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A Dynamic Neural Network Approach to Generating Robot's Novel Actions : A Simulation Experiment

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KAIST OIST

How to Teach Actions

"Tutoring"

Learning
From Demonstration

"Learned Actions"

Research Questions

"Tutoring"

Learning
From Demonstration

"Learned Actions"

"Novel Actions"

How can a robot generate novel actions from learning basic actions?

Research Questions

"Tutoring"

Learning
From Demonstration

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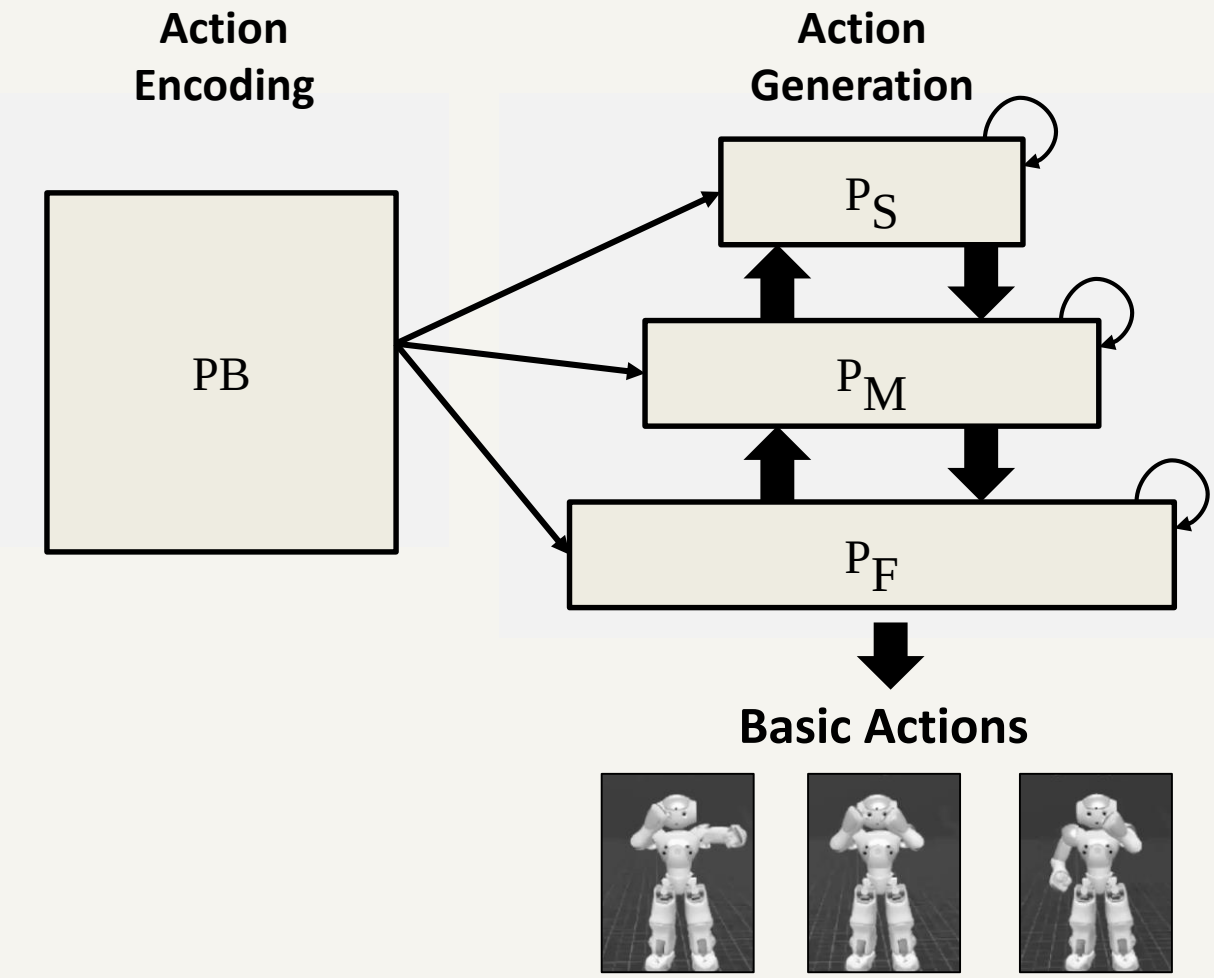
How can a robot generate novel actions from learning basic actions?

"Dynamic Neural Network Approach"

- Source of Novelty = Non-linear Memory Dynamics

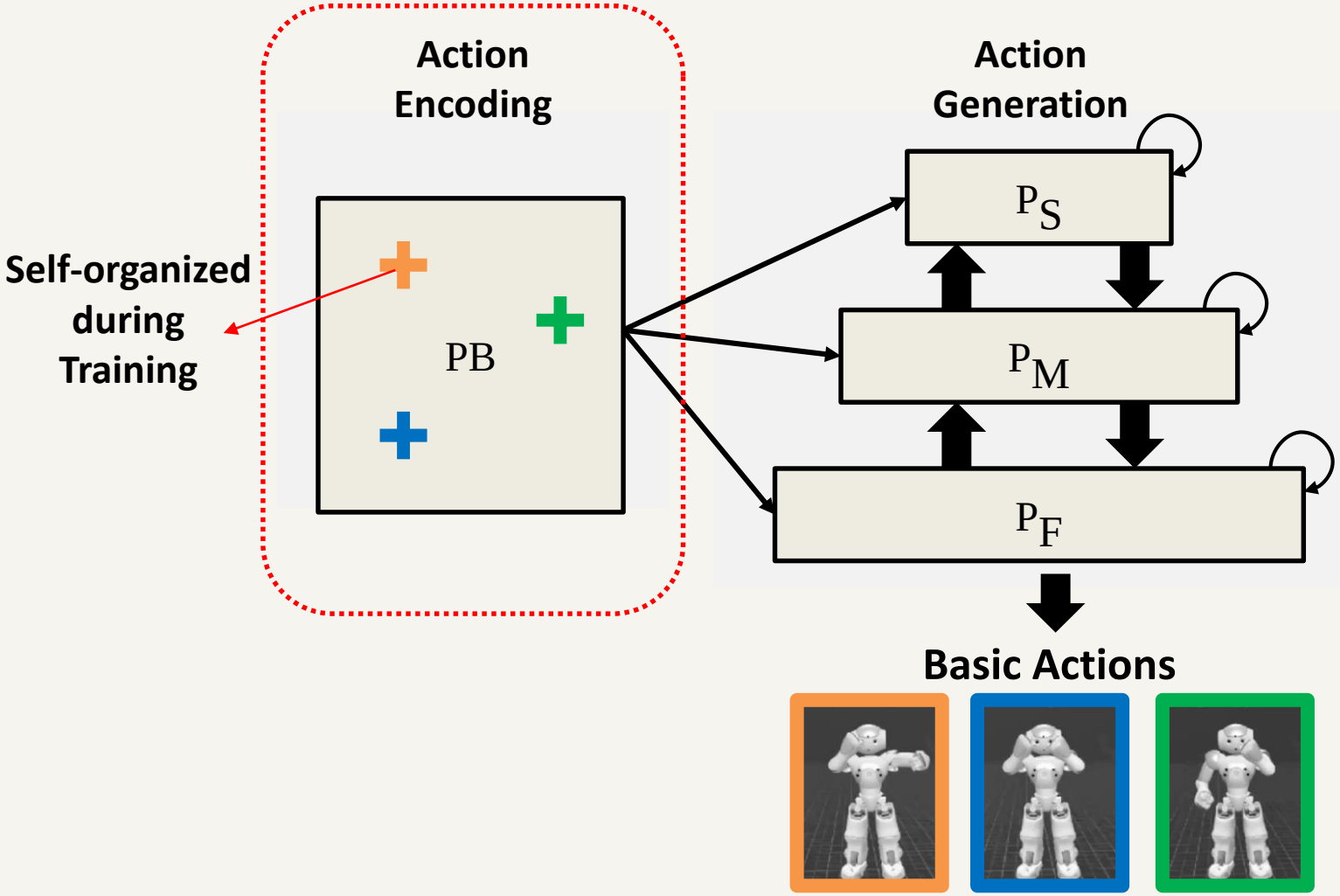
Dynamic Neural Network Approach

- **Multiple Timescales RNN with Parametric Biases**



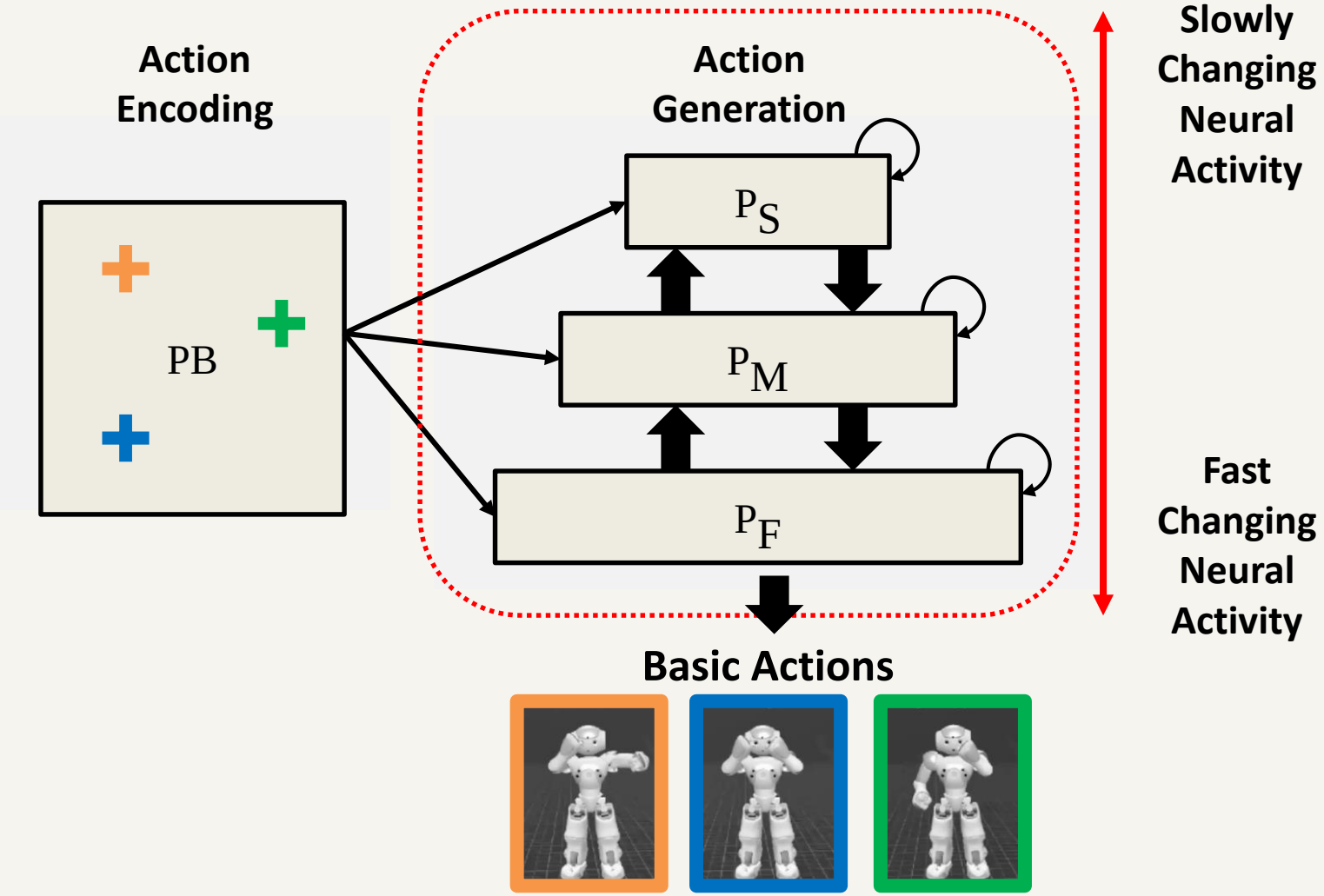
Action Encoding Module

- Maps robot's actions into the low-dimensional space



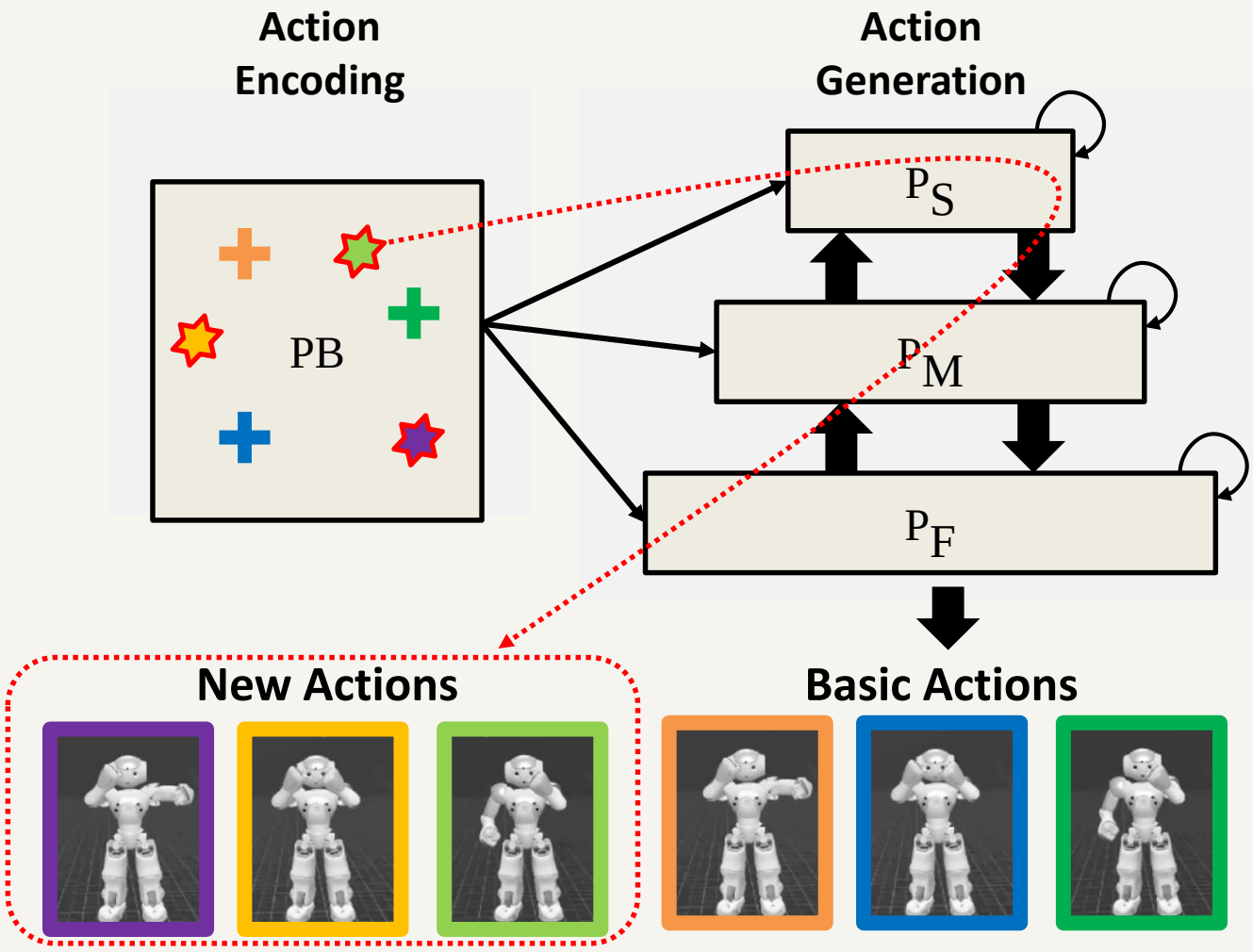
Action Generation Module

- Learns actions in a multiple timescales structure



Generation of Action

- **With given PB values in Action Encoding Modules**



Results – Generation of Novel Action

Six basic actions in training dataset

: Left Jab, Left Hook, Left Uppercut, Right Straight, Right Hook, Right Uppercut

Measuring the Level of Creativity

- **Appropriateness**
  - Actions that "can be used"
    - e.g., Maximum angular velocity < Threshold
- Novelty
  - Actions "different from learned action"
    - Distance(Learned Action, Generated Action)
- Diversity
  - Actions "different each other"
    - Distance(Generated Action, Generated Action)

		Closed-loop Ratio (γ) during Training		
		0.0	0.5	1.0
Appropriateness (%)	Unlearned	72.21	75.26	57.95
	Learned	11.23	7.58	40.02
	Subtotal	83.44	82.84	97.97
Novelty		26.02	31.71	18.53
Diversity		43.12	48.03	35.96

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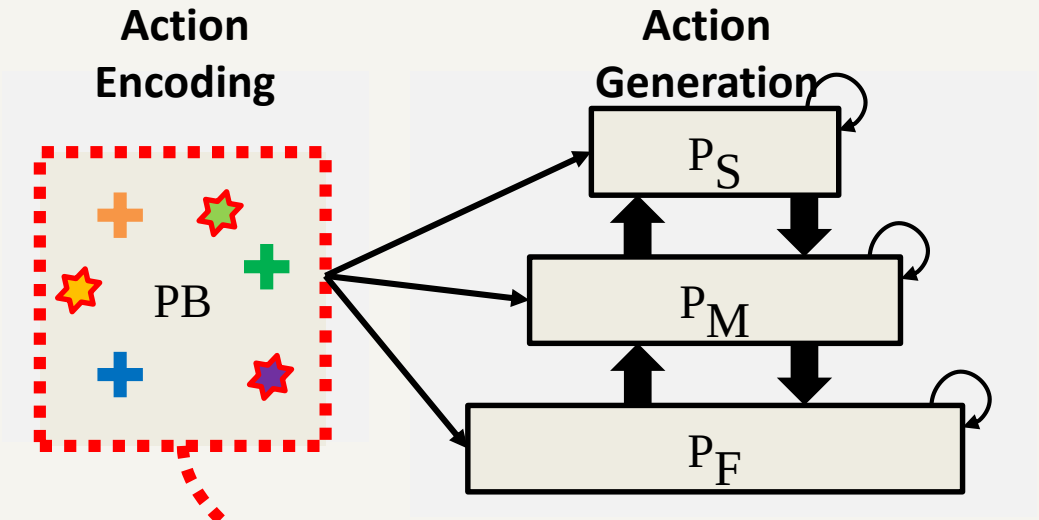
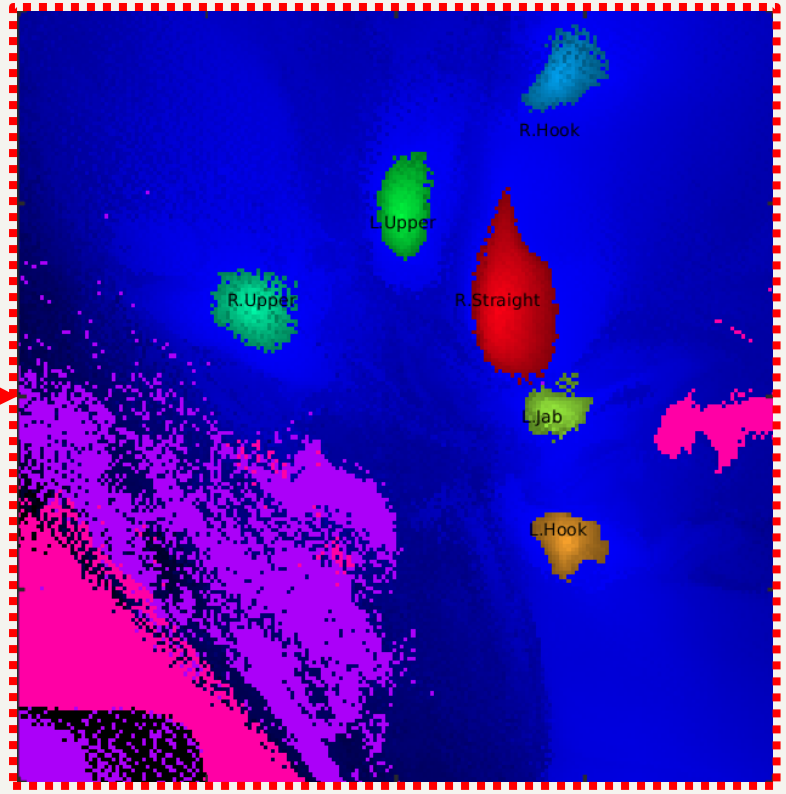
The model's level of creativity depends on the learning method.

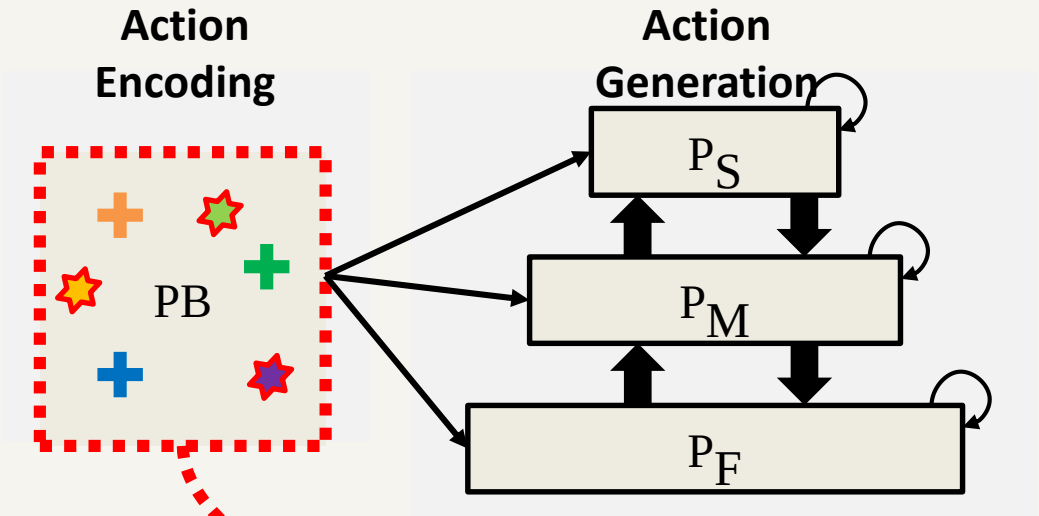
Internal Structure in the Action Encoding Module

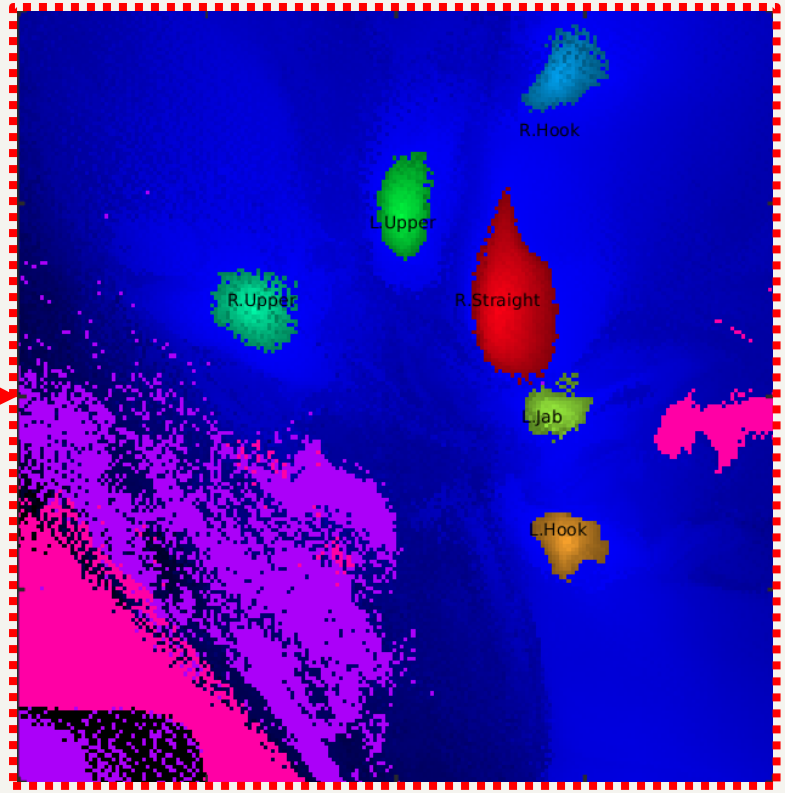




- 200 x 200 points in 2D PB Space
- Each point encodes one action
  - e.g., (0.3, 0.2) → Left Jab
  - e.g., (0.1, 0.5) → Right Straight

Internal Structure in the Action Encoding Module





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- Each point encodes one action
  - e.g., (0.3, 0.2) → Left Jab
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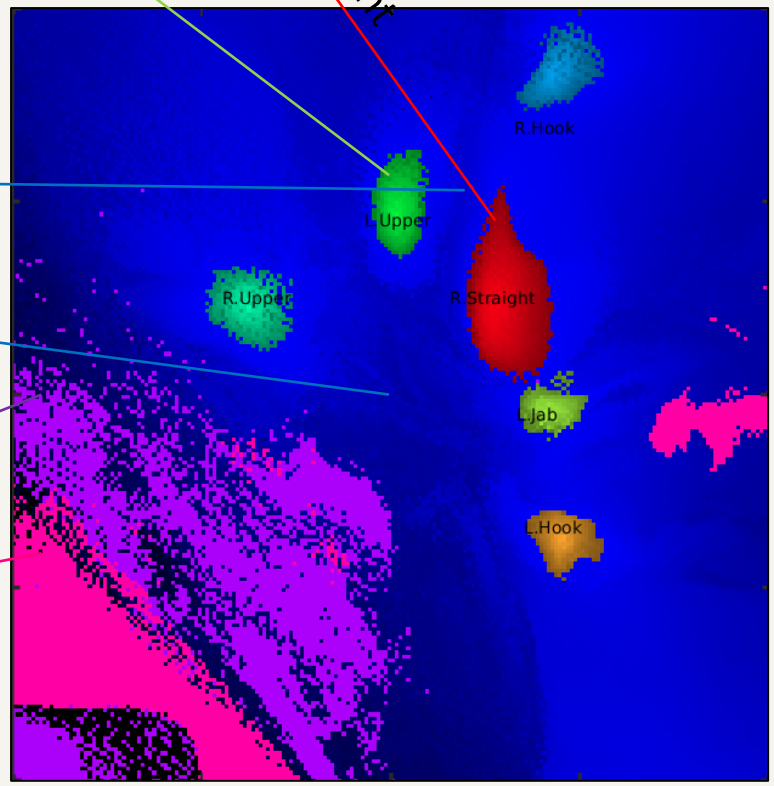
- **Self-organized during training**

Internal Structure in the Action Encoding Module

Actions learned during training



Novel Actions

Combination of Right Straight & Left Uppercut

Different from learned ones

Changing too fast

Not moving

Actions that cannot be used

Internal Structure in the Action Encoding Module

Actions learned during training

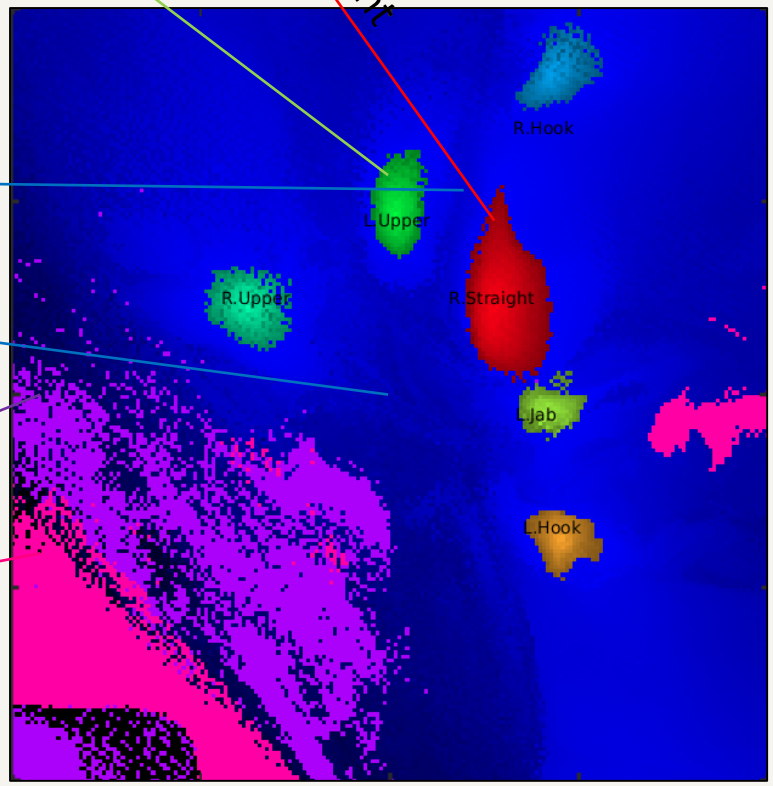
Left Uppercut

Right Straight

Novel Actions

Combination of
Right Straight & Left Uppercut

Different from learned ones



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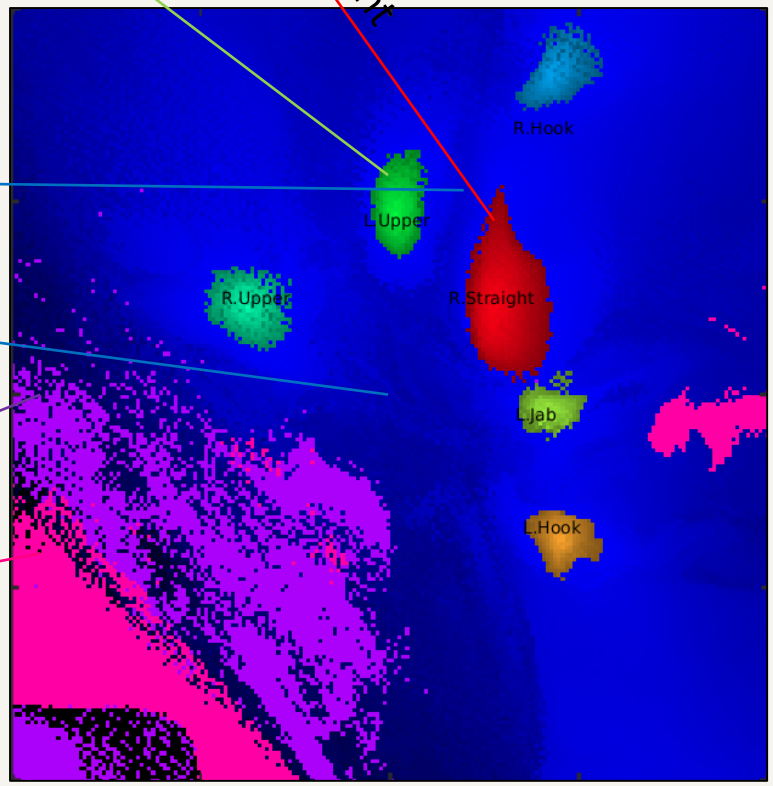
Actions that cannot be used

Internal Structure in the Action Encoding Module

Actions learned during training

Left Uppercut

Right Straight



Novel Actions

Combination of
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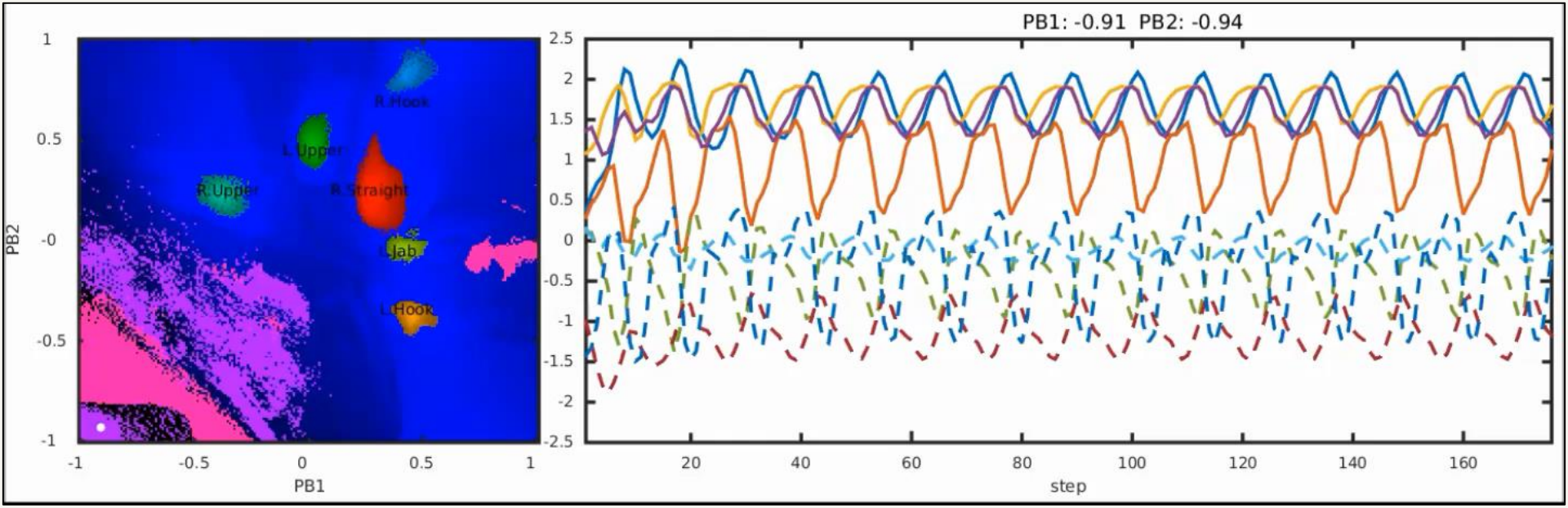
Internal Structure in the Action Encoding Module

"Rugged" PB Space

: Small changes in the PB Values ➔ Abrupt changes in robot's action

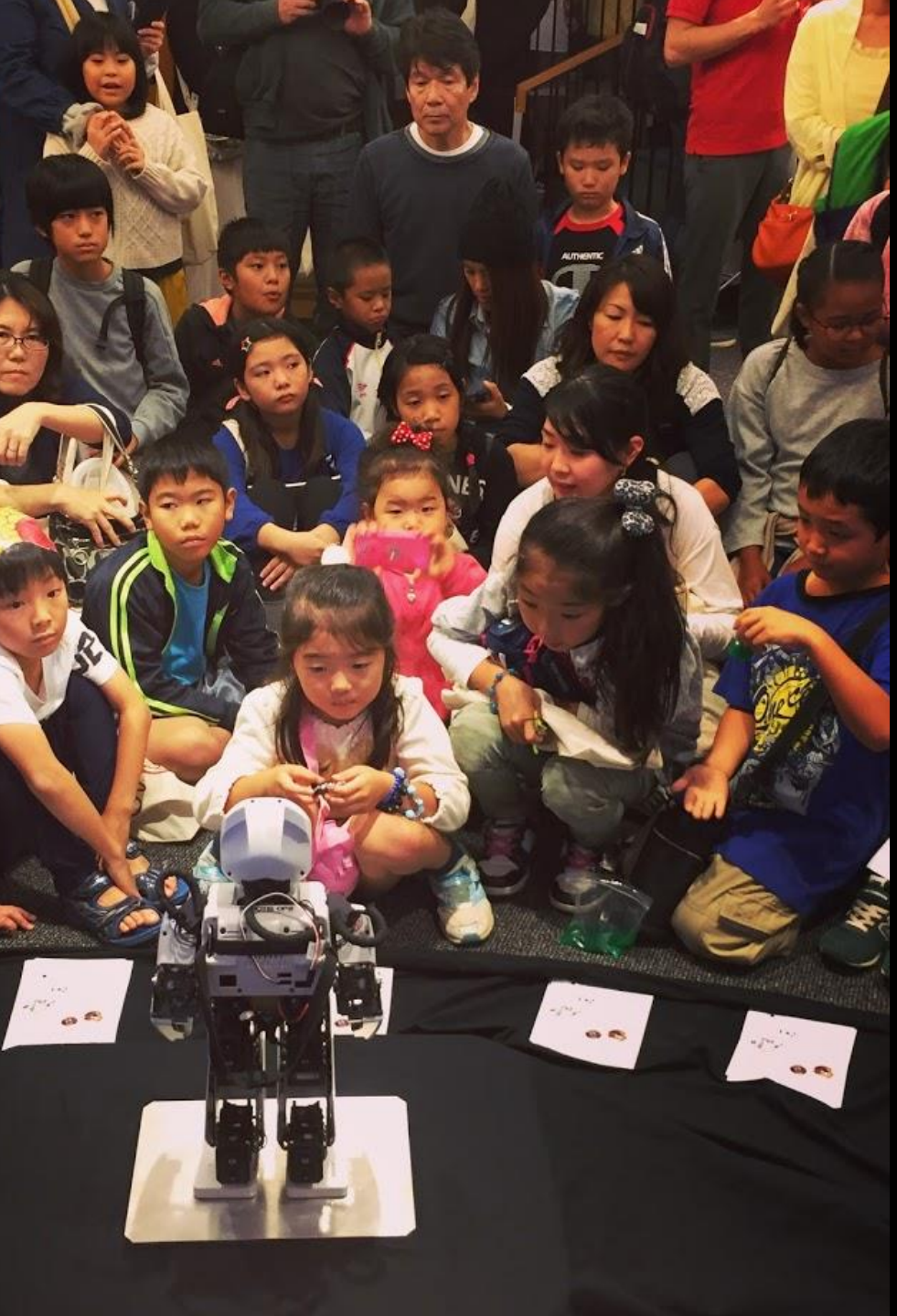


Current PB Value
(in Action Encoding Module)

Robot's Action
(Position values of 8 Joints)

Summary

- Generating Creative Robot Actions
  - From the Dynamic Neural Network Perspective
- Neural Network Model (MTRNN-PB)
  - Reproduces learned actions
  - Generates novel actions
    - Through modulating & combining those learned actions
  - Self-organizes non-linear memory dynamics
    - Source of novel actions



A photo from 2017 OIST Science Festival
"Creative Robot Dance Generation"
By Jungsik Hwang, Nadine Wirkuttis and Jun Tani

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[ThP10]

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