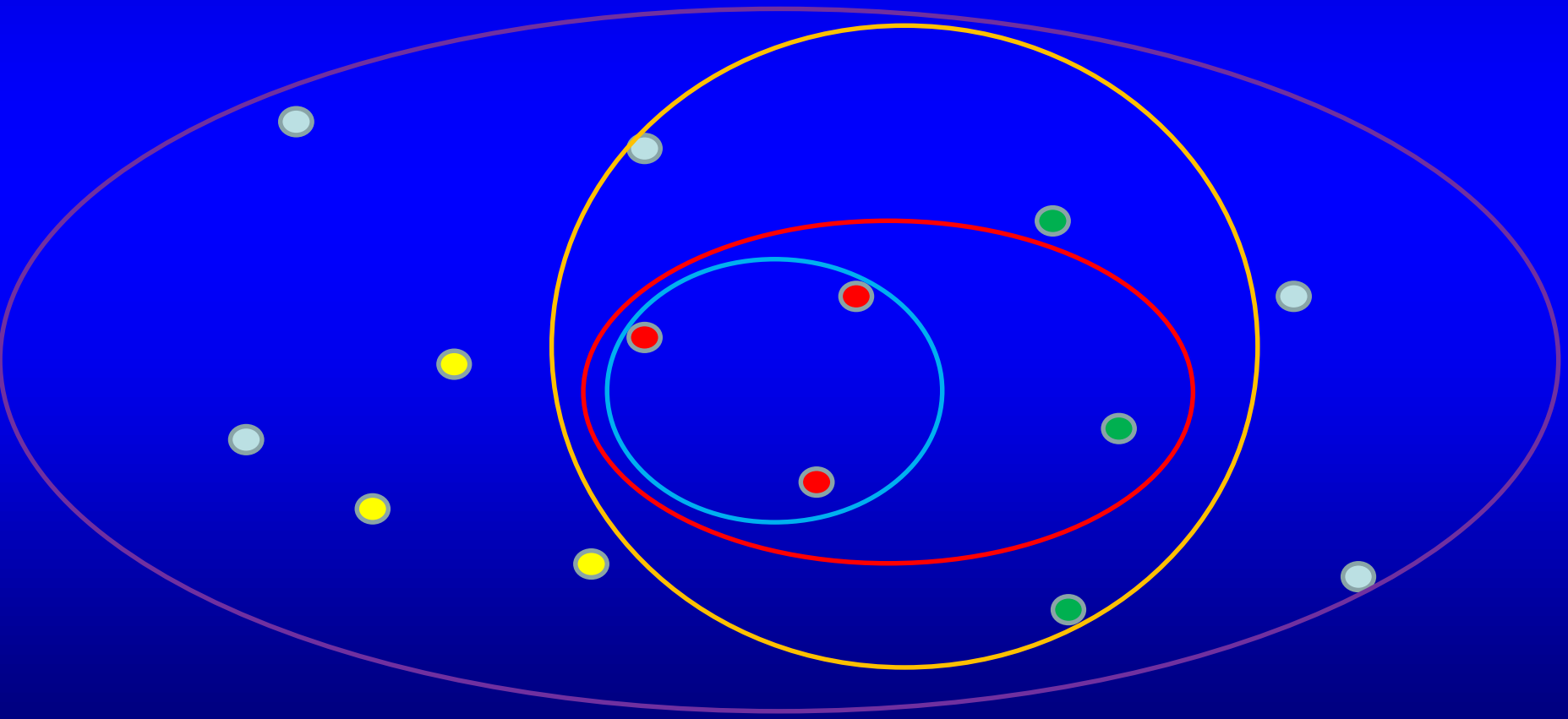
Current changes detection method



- Find the changes in the current level regarding the previous vector and wait for the steady state

Rule-based approaches for appliances identification

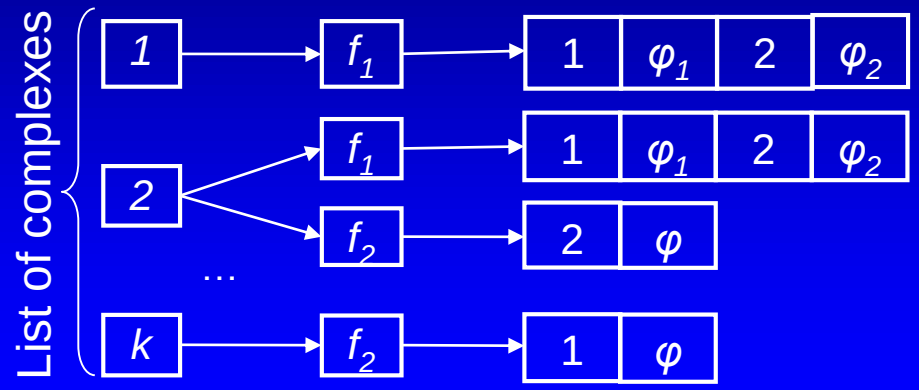
If (*conditions met*) then (*appliance identified*)



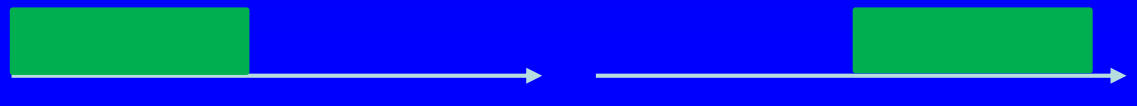
Rules induction

- Traditional expert system method, used mainly discrete versions of algorithms (AQ, CN2, etc.)
- High off-line computational cost (generation of rules)
- Knowledge easily interpretable by the human operator
- Premises=complexes

Complexes and selectors

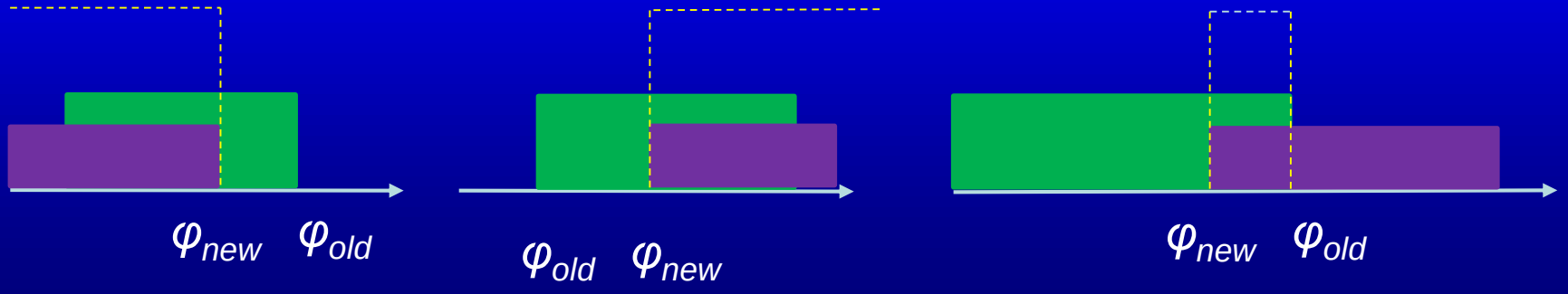


- Inequality:

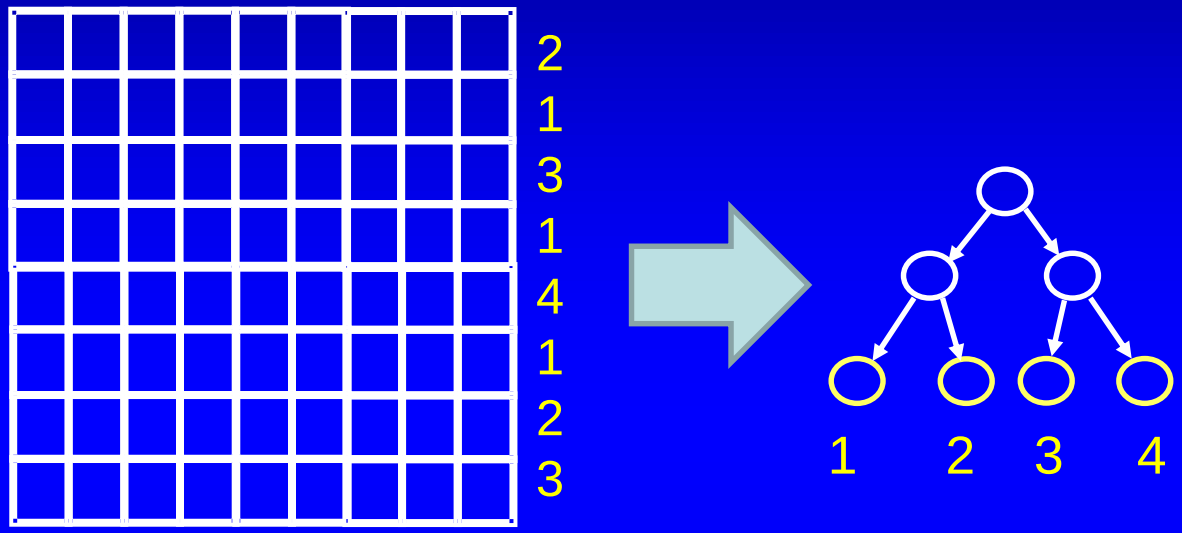


- Interval:

Complex specialization:

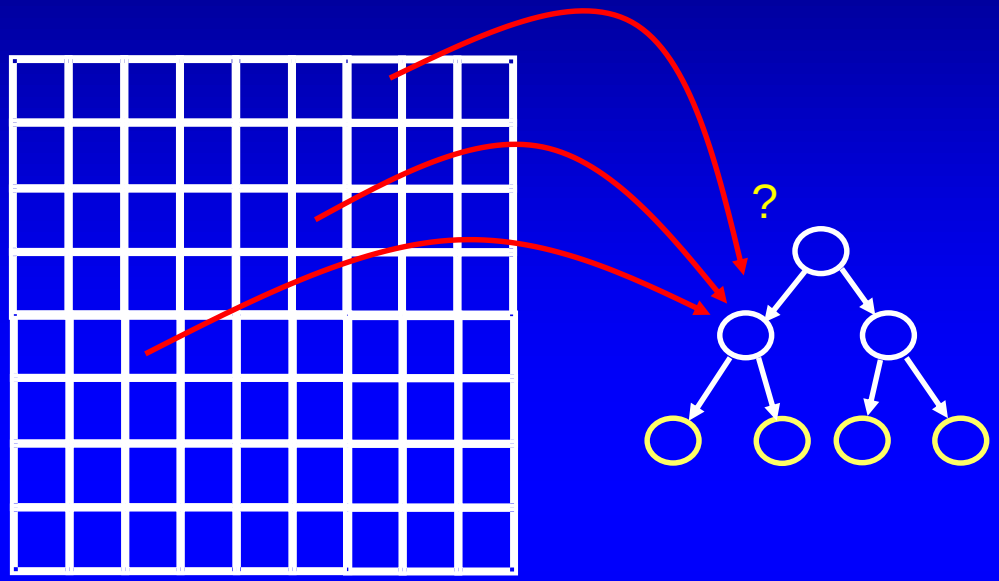


Decision trees



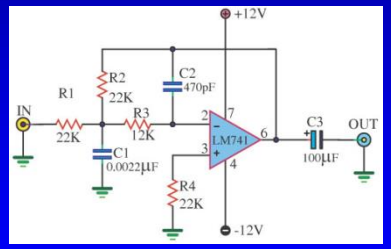
- Memory-efficient classifier
- Inherent machine-learning
- Problem of selecting one feature for the test when multiple are equally good!

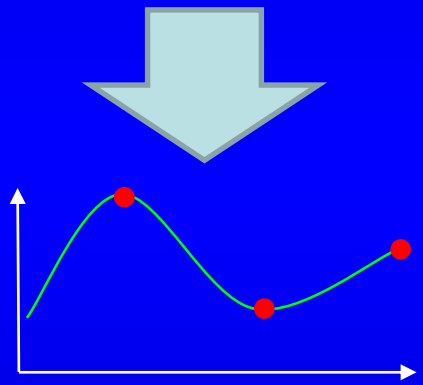
Decision tree variants

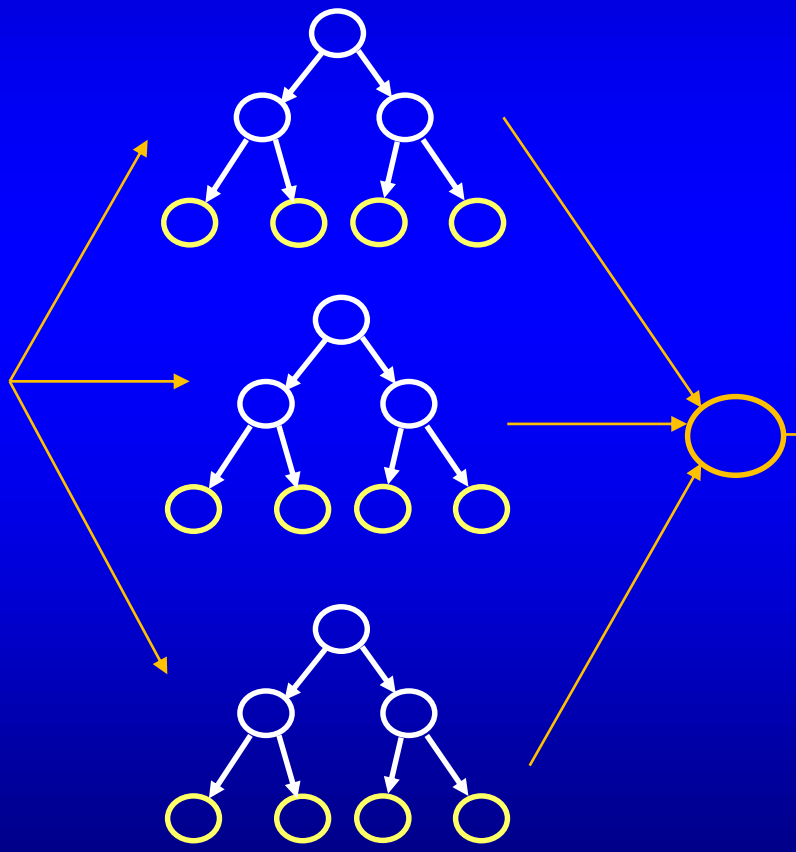


a) the largest distance from the neighbouring values
b) the smallest distance from the neighbouring values
c) the most frequent occurrence
d) the least frequent occurrence
e) random selection

Random forest – ensemble of decision trees



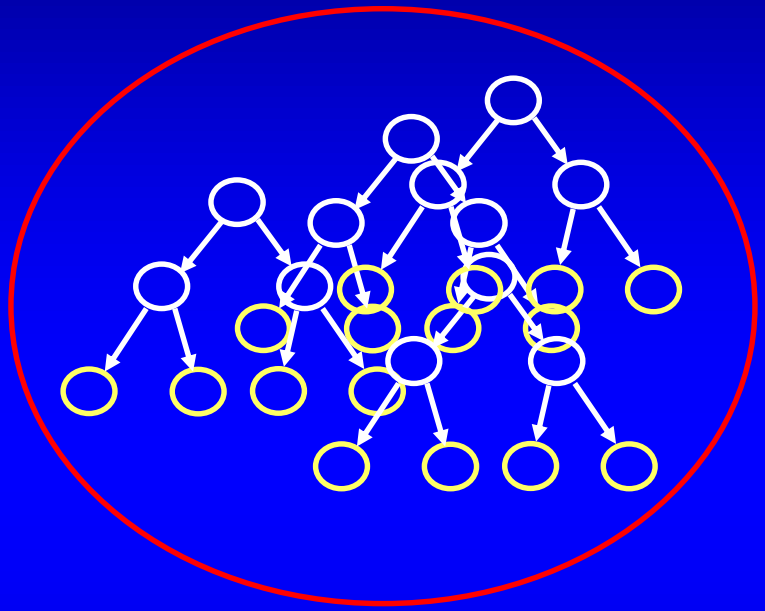


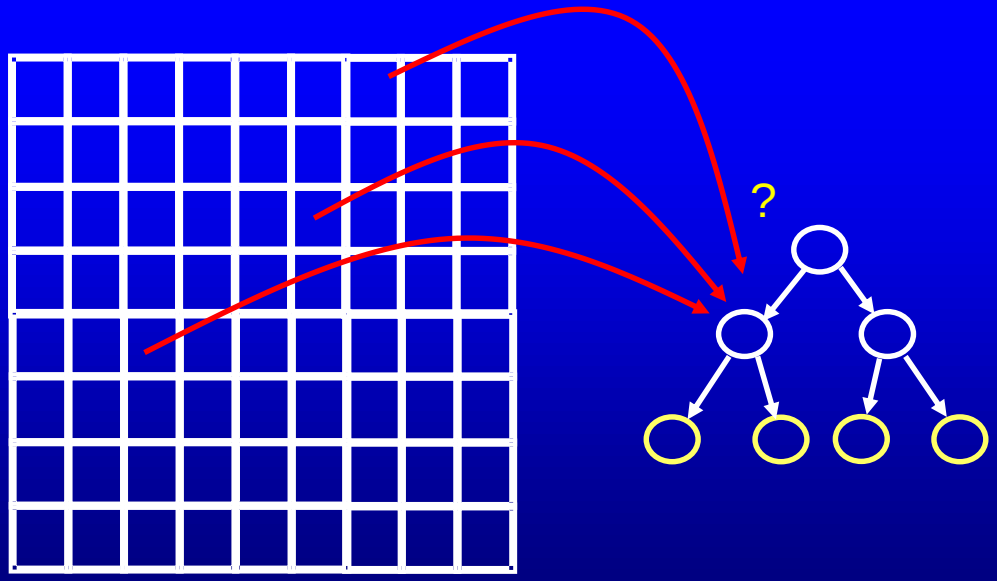


decision

Design problems

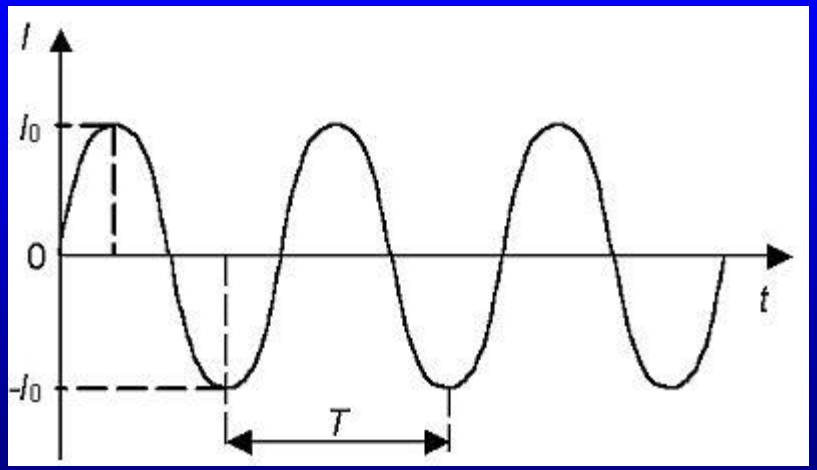
- Number of trees
- Number of candidates for the node test
- How to vote?

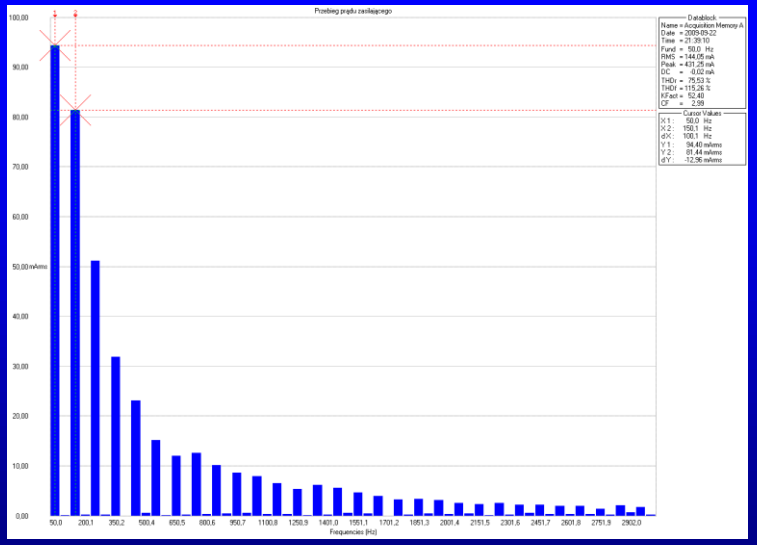




Experimental setup

- 6 different appliances of the binary state (on/off) considered
- 69 features extracted from the current and voltage patterns
- 2 kHz sampling





Results (pt. 1)

No	c	d_{DT}	d_{RI}	d_{RF}	d
1	1	1	1	1	**1**
4	3	1	3	3	**3**
8	0	0	0	0	**0**
12	5	1	-1	5	**?**
16	6	6	6	6	**6**
31	4	4	-1	4	**4**
51	3	2	2	2	**2**
58	0	0	0	1	**0**

0 – no change (false alarm)
1 – bulb
2 - dryer
3 – vacuum cleaner
4 – mixer
5 – blender
6 - kettle

Results (pt. 2)

Algorithm	*DT*	*RI*	*RF*	*d*
Overall accuracy	82.81	64.06	85.93	**92.96**
False alarm accuracy	97.82	66.30	94.56	**96.73**
Appliance identification accuracy	55.55	58.33	83.33	**83.33**

Conclusions

- The proposed method is able to detect turning on and off of most appliances
- The application of ensemble with the proper strategy allows for maximizing the identification accuracy
- Each classifier has distinct advantages, making it useful in different situations
- The system detects multiple false alarms, but these errors are corrected by the ensemble

Thank You for Your Attention