
development
language
children
Bruner
knowledge
learning
Vygotsky
Piaget
cognitive
environment
Vygotsky'szone
active
assistance
objects
social
child
stages
egocentric
scaffolding
proximal
assimilation
student
Piaget's
things
Zone
one
years
understanding
instructional
cultural
Development
discovery
learn
Society
Accomodation
concepts
develop
culture
VYGOTSKY
Scaffolding
Culture
use
thought
video
understand
Silverthorn
help
stage
structures
representation
progress
classroom
new
support
process
others
Learning
made
mental
PIAGET
throughout
difference
accomodation
class
work
activity
change
learner
person
children's
Theory
Important
together
child's
education
teaching
mind
abilities
strategies
limits
accommodation
age
ZPD
Difficulty
Create
represent
based
developmental
role
interested
Assimilation
within
works
provides
research
world
make
direct
Proximal
individual
guidance
eBrunercentrism
focus
Stages
believed
animals
material
may
young
Knowledge
changed
beyond
teacher
concept
ideas
higher
Stage
period
life
natural
speech
participant
processes
Sociocultural
students
private
thinking
plays
central
learners
capable
closely
relationships
psychological
provided
perform
educational
interactions
Epistemology
transmitted
movements
Operations
becomes
Principle
set
come
get
PIAGET'S

The presentation for the committee of Doctoral School

Constructivist Cognitive Architecture

Jianyong XUE

Université de Lyon, LIRIS CNRS UMR5205
Université Claude Bernard Lyon 1

14.05.2020

Outline

- Introduction
- Related work
- Principal objectives
- Research progress
- Study and training process
- Summery of my previous work
- Next step
- Conclusion
- Schedule

Introduction

- Learning from interactions plays a foundational part in knowledge construction.
- Traditional learning approaches strongly rely on specific problems proposed by the designer.
  - Supervised learning
  - Reinforcement learning
- Alternative learning algorithms :
  - Constructivist learning,
  - Developmental learning
  - Lifelong learning
  - Enactive learning
  - Constitutive autonomy
- My work will focus on **Developmental learning** and **constructivist learning.**

Related work

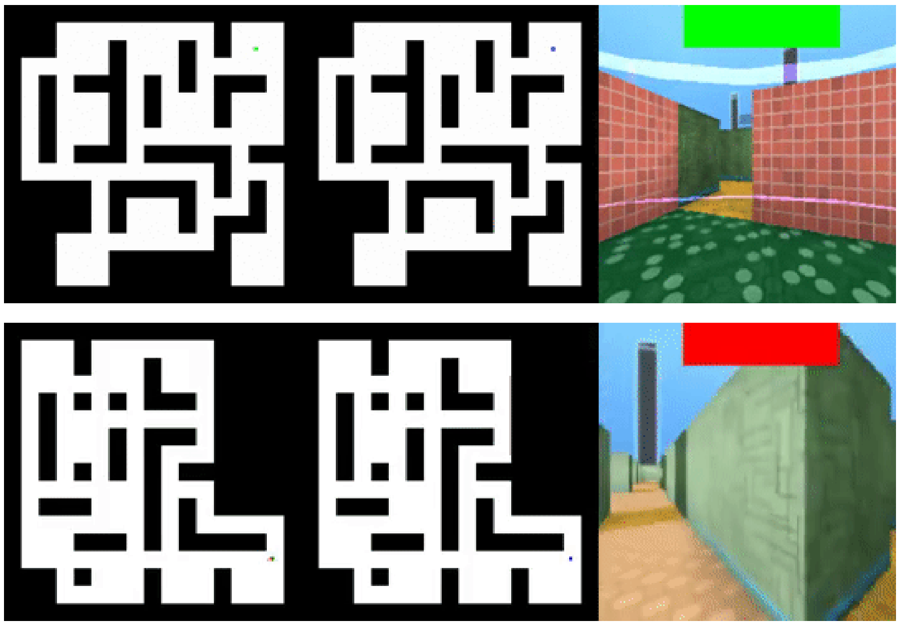


Fig. 1. Reward visualization. The results from Google and ETH's model about "Episodic curiosity through reachability".(See the link: https://ai.googleblog.com/2018/10/curiosity-and-procrastination-in.html)

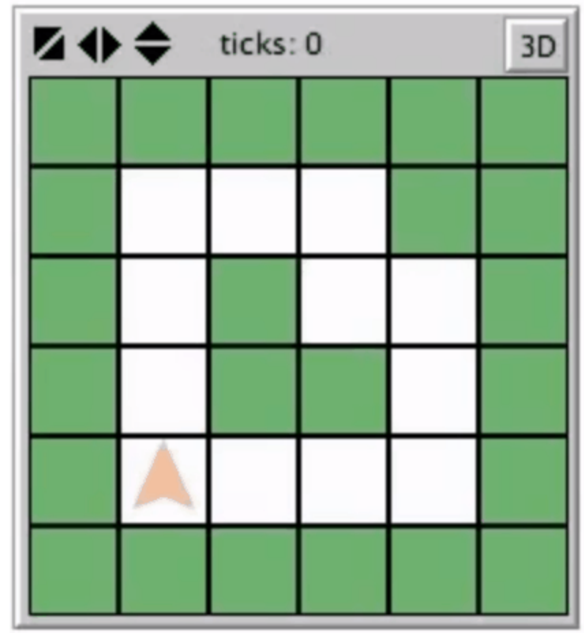


Fig. 2. Demonstration of developmental learning. This result comes from the IDEAL MOOC of Olivier Georgeon, the link is: http://liris.cnrs.fr/ideal/mooc/, the video from: https://www.youtube.com/watch?v=LVZ0cPpmSu8

Research objectives

- Knowledge construction through interactions between the agent and the environment with primitive behaviors.
- Context adaptation and effectively generate proper behaviors for situated interactions.
- Hierarchical sequential learning with reasoning mechanism into a more higher-level and have capabilities to gain awareness of the environment.
- Learning integrated with spatial memory and maintaining a representation of the surrounding environment
- The construction of interaction interpretation mechanisms based on the robot's interactions with humans and learning feedbacks from actions performed on the interactive situation

Research goal

The short-term goal is to create new cognitive architectures which could let the agent construct their own knowledge of their environment through experience, rather than exploiting pre-coded knowledge.

The Long-term goal is that the agent could comprehend the context and have capabilities to generate proper behaviors for flexible interactions to obtain positive experiences.

Research progress (1)

Causality reconstruction by an autonomous agent

- Following with the constructivist paradigm, a self-motivated agent designed to learn regularities of actions and feedback through experiences of interaction.

- With learned regularities, the agent could organize its behaviors to fulfill a form of intentionality defined independently.

- Explanation of the causal model and regularities of interactions to represent the “world”.

Causal model

- Hypothesis:
  - Regularities of interaction are caused by the presence of stable objects surrounding the agent.
- Abductive reasoning:
  - Construct a hypothetical configuration of the agent and physical objects to explain Stable Interactional Situations (SISs).
  - Construct hypothetical displacements of objects to explain transitions between SISs.

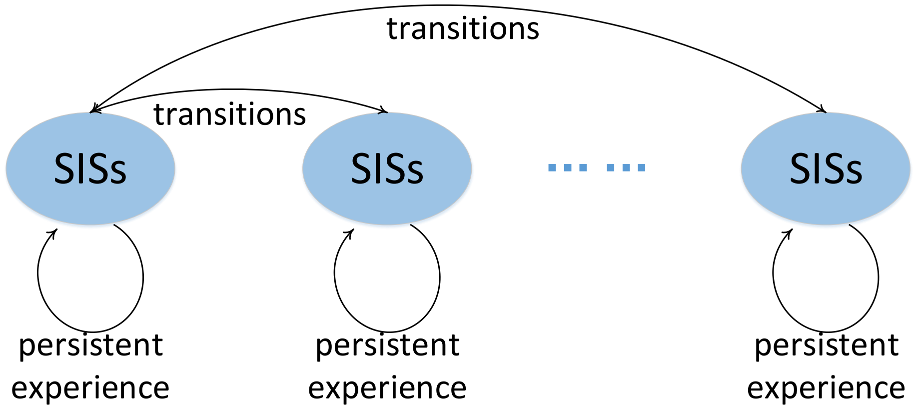


Fig. 3. Causality Reconstruction

Algorithm

- The discovery of stable interactions
  - Definition: Experience = <action, feedback>
  - Moods: *curious*, *excited* and *confident*.
  - Looking for experiences that could be repeated in a row.
  - New experiences are been created based on the *BeliefState*.

- The transitions construct between stable interactions
  - Context recognition.
  - Combination with interaction patterns.
  - The construction of the Petri-Net.

Experiment settings

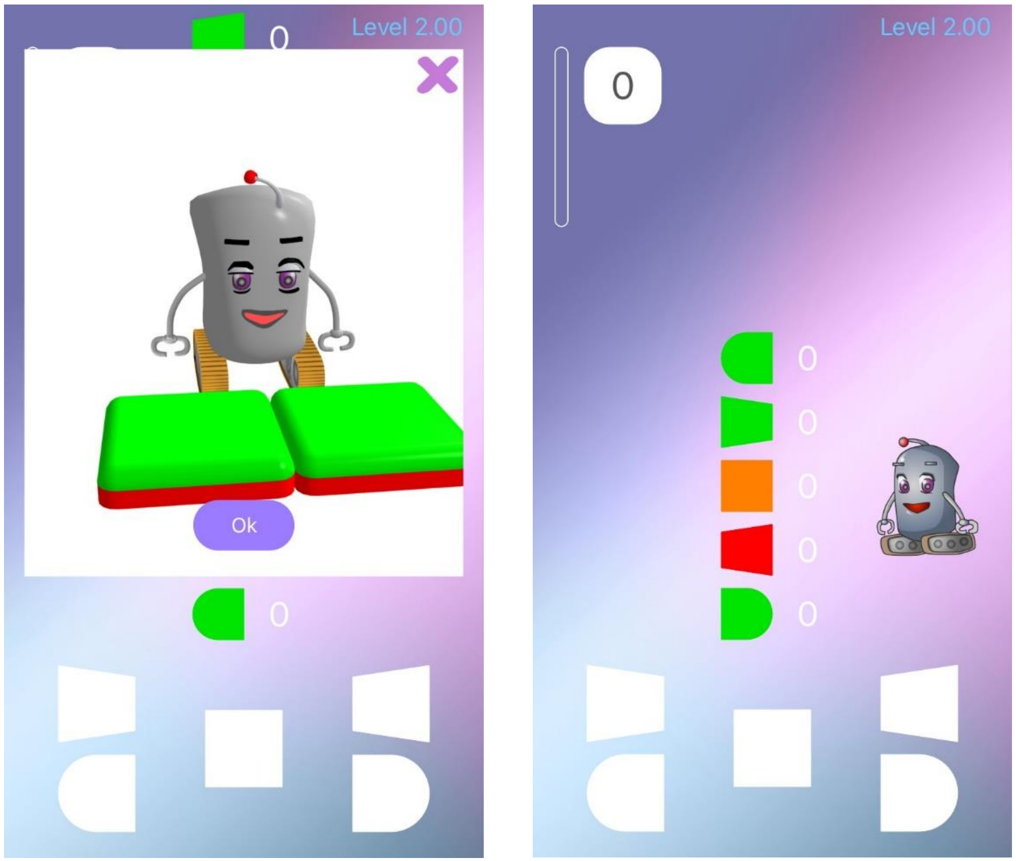


Fig. 4. Little AI's user interface and Level 2.00

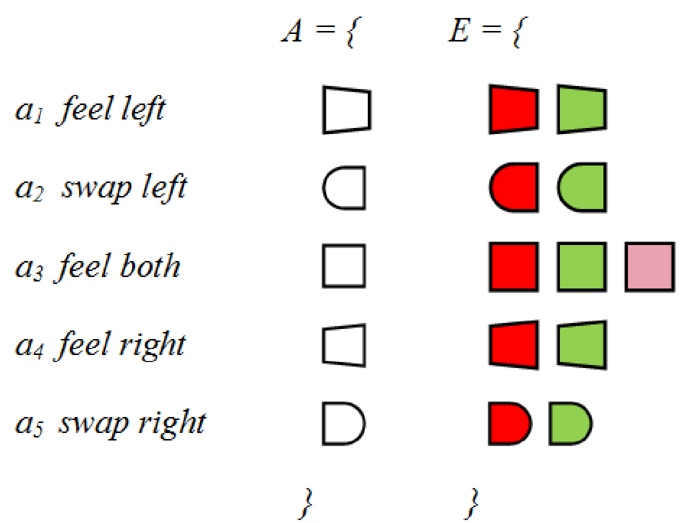


Fig. 5. Actions and experiences

Little AI

Interaction Traces

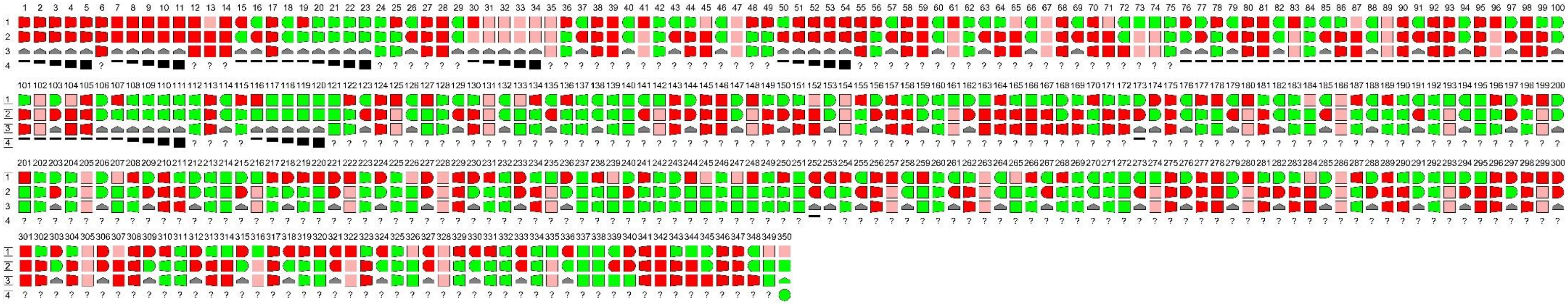


Fig. 3. Trace of the first 350 interaction cycles in our experiment.

Line 1: intended experiences.
Line 2: enacted experiences.
Line 3: belief states: unknown (grey triangle) / known state represented by its corresponding persistent experience.
Line 4: mood: curious (question mark), excited (increasing black bars), or confident (green circle).

Causal model results

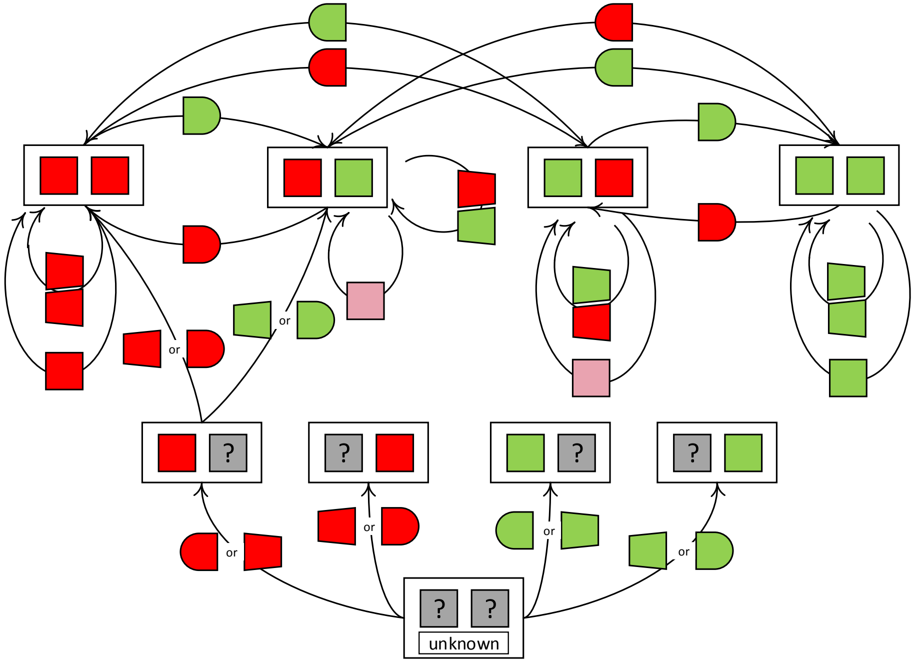


Fig. 6. A causal model (Petri Net) learned by the agent from regularities of interactions

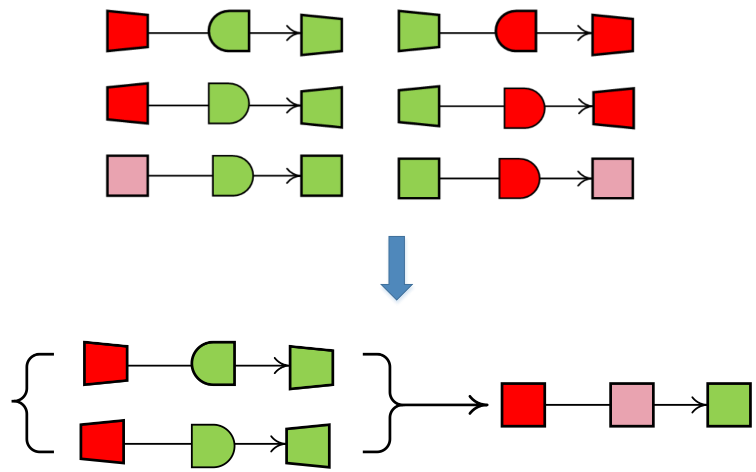


Fig. 7. Patterns of experiences and regularities the agent has learnt

Research progress (2)

Hierarchical sequential learning with intrinsic motivation

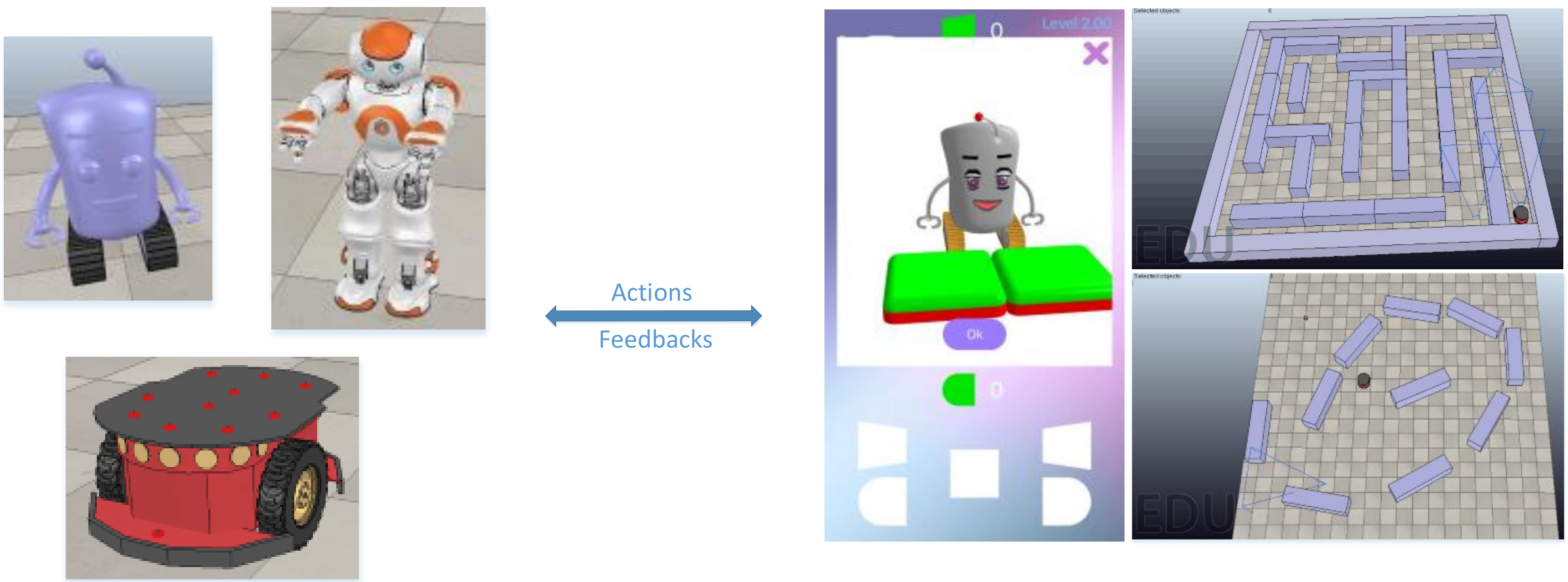
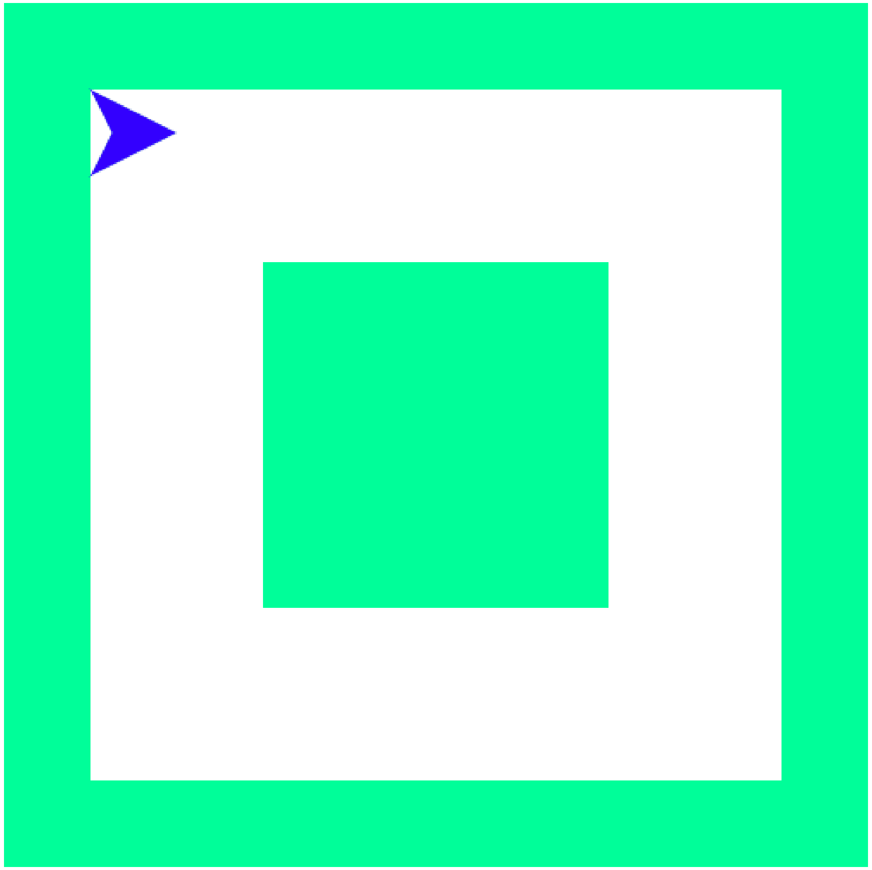


Fig. 8. The robots with its different interactive environments

Hierarchical sequential learning with intrinsic motivation



Parameters	
current direction:	right
next direction:	
Interaction valence:	3
Generated action:	

Experiment 1. An agent-environment interactive environment for interacting.

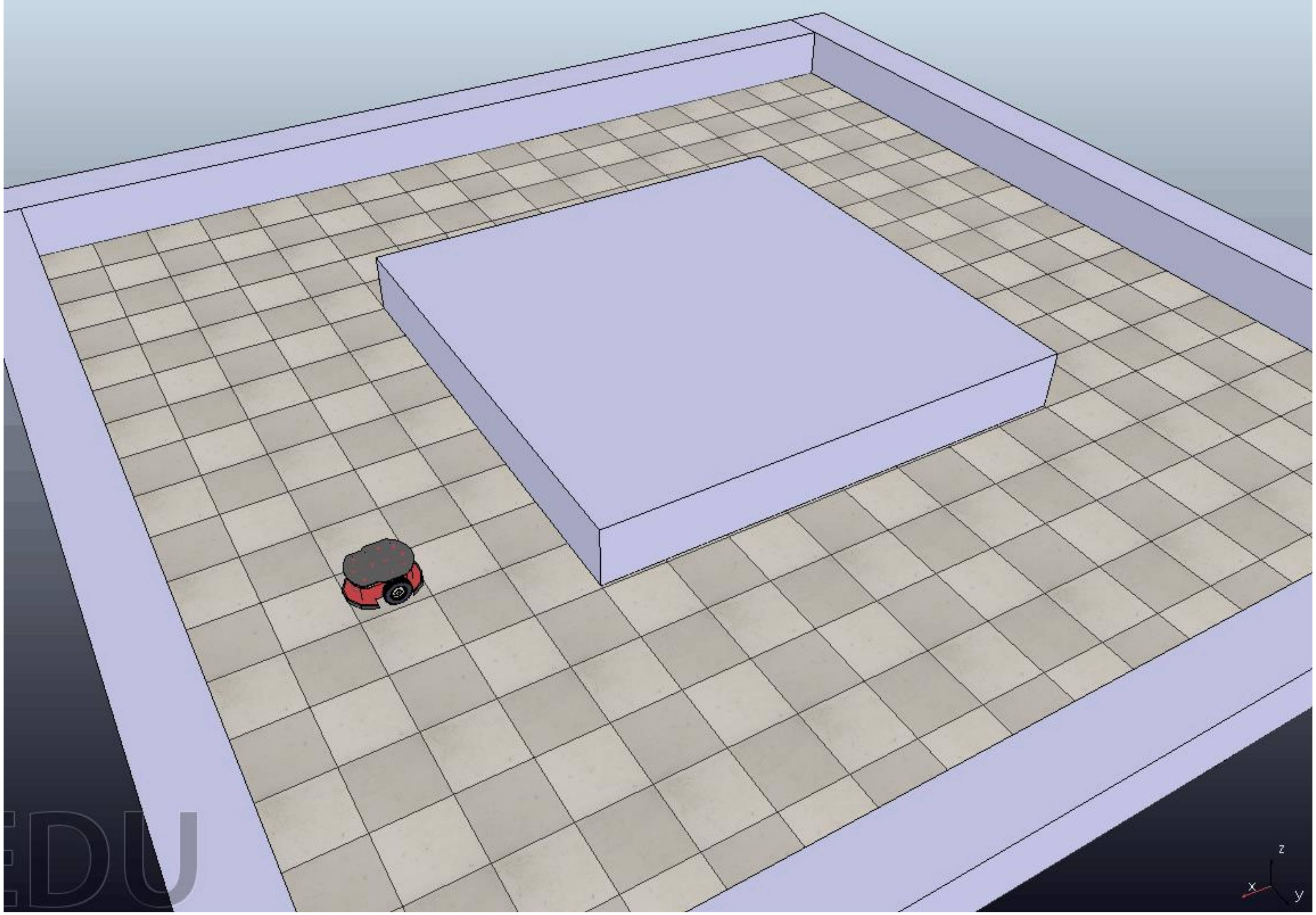
with lazy learning for knowledge transfer

START Check the function

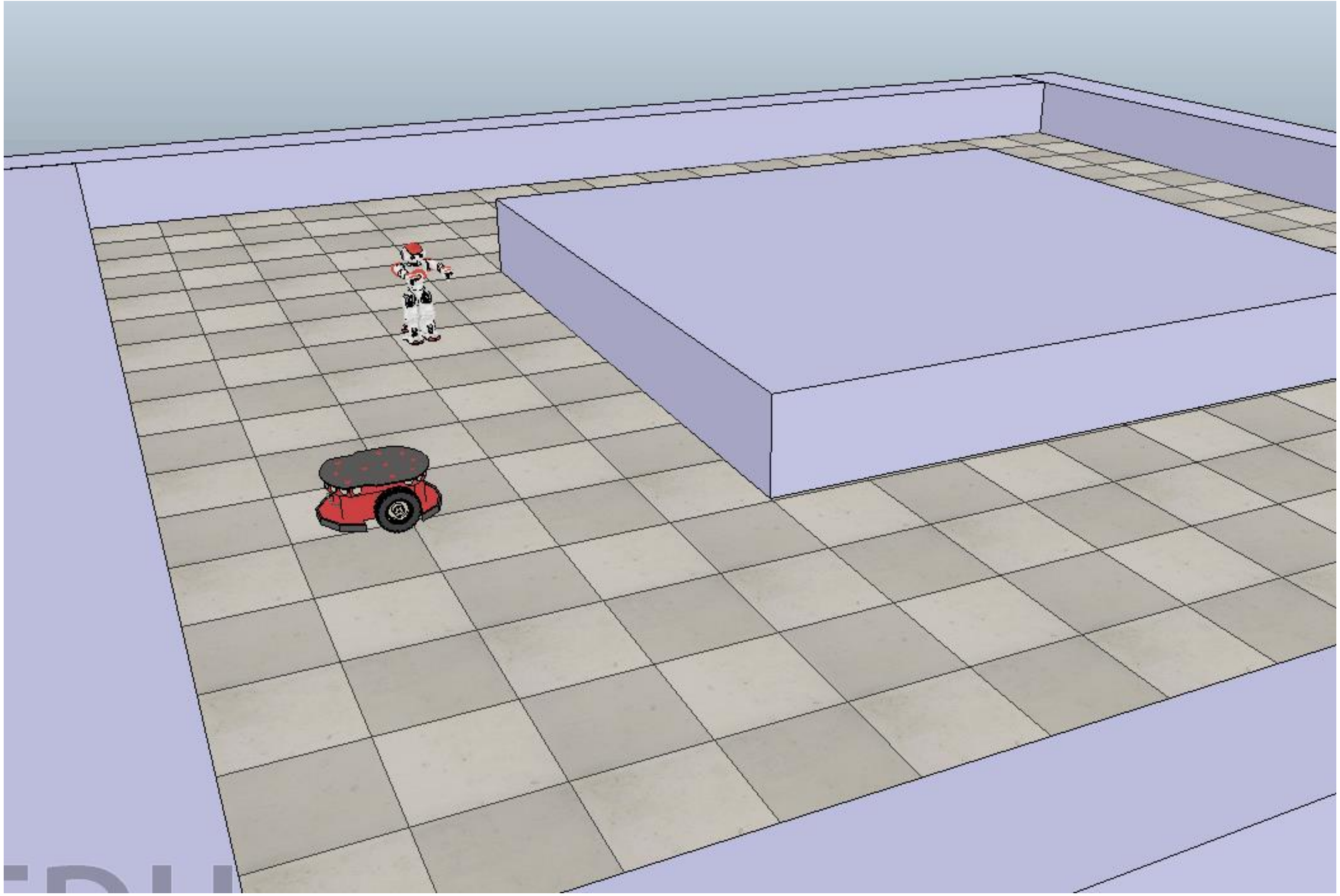
The purpose of designing this experiment

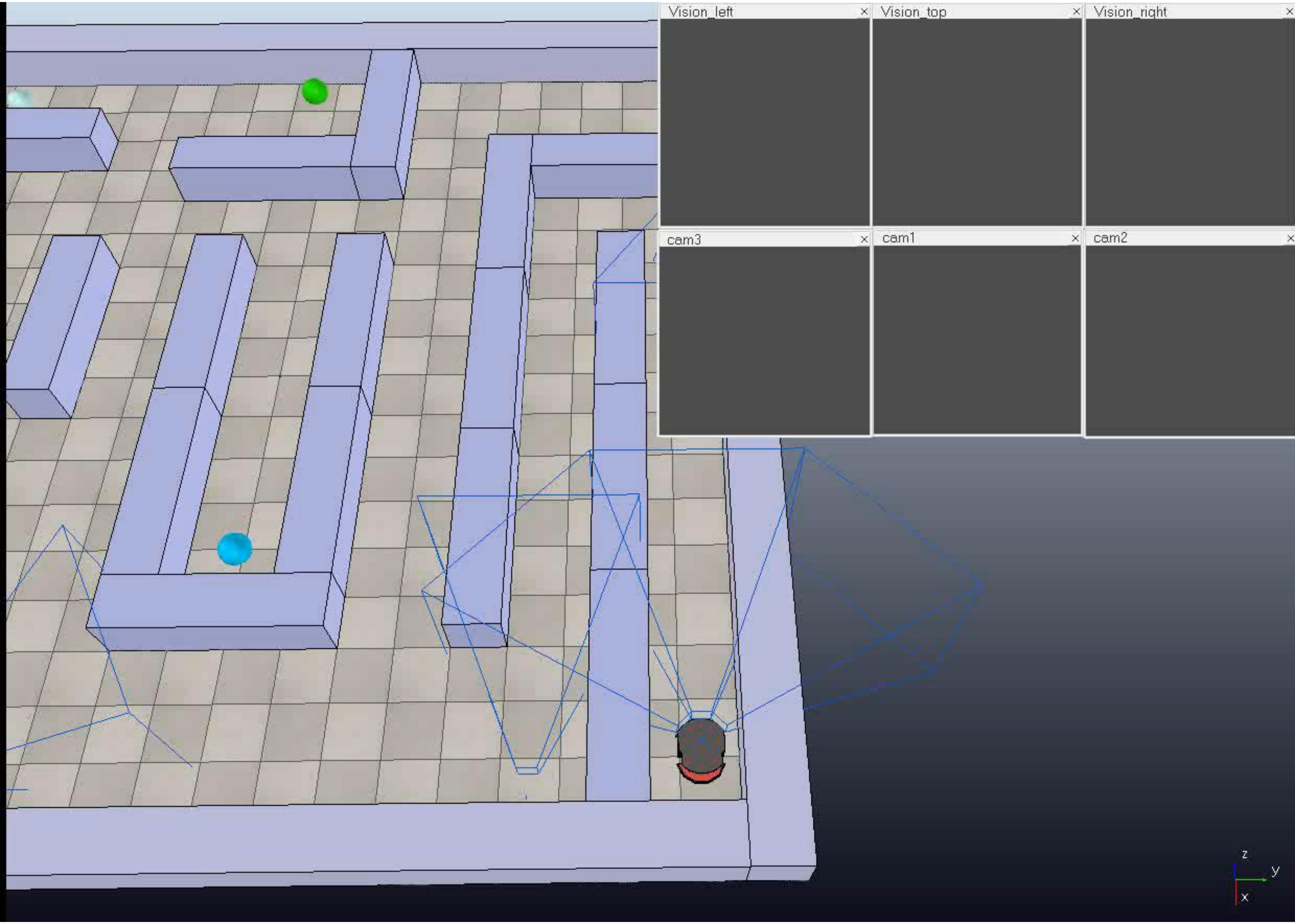
- Knowledge construction by interacting with the environment.
- Combined with Intrinsic motivations (curiosity, attention mechanism) lead the agent to generate new behaviors.
- Learning to transfer into a different new environment with learned behavioral patterns.
- 2D spatial memory with this learning process enables me to use it as building blocks for the spatial learning in 3D spaces.

The implementation of hierarchical sequential learning in a 3D environment



An environment for Robots-Objects interaction




Vision_left
Vision_top
Vision_right
cam3
cam1
cam2
z
y
x

Study and training process

- Doctoriales : séminaire de doctorants au service de l'innovation des entreprises & organisations, 30/04/2018, volume horaire: 21 heures.
- Recherche et industrie : les enjeux de la Propriété Intellectuelle, 18/06/2018, volume horaire: 12 heures.
- Français langue étrangère, 22/11/2017, volume horaire: 36 heures
- Carrières académiques et industrielles : que faire avec un doctorat en informatique organisée par SIF/SPECIF Campus, 06/12/2018, volume horaire: 6 heures.
- Histoire des Sciences et des Techniques, 08/01/2018, volume horaire: 42 heures (en cours).

Trainings Hours:

36 hours + 12 hours + 21 hours + 6hours + 42 hours = 117 hours.

Summary of my previous work

Questions remain and pose several challenges:

- The Petri-Net would be too significant huge when the agent faced with more complex tasks.
- How the algorithm could construct a theory that involves a representation of its environment with tiles and their sides.
- How to design an efficient cognitive architecture which fits with agent's continuous interaction with the environment and new learned behavioral patterns with progressive learning? Is there any efficient structure of behavioral patterns exist?
- Being placed in a new and complex environment, how can the agent transfer the knowledge they have learned to face this new challenge?

Next Step

- Study
  - I will finish my 100 training hours with a minimum requirement of at least 30 hours in the “Formation Scientifique” and the “Formation à l'Insertion Professionnelle”.

- Research
  - Learning of hierarchical sequence by memorizing patterns from feedback for higher-level learning.
  - The implementation of rudimentary spatial memory.
  - Context learning with spatial memory for agent-environment coupling.
  - Expressing the learning process with motivational states.
  - Gestures acquisition and adaptation with human-robot interactions.

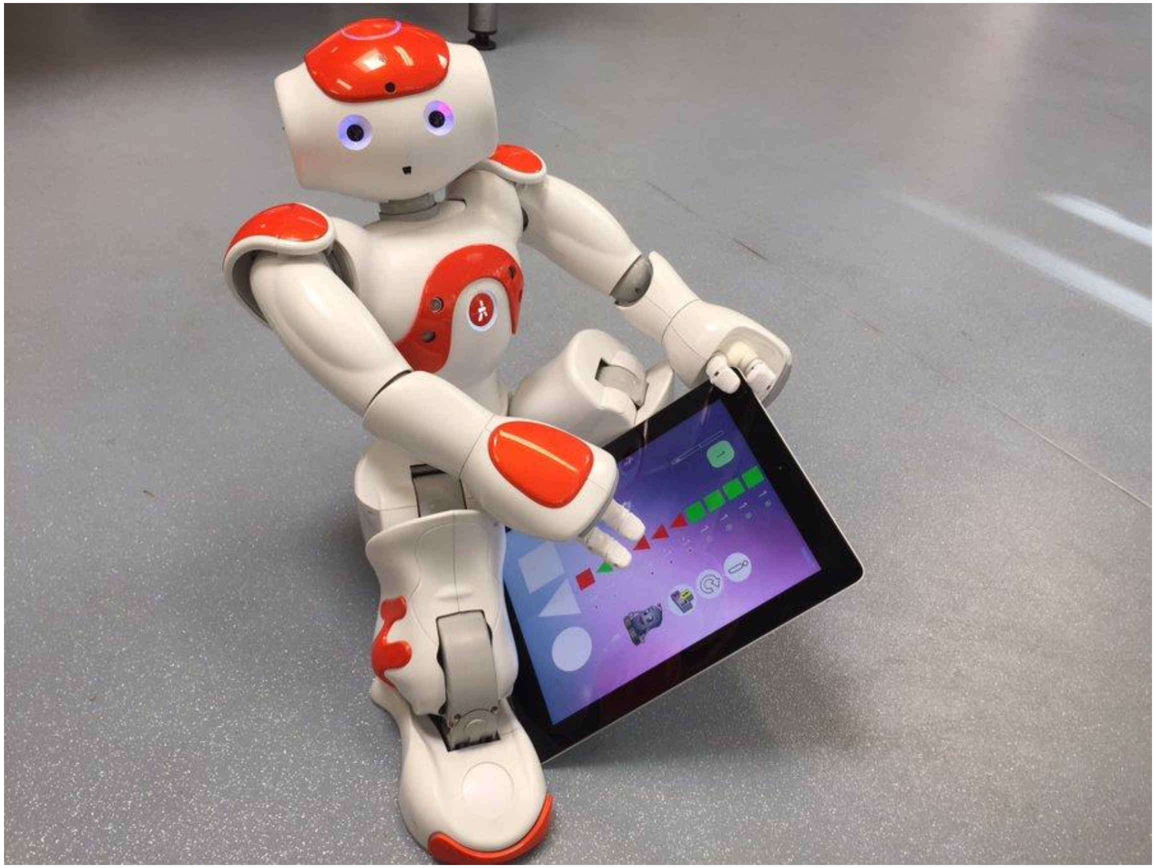
In addition

- Inspirations from hierarchical sequential learning, intrinsic motivation, episodic memory and attention mechanism give us different solutions and could facilitate to solve problems for acquire “high-level knowledge”.
- Designing comparative experiments to verify those solutions.
- I need to find my own ways and innovative solutions to solve these problems.

Schedule

Target publication	**Deadline**	**Research contents**
IEEE Transactions on Autonomous Mental Development	June 10th, 2019	Hierarchical sequential learning with attention mechanism.
IEEE Transactions on Cognitive and Developmental Systems	September 10th, 2019	Spatial learning with episodic memory
International Conference on Autonomous Agents and Multiagent Systems	November 16th, 2019	Gestures acquisition and adaptation with humanrobot interactions.
International Conference on Learning Representations	January 22th, 2020	Expressing the learning process with motivational states
Joint IEEE International Conference on Development and Learning and on Epigenetic Robotics	February 22th, 2020	Expression of the learning process with motivational state and analysis of interactions traces.
Forward	Forward	Reservation

Thanks for your attention!



NAO Robot is playing with Little AI !

Roadmap being built with 3 Monte Carlo simulations per randomly selected node pair.