Crowd-computing in social robot applications: A preliminary case study

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1. Cyber-Physical Systems (CPSs), in perspective (9 slides).

2. Social robots, crowd-computing (2 slides).

3. A preliminary case study (12 slides).

1. Cyber-Physical Systems (dfn)

- CPSs (Cyber-Physical Systems) are technical devices with certain adaptive, sensing and reasoning abilities.

Ongoing initiatives regarding CPSs:

- Industrie 4.0 initiative (Germany).
- The Industrial Internet initiative (USA).
- The Society 5.0 initiative (Japan).

- The CPSs in our interest are Social Robots in children (special) education applications. Our interest is not in “learning about robotics”, but rather it is in “robotics assisted learning”.

- Our technical challenge boils down to mathematical modeling based on both numerical data and non-numerical data.

Our Proposal

Many types of data are partially (lattice) ordered. Therefore, we propose:

- Engage mathematical lattice theory in order to unify numerical data and non-numerical data in certain CPSs applications.

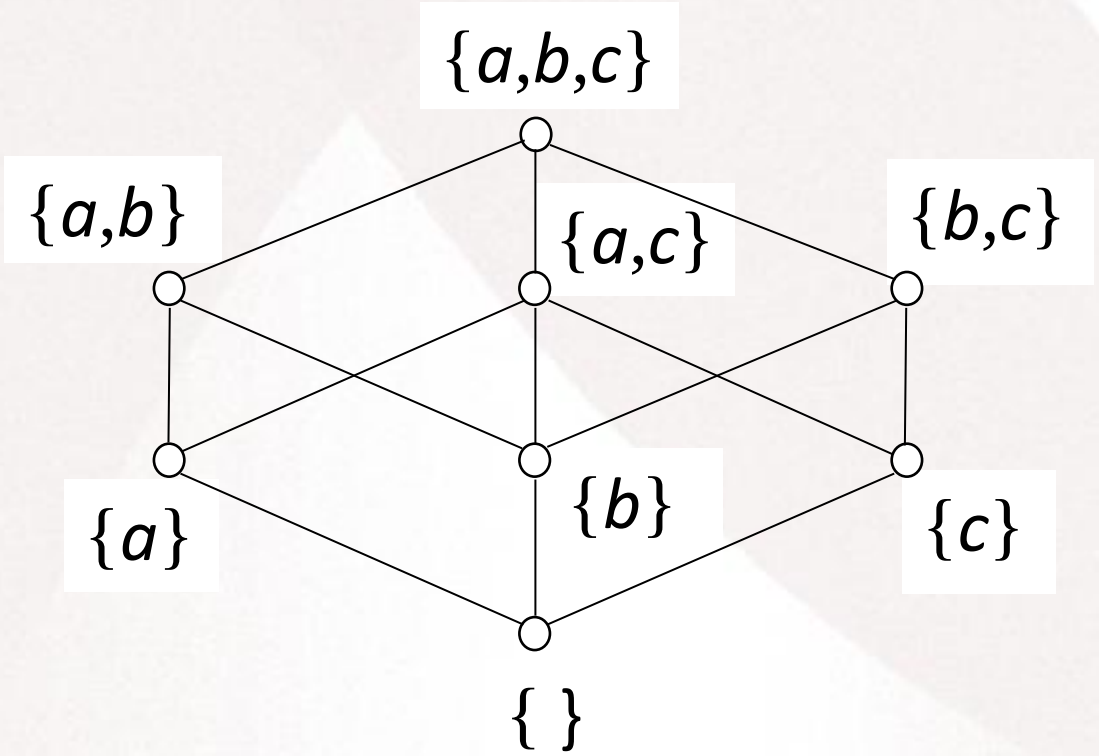
Specific examples follow

Example 1:

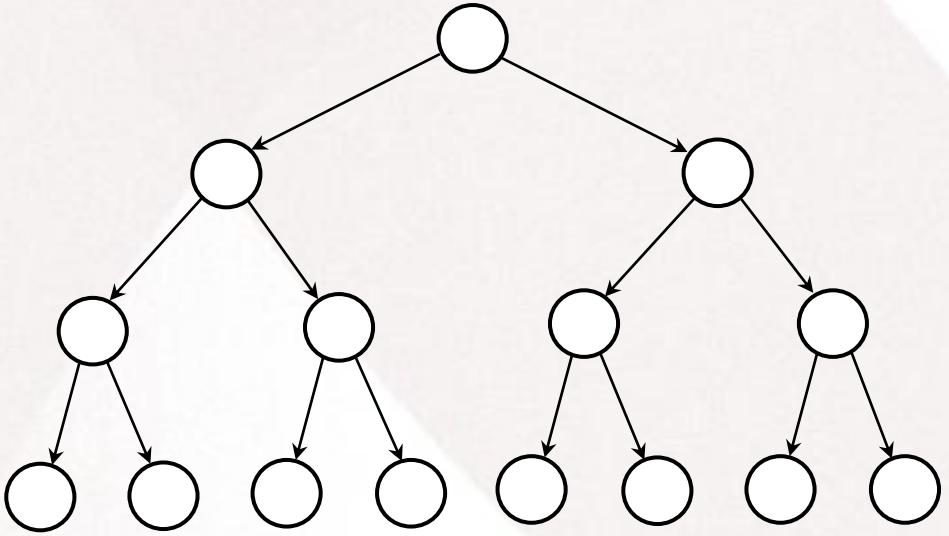
The line of real numbers

Example 2:

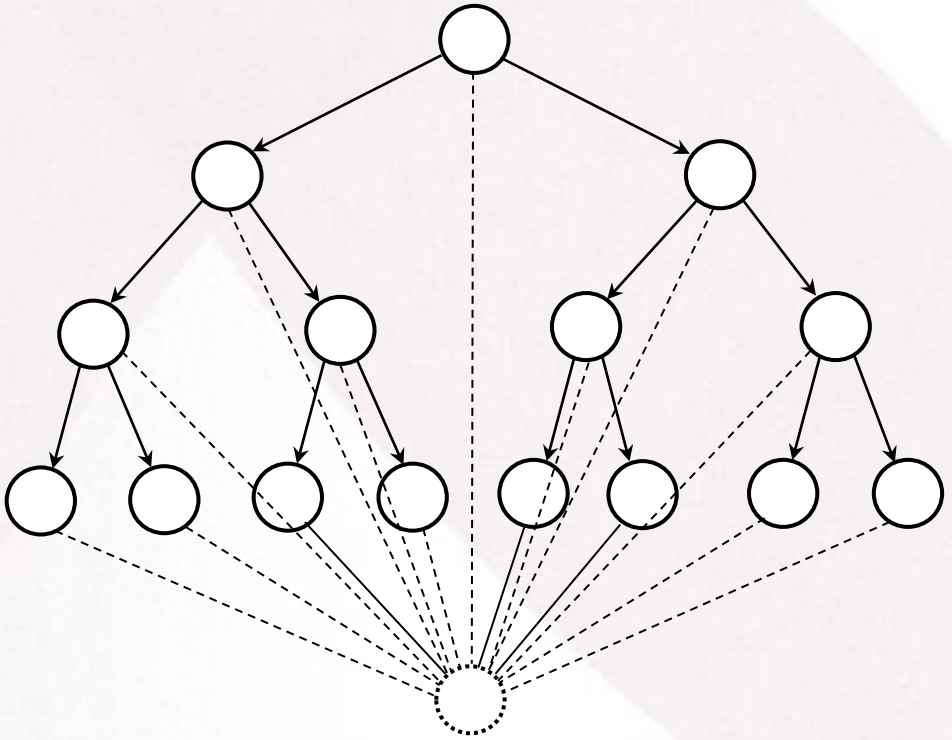
A Boolean lattice (e.g. propositions, sets)



Example 3:
A tree (e.g. ontologies)

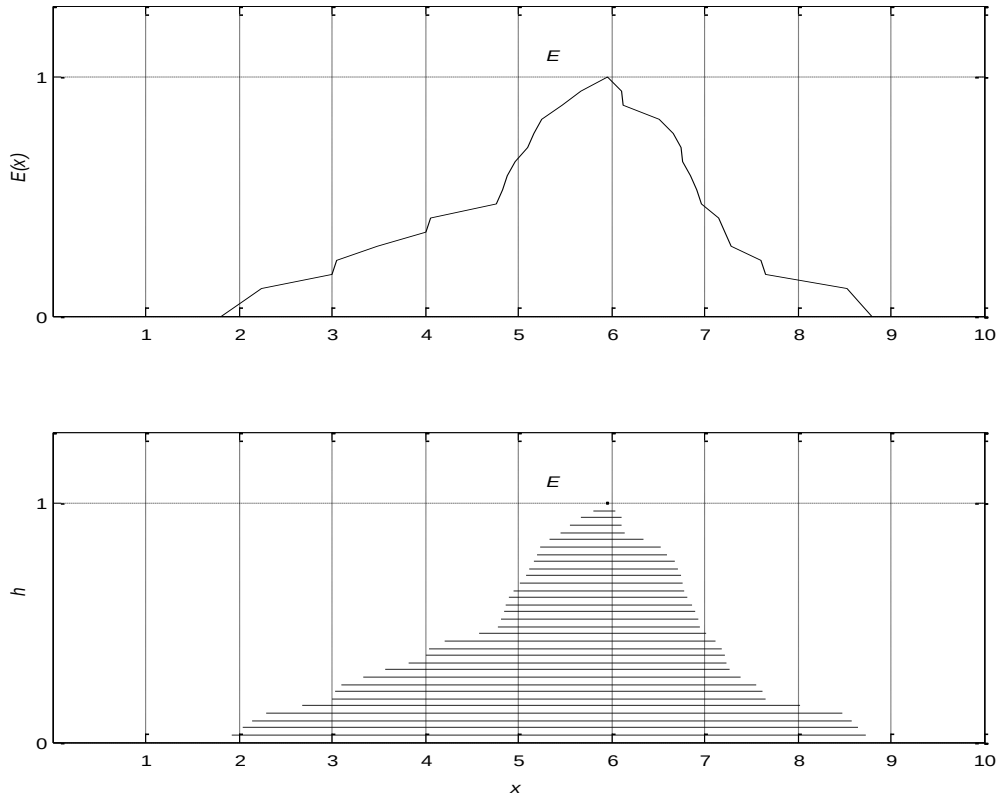


Example 3 (*cont.*)



Example 4:

Intervals' Numbers (INs) (e.g. fuzzy numbers, probability distributions)



(Here, we employed INs in fuzzy rules)

Hence,

the **Lattice Computing (LC)** paradigm has emerged for computing with *semantics* instead of merely *number crunching*.

2. Social robots

Crowd-computing (dfn)

- “harnessing the power of people out in the Web to do tasks that are hard for individual users or computers to do alone. Like cloud computing, *crowd computing* offers elastic, on-demand human resources that can drive new applications and new ways of thinking about technology.”

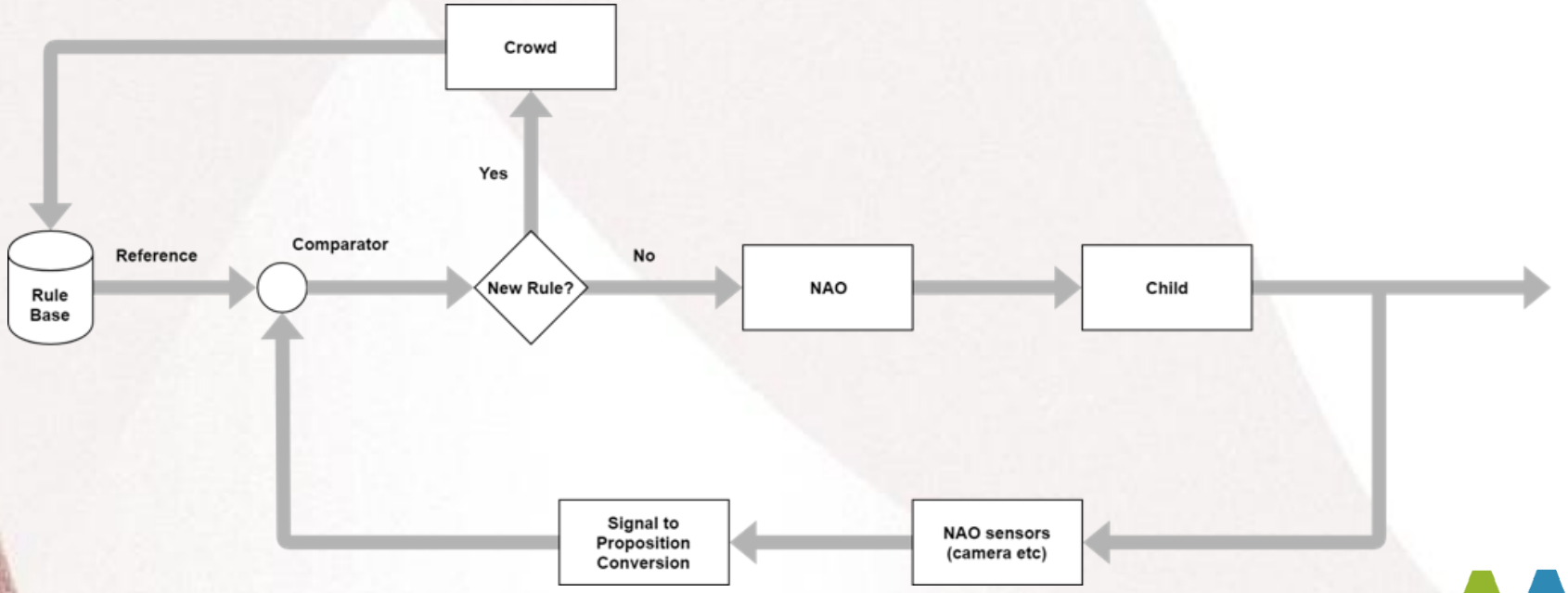
3. A case study

- While social robots become ever more popular, novel modeling and control methodologies are sought toward optimizing their engagement.

- A novel feedback control, namely “AB-scheme”, is proposed using a resultant sentence, induced by crowd-computing techniques, as Reference to be compared with a computer-vision induced sentence toward driving a linguistic controller.

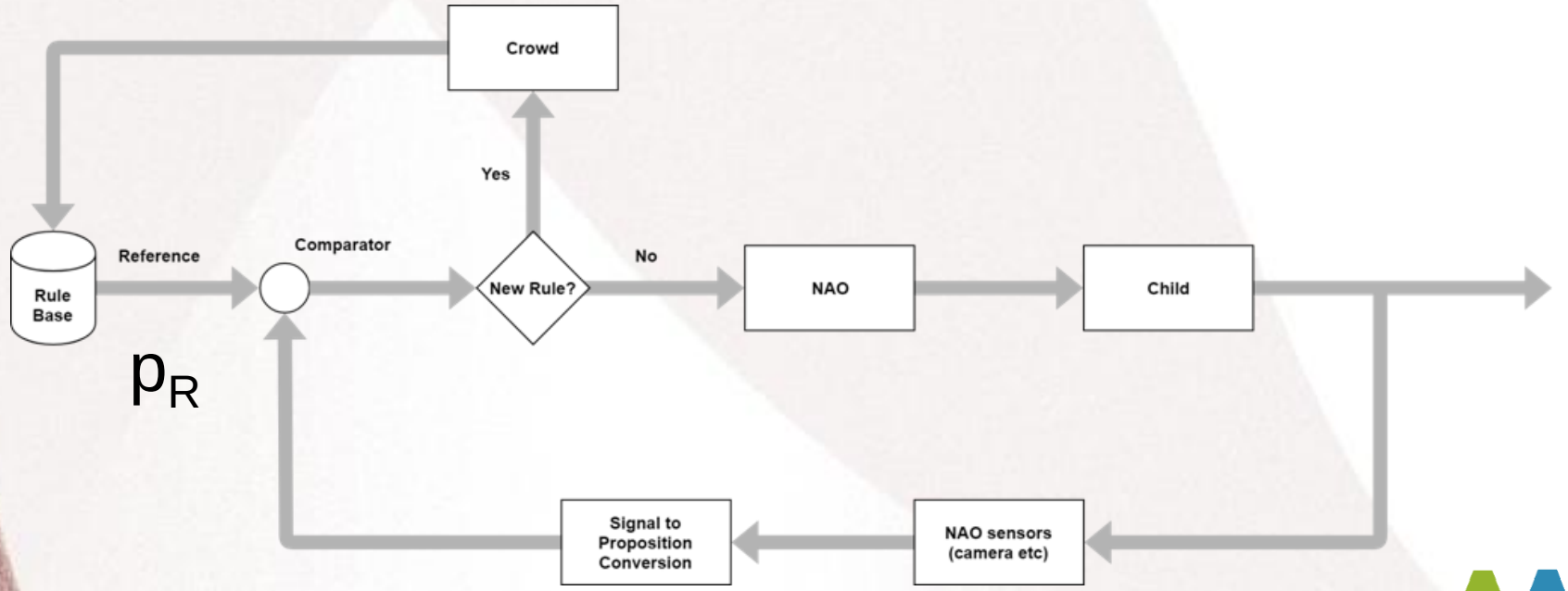
The AB-scheme

a. A Rule Base includes deterministic knowledge elicited from experts and represented by (fuzzy) rules.



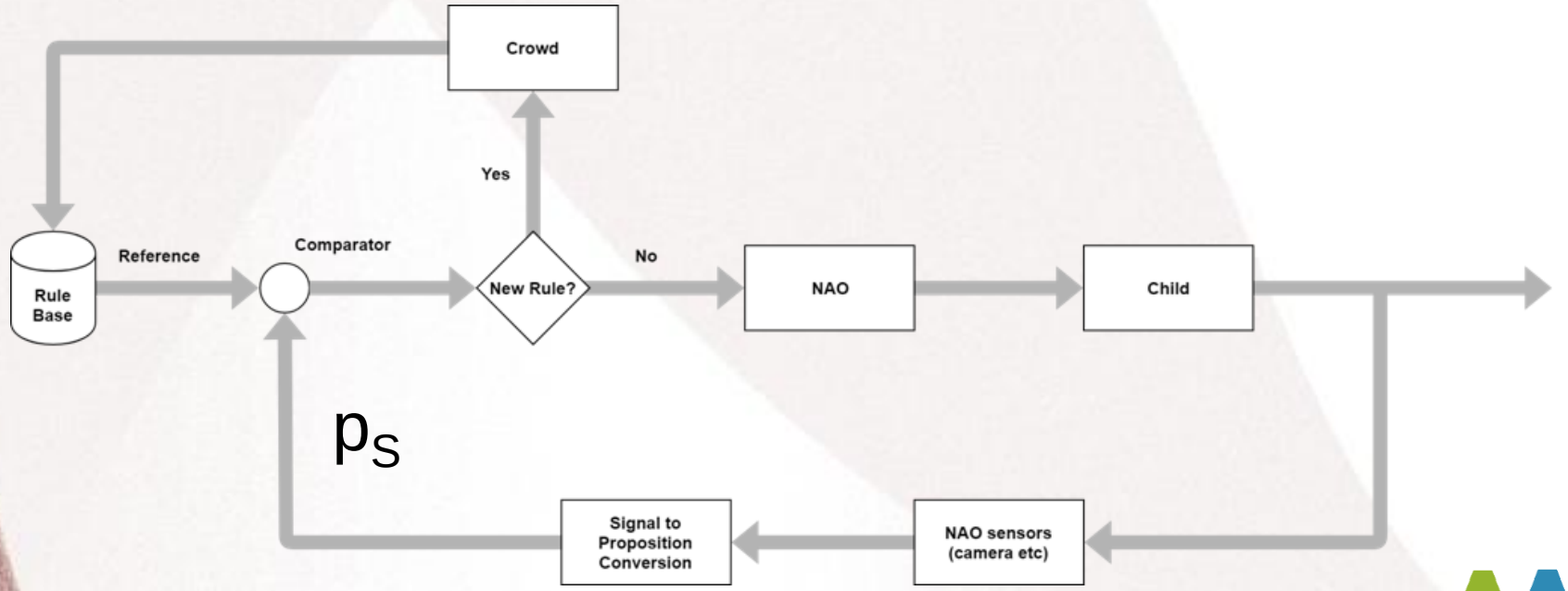
The AB-scheme

b. The Rule Base calculates a Reference proposition p_R as an input to a Comparator.



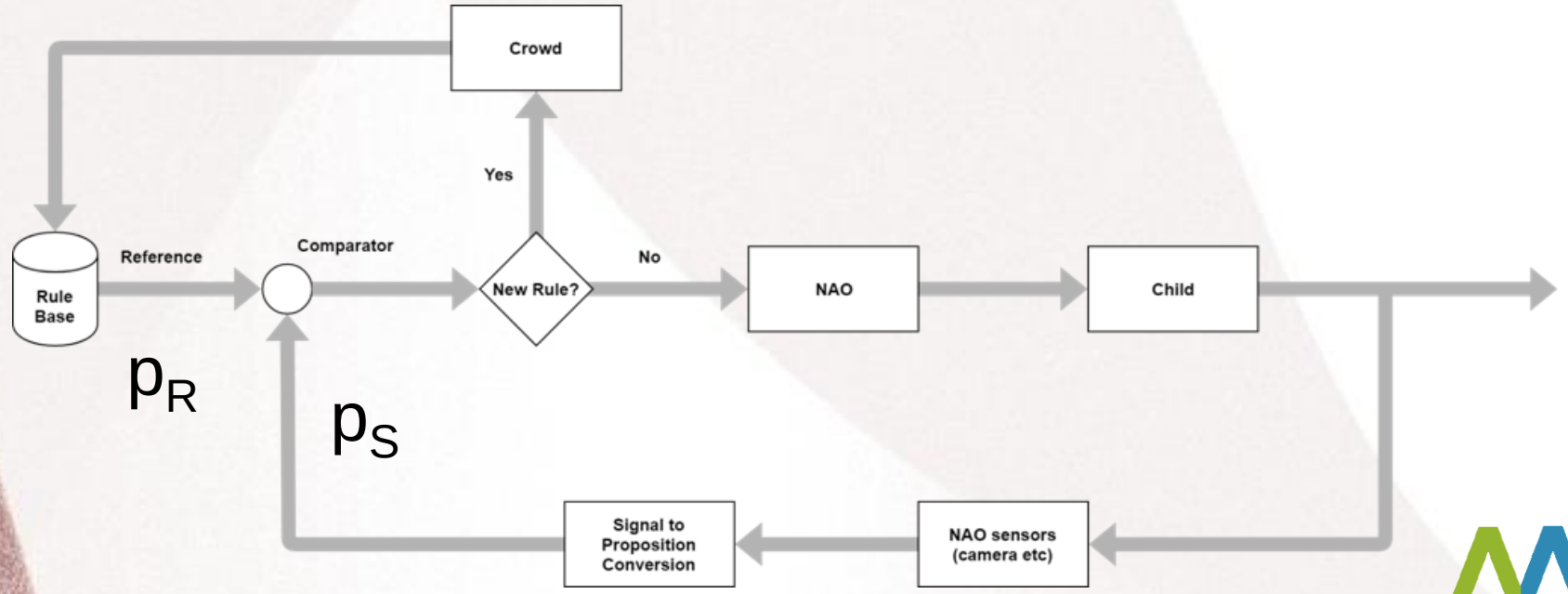
The AB-scheme

c. NAO sensor signals are processed toward inducing a proposition p_S.

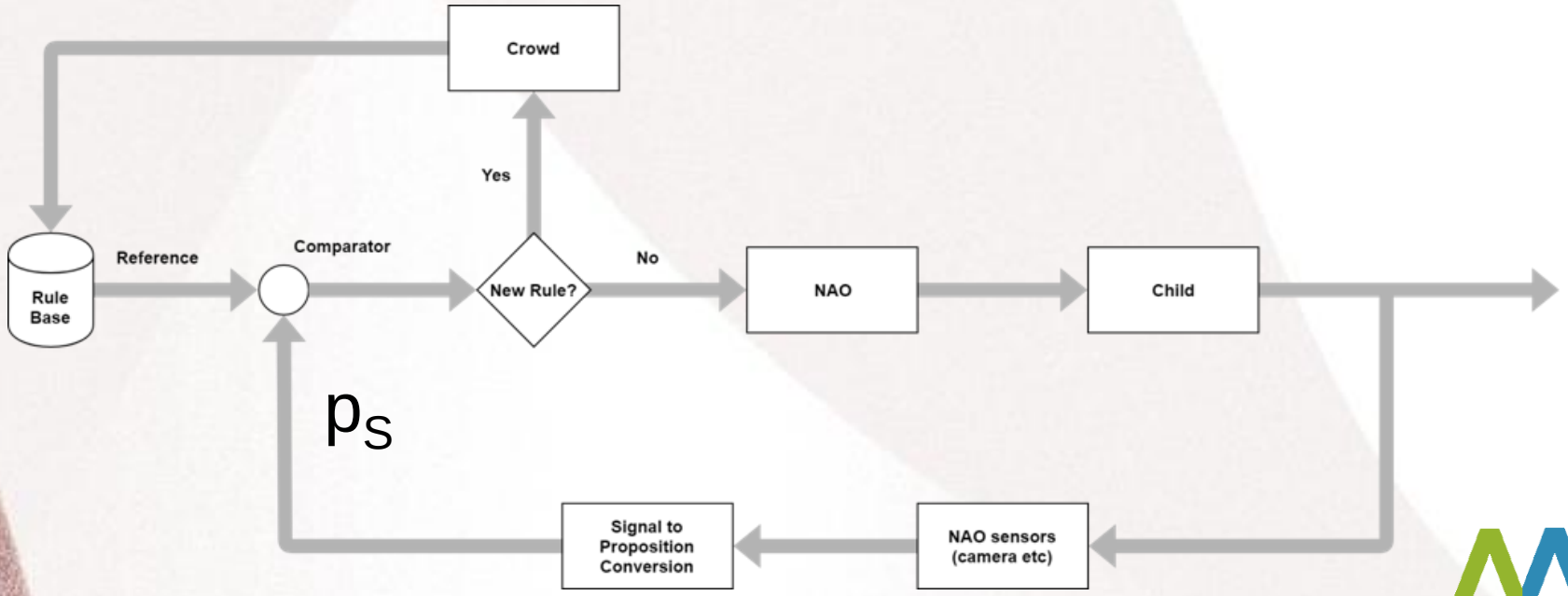


The AB-scheme

d. The propositions p_R and p_S are compared toward driving a Linguistic Controller (in the NAO robot) toward bringing the Child to the desired Reference.



The induction of proposition p_S from sensory data was necessary toward eliciting the verbal advice of experts via a Social (Internet-based) Network.



A-B Scheme “Principles”

- If the sentence induced by computer vision appears for the first time then it is sent to the Crowd.
  - The Crowd suggests an action to be implemented by NAO.
  - This process continues until the child’s expression is “Happy”.
  - The rule is stored in the Rule Base for future use.
- If the sentence has appeared previously then the corresponding rule is used.

A-B Scheme Application

Visual Pattern Recognition

- Gender (2) - Face Recognizer.
- Age (14 age groups) - Convolutional Neural Network (CNN).
- Game (3 different) - Cascade Classifier.
- Expression (5 different) - Face Recognizer.

3*14*5*2 = 420 combinations are possible

Sentence Example:

“A boy 5 years old is playing with a board-game, and he is smiling.”

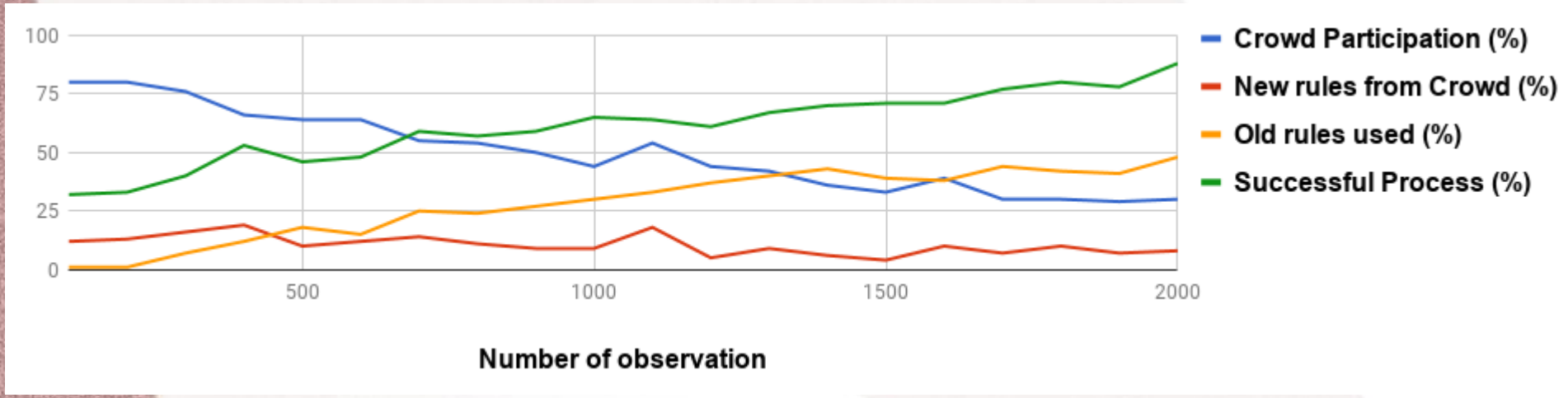
A-B Scheme Application

Training Data Information

Feature	Dataset (number of images)	Image dimensions (px)	Training time (hours)
Age	0	0	0
Expression	400	various	4
Gender	>41.000	100X100	72
Game	>45.000	50X50	1260

Preliminary Application Results

After 2000 times, the success percentage (Happy Child) reaches 88%.



Conclusions

- The software/hardware infrastructure, necessary for elaborate experiments in the future, is developed.
- Preliminary application results, demonstrated here, have been encouraging.
- Our proposed techniques are expected to enable the engagement of lower skilled personnel for delivering (much) higher skilled instruction in University Teaching /Instruction and beyond.

Thank You

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