The ContextAct@A4H real-life dataset of daily-living activities

Activity recognition using model checking

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Long-term motivation

Smart Homes for Elder Care

Increase in limited function

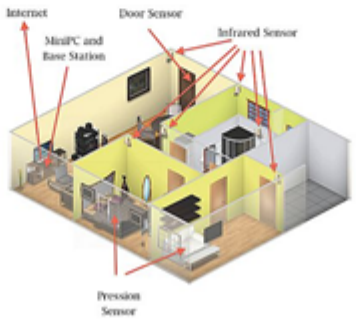
Home

Home with assistance

Retirement homes and assisted living facilities

Nursing homes

Ambient assisted living



Agenda

- Context Sensing in Amiqual4Home
- Manual Activity Annotation in ContextAct@A4H Dataset
- Activity Recognition using model checking
  - Activity Recognition on ContextAct@A4H Dataset
- Conclusions and Perspectives

Why a daily living activities dataset?

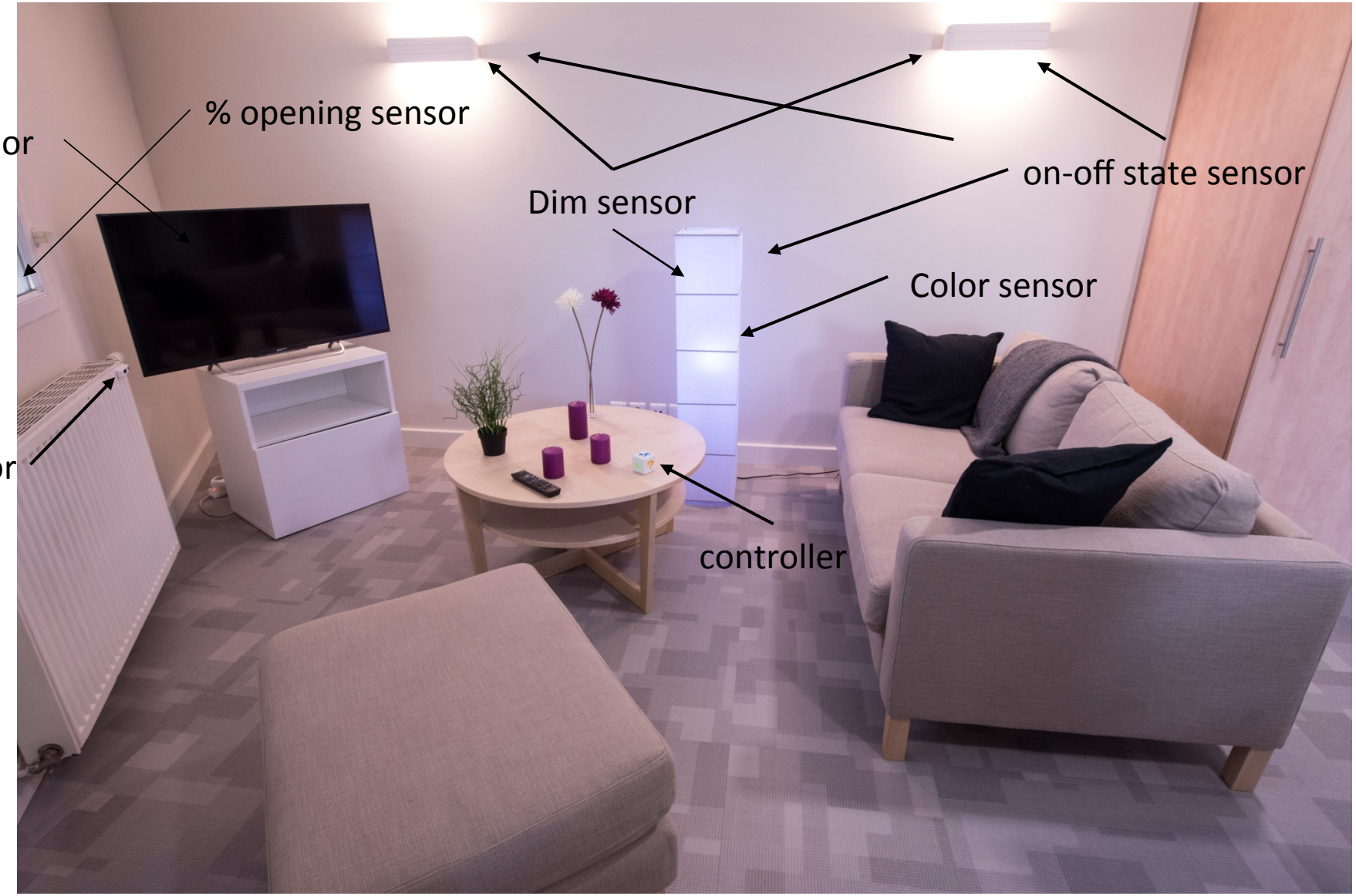
ong-term objective

Study how contextual changes affect user behavior and preference

This work

- Collecting dataset to prove viability of unobtrusive automatic daily activity monitoring
- Sharing data for more research

nobtrussive and stigma-free sensing at home



perature sensor

idity, noise,
, lighting
ors
oor
tioning

What’s Context in this work?

Context describes features of the environment within which the activity takes place

Conditions

Indoor	Outdoor
	

When I had visit

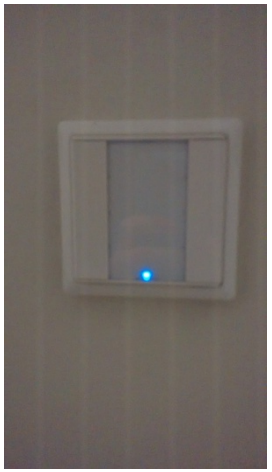
When there were loud oises

When it was sunny

When it was cold

Sensing Infrastructure

Sensing Direct user interactions: activities



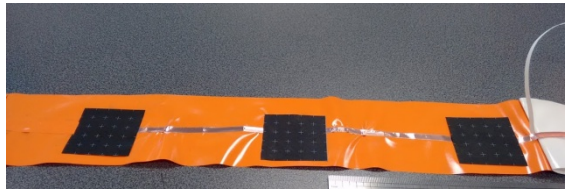
Magnetic sensors for door and window closing/ opening

Switches (lights, curtains, music)

Cube (music, tv, lamps)

Sensing Infrastructure

Sensing Indirect user interactions



Bed pressure

Electric consumption (on/ off of electric appliances)

Water consumption (Usage of shower, dishwasher, handwasher and toilet)

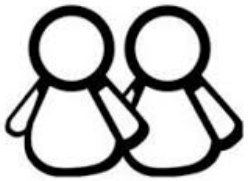
Sensing Infrastructure

Sensing Context data

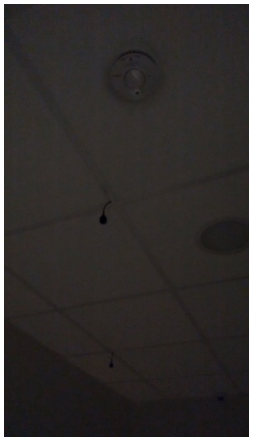
openweather.com

For each room:

- Noise
- Humidity
- Temperature
- Presence
- Lighting level
- CO2 level



Number of persons (visitors) (user annotated)



ContextAct@A4H Dataset: metrics

- 125 variables
- 28 days of data
- 473 011 tuples of data in change point representation
- 397 activity observations

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Stated context: Activity

Reduce burden of annotation

Shower

Sleep

Work

Eat

Cook

Wash Dishes

Watch Tv

Go to bathroom

Gathering declared activity (start and end)

Using strategically placed interfaces

Gathering declared activity (start and end)

Web and mobile interfaces

ContextAct@A4H Dataset: metrics

- 125 variables (interesting for us, others: electrical variables, music information)
- 28 days of data
- 473 011 tuples of data in change point representation
- 397 activity observations

Agenda

- Motivation: why a daily living activities dataset?
- Context Sensing in Amiqual4Home
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nferring activities using model checking

Model checking is a technique based on temporal logic.
→ we use action based temporal logic MCL

ool used:
he CADP (INRIA/Convecs) toolbox for the verification of asynchronous concurrent
ystems and more specifically the EVALUATOR 4.0 model checker for MCL

Usually: model checking requires a formal specification of a system (not necessarily a trace) and then checks for its correctness with respect to requirements expressed in temporal logic

We adapted it to make a continous model checking that tells what activity has just occurred. The dataset takes the place of the formal specification (*runtime model checking*).

MCL: a language with several layers

- ***Action***: conditional pattern that matches individual events
- ***Action formula***: combination of actions using connectors **and**, **or**, **not**, …
- ***Action regexp***: combination of action formulas using regexp operators **.**, *, **|**, … that matches a sequence of events
- ***State formula***: constant **true**/**false** + combination of regexps and formulas using *temporal logic modalities* and *parameterized fixpoint operators*
  Restricted use in this work (sufficient as we work on sequences):
  - Possibility modality **<** *R* **>** *F* that is true if a sequence of events matches regexp *R* and finishes in a state where state formula *F* holds
  - Minimal fixpoint **mu** Z (Y_1, …, Y_n) **.** F that denotes a « recursive » parameterized state formula
- ***Macro definition***: named definition of an action, formula, or regexp for easy abstraction and reuse (similar to a function)

Semantic description of a simple event

- Description using an MCL **action**
- Abstraction using an MCL **macro definition**

```
macro Office_Light_On () =
  { A ... !"L14" ?value:Nat where value > 0 }
end_macro
```

Semantic description of a complex event

- Logical combination of simple events
- Description using an MCL **action formula**
- Abstraction using an MCL **macro definition**

```
macro Cooking_Appliance_On ()

= (Cooktop_On or Oven_On) end_macro
```

Activity defined as an ordered composition of complex events

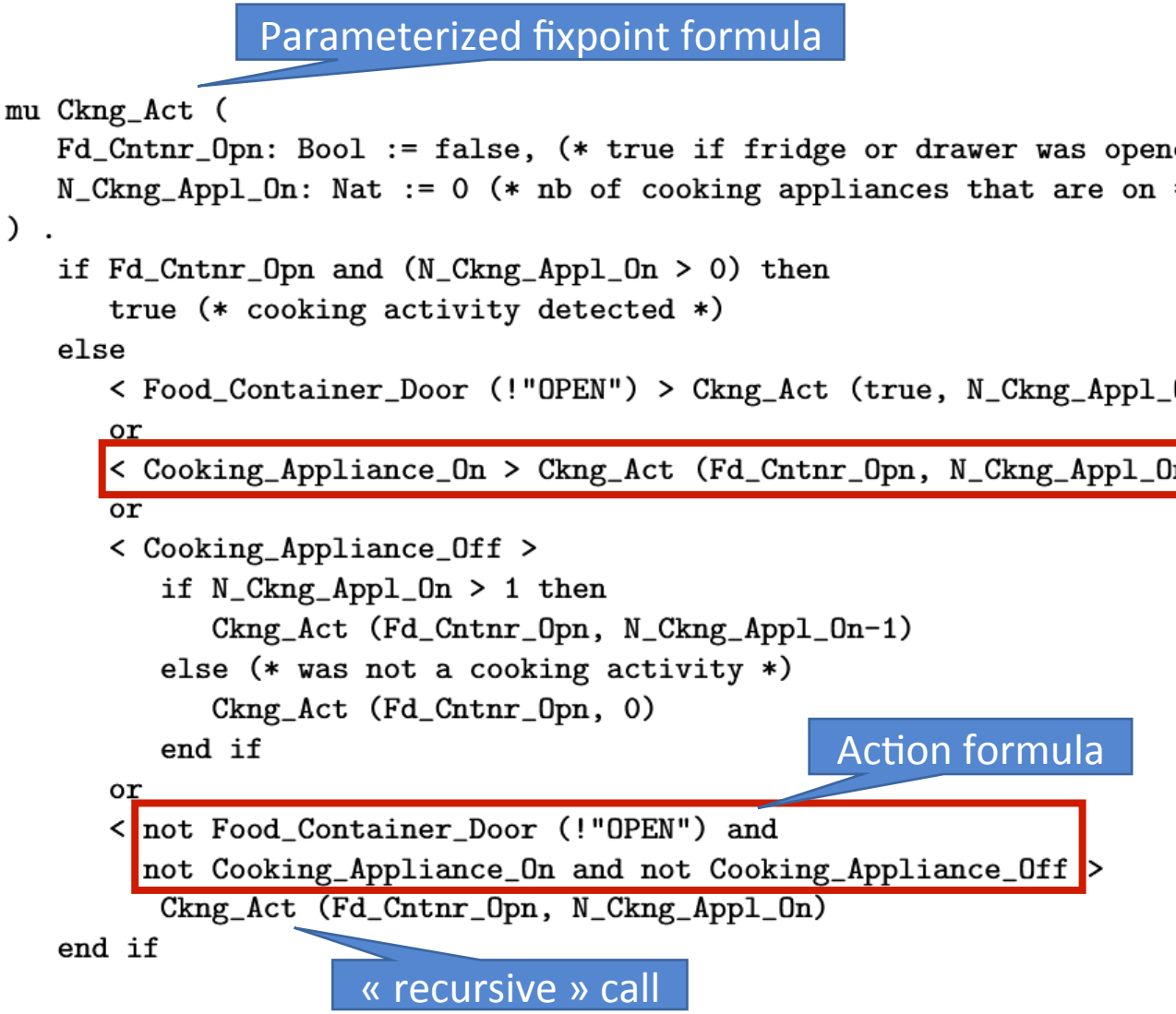
- Temporal combination of complex events
- Description using an MCL **state formula**: temporal modality

```
<
  true* .

  (* debut de l'activite "se doucher" *)
  Porte_Douche (!"OPEN") .
  (not Porte_Douche (!"CLOSED"))* .
  Porte_Douche (!"CLOSED") .
  (not Porte_Douche (!"OPEN"))* .
  (Douche_Eau_Froide_On or Douche_Eau_Chaude_On) .
  (not Douche_Eau_Froide_Off and not Douche_Eau_Chaude_Of

  (* fin de l'activite "se doucher" *)
  (Douche_Eau_Froide_Off or Douche_Eau_Chaude_Off) .
  (not Porte_Douche (!"OPEN"))* .
  Porte_Douche (!"OPEN")
> true
```

Regexp
(sequence of event

Activity defined as an unordered composition of complex events

- Temporal combination of complex events
- Description using an MCL **state formula**: parameterized fixpoint



sults of Activity Recognition using model checking o
ntextAct@A4H Dataset

Activity	Precision	Recall	Avg. time diff (minutes)
Sleep (start)	78 %	95%	4,42
Toilet use (end)	98 %	78 %	0,71
Cooking (start)	81 %	88%	1,5
Taking a shower (end)	70 %	89 %	3
Washing dishes (start)	14%	97%	12,45

Table 2: Activity recognition results with model checking approach

Discussion

- Complex event specification
- Analysis from the log – no data segmentation needed but activity specification required
- Model checking approach tells when the event occurred taking into account what has happened
- Temporal restrictions can be added
  - i.e. last 15 minutes, maximum gap between events to improve accuracy

Conclusions and perspectives

- Model generalization still required but Model checking for activity recognition offers promising perspectives

- The approach is feasable and using context enables personal services
  - behaviors and preferences

- ContextAct@A4H, a rich public dataset
  - variety of sensors and variables

- Further research on contextual behaviour patterns

The ContextAct@A4H real-life dataset of daily-living activities

Activity recognition using model checking

Get the data!

https://goo.gl/EdCPUF

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