Pronunciation Adaptive Self Speaking Agent Using WaveGrad

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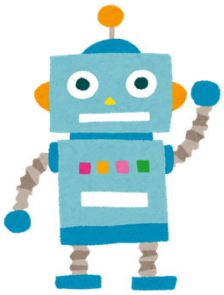
Automatic Spoken Language Acquisition

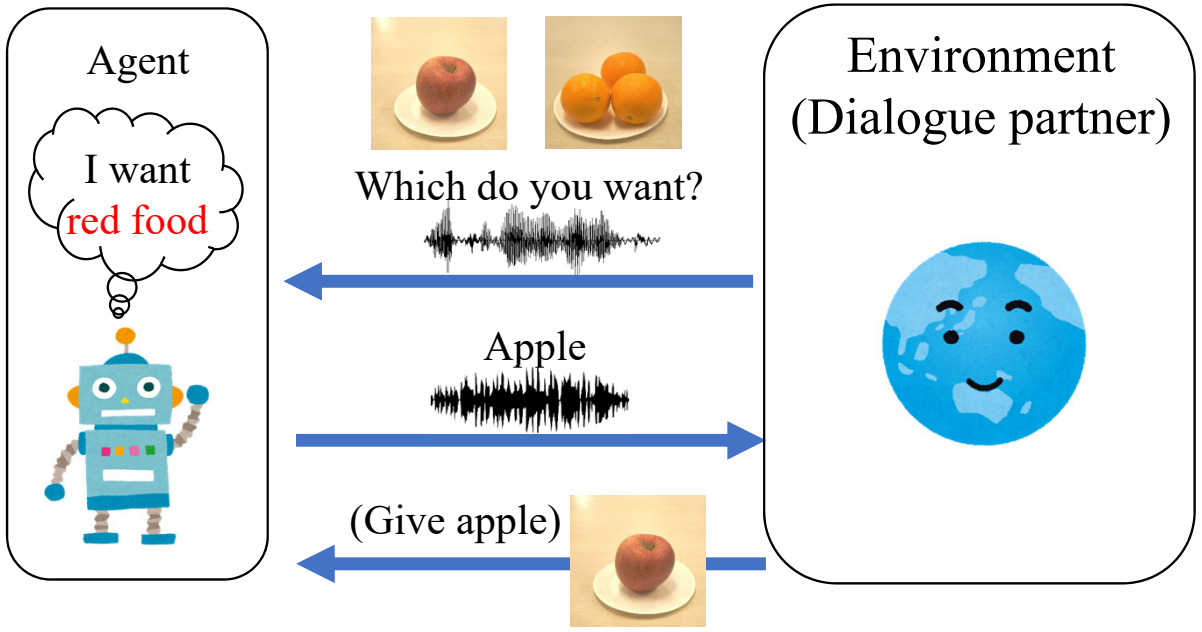
- Human babies learn language making a closed learning loop in human society
- They learn new words as well as their pronunciation without relying on labeled data

No initial knowledge of any language



Agent
(Human or AI)

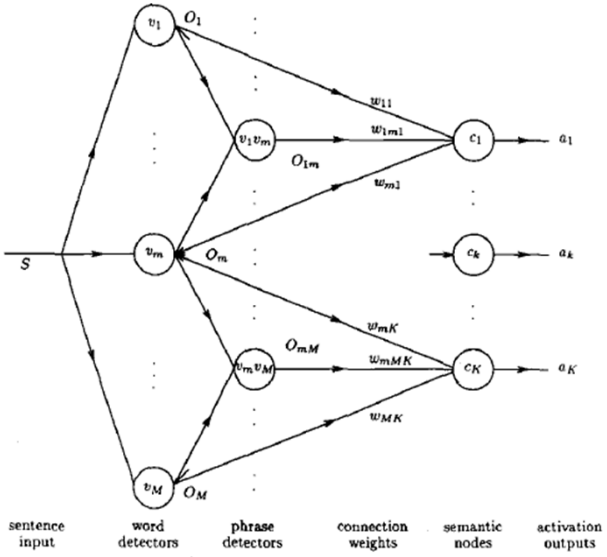
Learns spoken utterances as a means to interact with the environment



Related Works

[Gorin+ IEEE Trans. Speech and Audio Processing 1994]

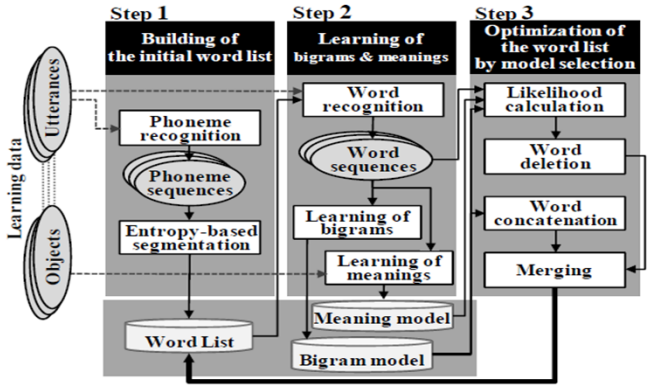
① Word discovery
② Semantic grounding
③ Action learning[1]
④ Pronunciation learning



[1] Action space is pre-defined

[Taguchi+ Interspeech 2011]

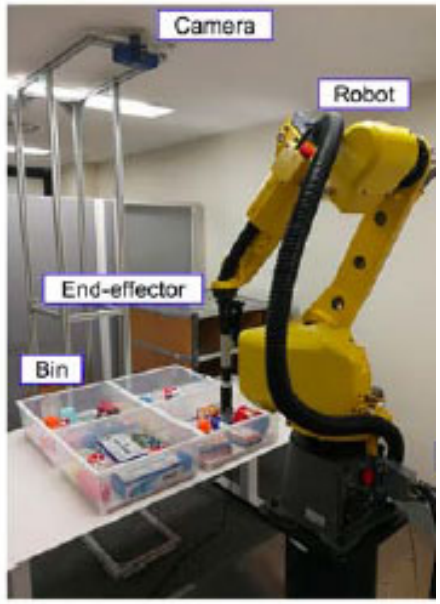
① Word discovery[2]
② Semantic grounding
③ Action learning
④ Pronunciation learning



[2] Phoneme recognizer is pre-trained

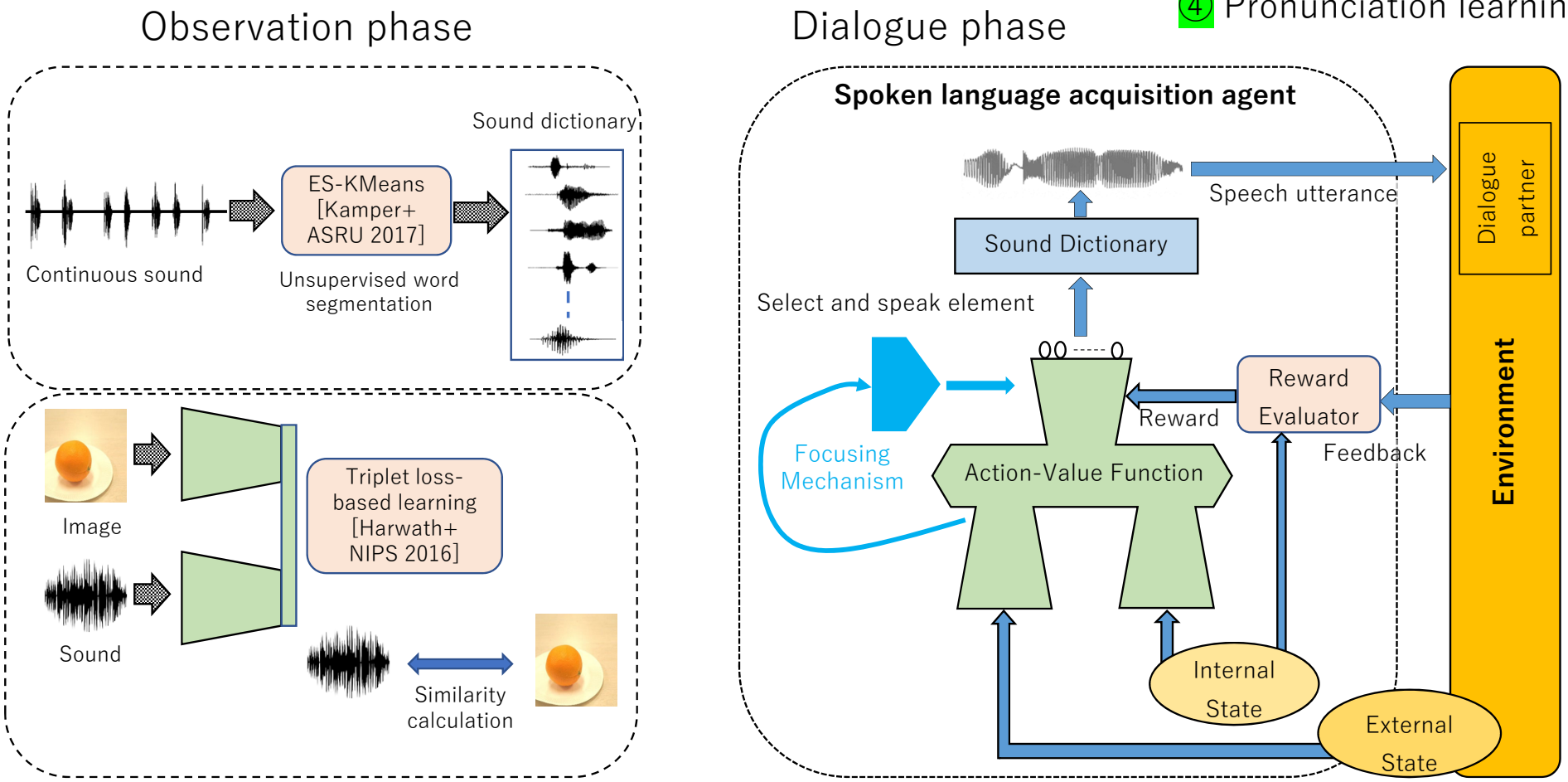
[Hatori+ IEEE ICRA 2018]

① Word discovery
② Grounding
③ Action learning
④ Pronunciation learning



Zhang's Agent [Interspeech 2020]

① Word discovery
② Semantic grounding
③ Action learning
④ Pronunciation learning



Pros and Cons of Using Sound Dictionary

- Pros:
  - Discretizes the action space of utterance pronunciation, and makes the reinforcement learning efficient
- Cons:
  - Can not adapt pronunciation other than changing segment selection

Our idea: Replace the sound dictionary with a generative neural vocoder

	Sound Dictionary	Neural Vocoder
Discrete/Compact Action Space	✓	✓
Adaptability		✓

Neural Vocoder

- Unconditional Training:
  - Generate waveform by random sampling without conditioning
  - Sounds like human baby's babbling

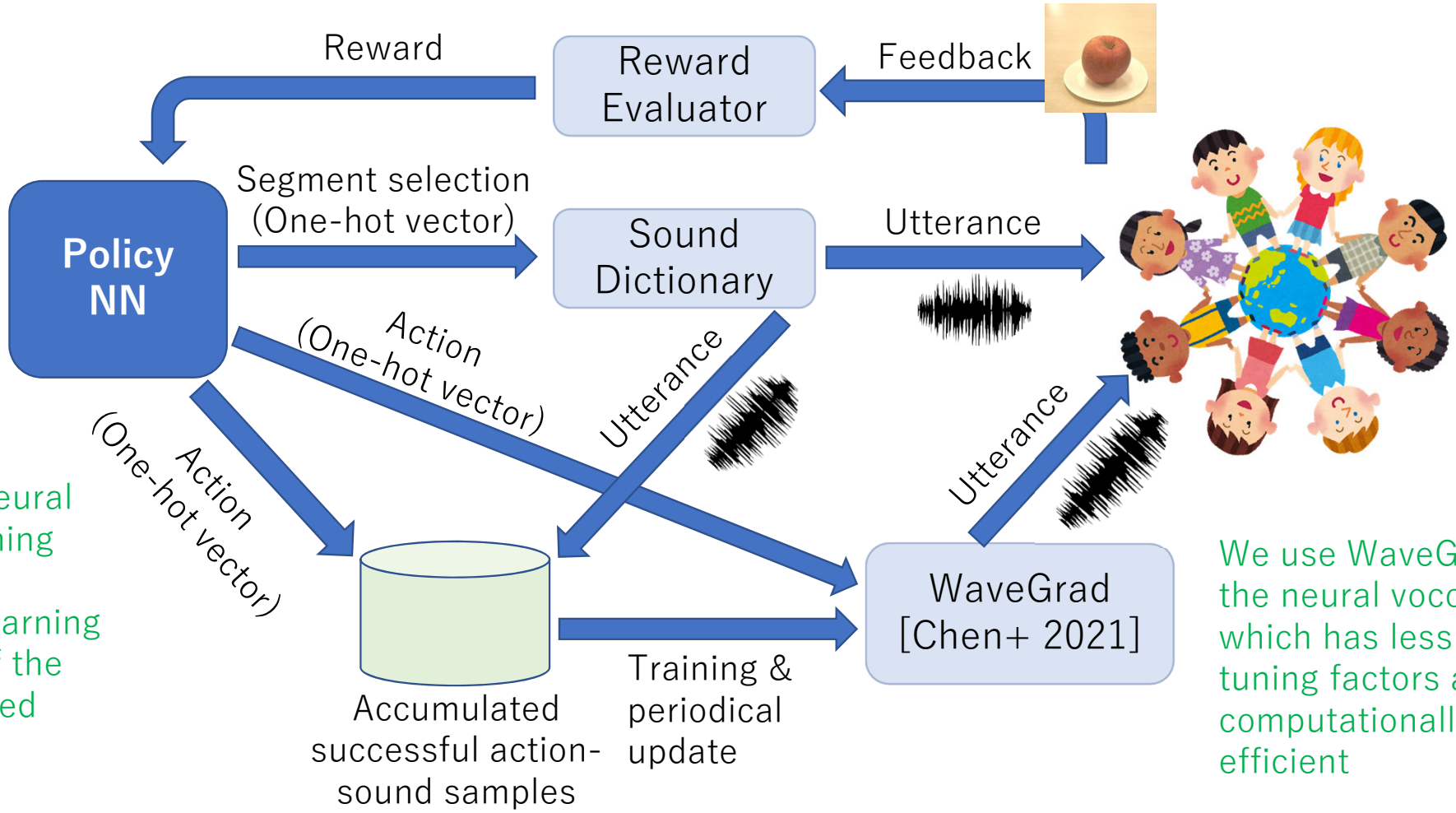
WaveNet [Oord+ 2016]
with unconditional training


original


generated

- Semi-conditional Training:
  - Conditioned on time invariant information
  - It can be word ID as in DiffWave [K. Kong+ ICLR 2021]

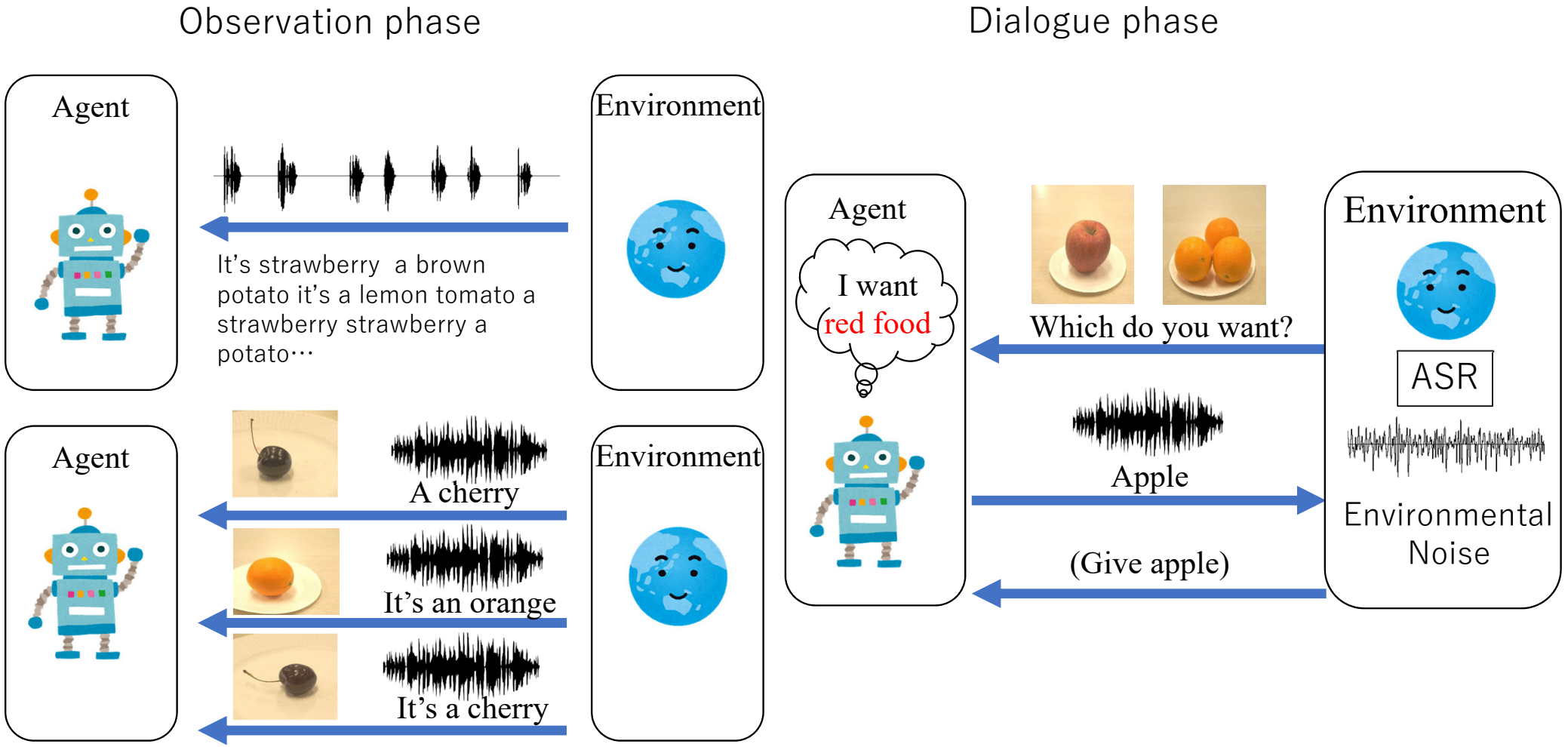
Proposed Self-Supervised Learning Method



Embed the neural vocoder learning into the self-supervised learning framework of the dialogue-based learning

We use WaveGrad as the neural vocoder which has less tuning factors and is computationally efficient

Task Design

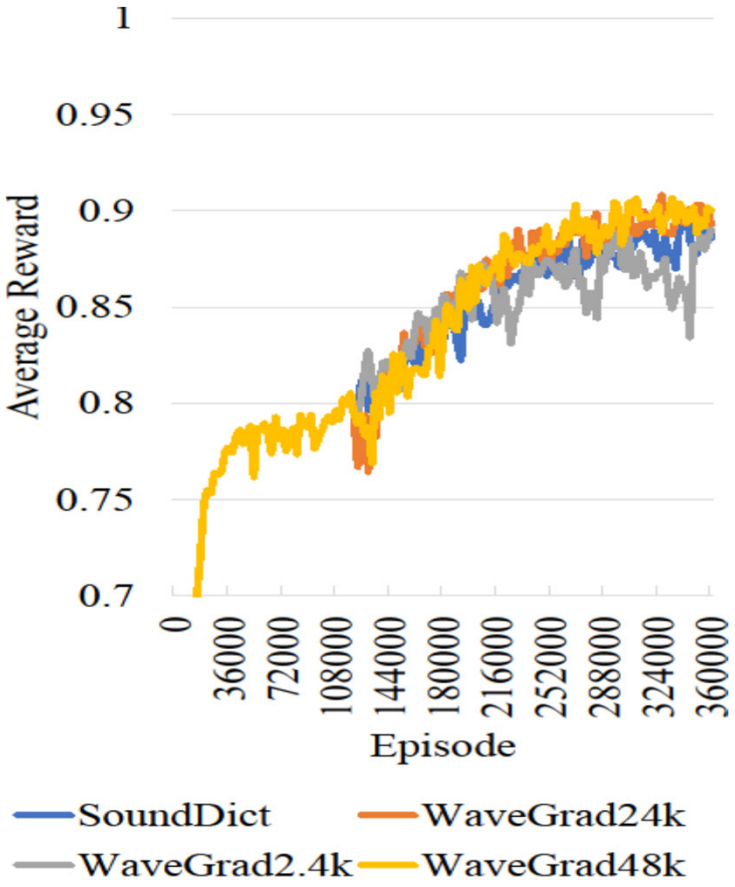

Observation phase
Dialogue phase
Agent
Environment
It's strawberry a brown potato it's a lemon tomato a strawberry strawberry a potato…
Agent
A cherry
It's an orange
It's a cherry
Environment
Agent
I want red food
Which do you want?
Apple
(Give apple)
Environment
ASR
Environmental Noise

Experimental Setup

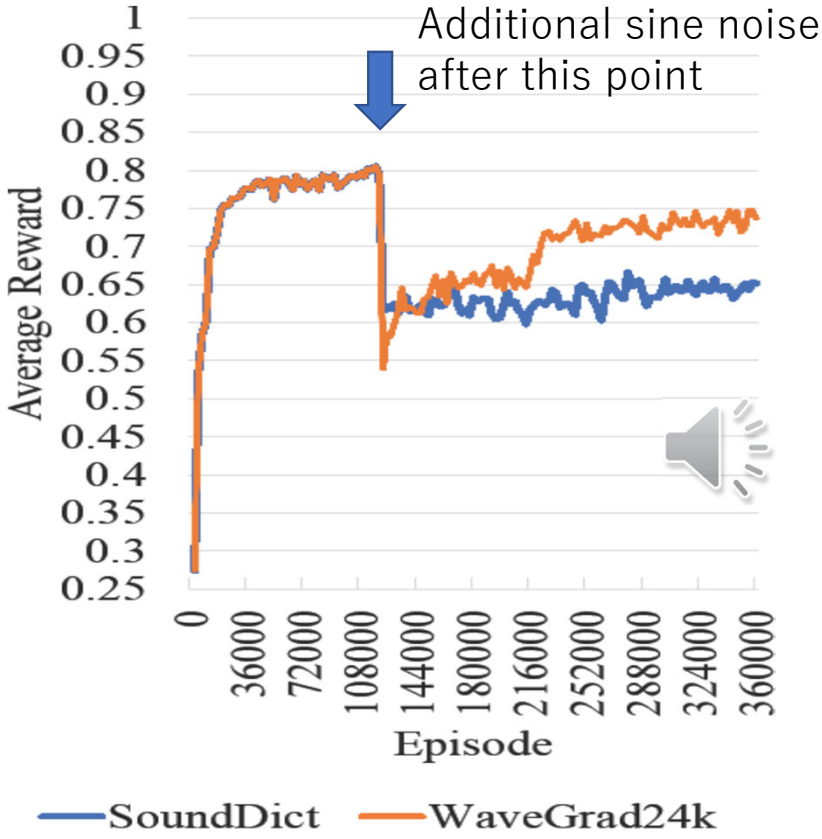
- Baseline:
  - Zhang's system
- Image dataset:
  - Food type: 8
  - Number of training images: 90 per each food
- Observation phase
  - Audio description: Generated using Google Text-To-Speech using templates
    - "<food>"
    - "A<food>"
    - "A<color><food>"
    - "It's a<food>"
- Dialogue phase
  - Sound dictionary size: 12,000
  - Noise condition: White noise + additional sine noise after 120,000 episodes

Results

Steady environment with white noise



Changing environment with additional sine noise after 120,000 episodes



Summary and Future Work

- **Summary**:
  - We proposed a pronunciation adaptive spoken language acquisition agent using WaveGrad
  - The WaveGrad learning is embedded in the self-supervised learning approach
  - The agent can automatically adapt its pronunciation to a changing environment
- **Future work:**
  - Improve the sample efficiency of the pronunciation adaptation by introducing model adaptation techniques
  - Support multi-word utterances by extending observation and dialogue learnings

Spolacq toolkit: https://github.com/tttslab/spolacq