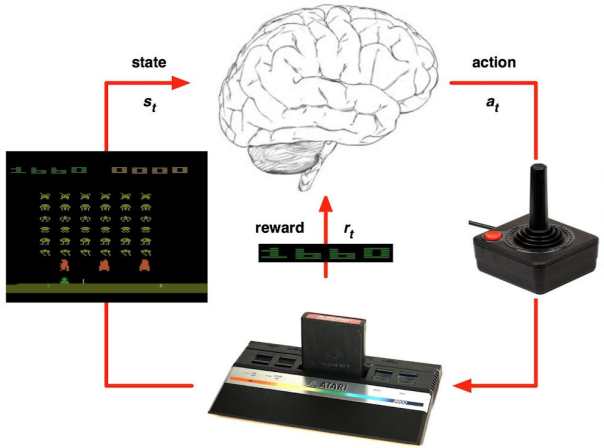


Deep Learning for Video Game Playing

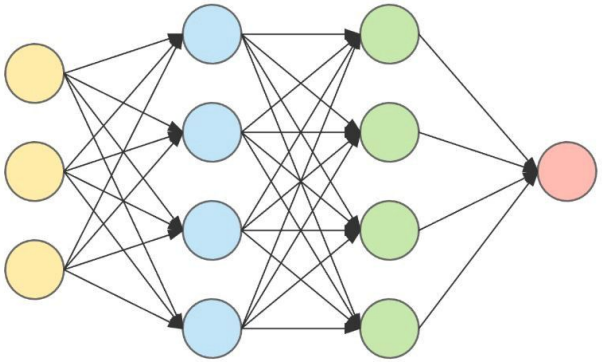
Authors: Niels Justesen, Philip Bontrager, Julian Togelius, Sebastian Risi

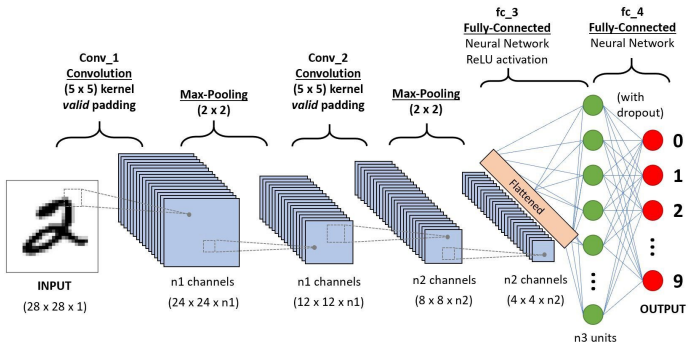
Presented by: Runsheng (Benson) Guo

Outline

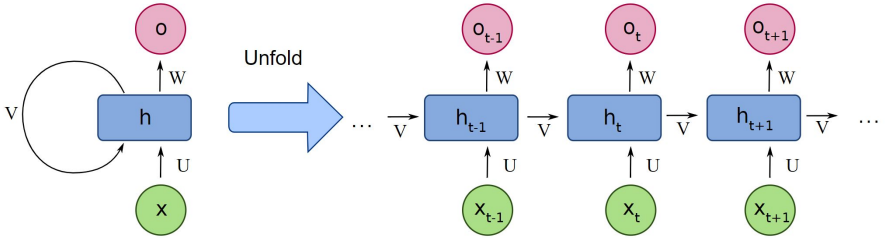
- Background
- Methods
- History
- Open Challenges
- Recent Advances

Background: Neural Networks





Convolutional Neural Network



Recurrent Neural Network

Background: Neural Network Optimization

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning
- Evolutionary Approaches
- Hybrid Learning Approaches

Methods

Platforms:

- Arcade Learning Environment (ALE)
- Retro Learning Environment (RLE)
- OpenAI Gym
- Many more!

Genres:

- Arcade Games
- Racing Games
- First-Person Shooters
- Open-World Games
- Real-Time Strategy
- Text Adventure Games

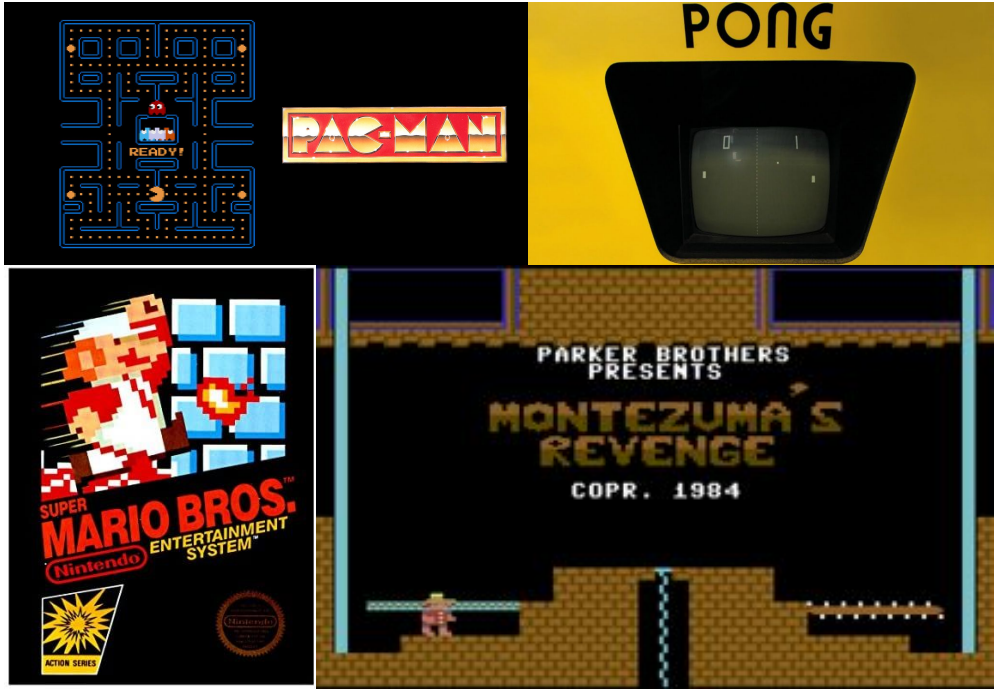
Methods: Arcade Games

Characteristics:

- 2-Dimensional Movement
- Continuous-time Actions

Challenges:

- Precise timing
- Environment navigation
- Long term planning



Methods: Arcade Games

Deep Q-Learning:

- Replay buffer, separate target network, recurrent layer
- Distributed DQN
- Double DQN
- Prioritized experience replay
- Dueling DQN
- NoisyNet DQN
- Rainbow

Actor-Critic:

- A3C
- IMPALA
- UNREAL

Methods: Arcade Games

Other Algorithms:

- Deep GA
- Frame prediction
- Hybrid reward architecture

Montezuma's Revenge:

- Very sparse rewards
- Hierarchical DQN
- Density models
- Text instructions

Methods: Racing Games

Characteristics:

- Minimize navigation time
- Continuous-time Actions

Challenges:

- Precise inputs
- Short & long term planning
- Adversarial planning

Methods: Racing Games

Paradigms:

- Behaviour reflex (sensors → action)
- Direct perception (sensors → environment information → action)

Algorithms:

- (Deep) Deterministic policy gradient
- A3C

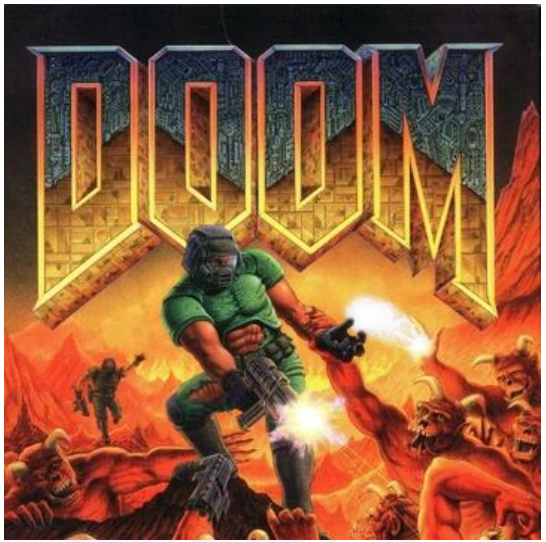
Methods: First-Person Shooters

Characteristics:

- 3-Dimensional Movement
- Player Interaction

Challenges:

- Fast reactions
- Predicting enemy actions
- Teamwork



QUAKE III
ARENA

Methods: First-Person Shooters

Algorithms:

- Deep Q-learning
- A3C
  - UNREAL
  - Reward shaping
  - Curriculum learning
- Direct future prediction
- Distill and transfer learning
- Intrinsic curiosity module

Methods: Open-World Games

Characteristics:

- Large world to explore
- No clear goals

Challenges:

- Setting meaningful goals
- Large action space

Methods: Open-World Games

Algorithms:

- Hierarchical deep reinforcement learning network
- Teacher-student curriculum learning
- Neural turing machines
  - Recurrent memory Q-network
  - Feedback recurrent memory Q-network

Methods: Real-Time Strategy

Characteristics:

- Control multiple units simultaneously
- Continuous-time Actions

Challenges:

- Long term planning
- Delayed rewards

Methods: Real-Time Strategy

Algorithms:

- Unit control
  - Zero order optimization
  - Independent Q-learning
  - A3C
    - Multiagent Bidirectionally-Coordinated Network
    - Counterfactual Multi-Agent
- Build order planning
  - Supervised learning
  - Reinforcement learning
    - Double DQN
    - Proximal Policy Optimization

Methods: Text Adventure Games

Characteristics:

- Text-only states & actions
- Choice, hyperlink & parser interfaces

Challenges:

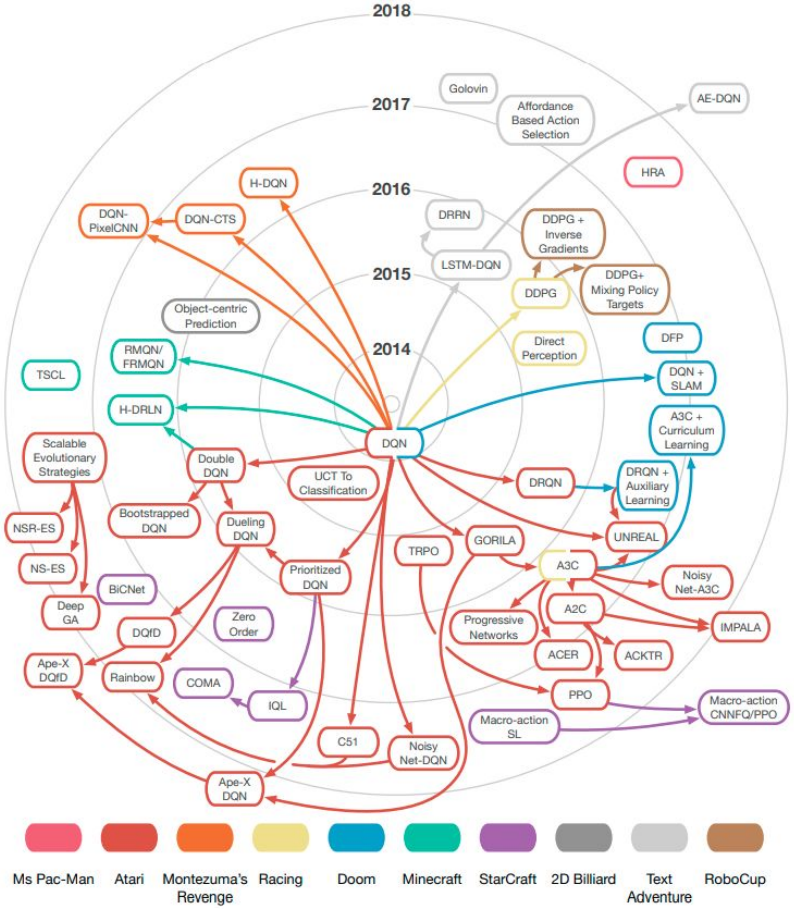
- Natural language processing
- Large action space

Methods: Text Adventure Games

Algorithms:

- LSTM-DQN
- Deep Reinforcement Relevance Net
- State affordances
- Action elimination network

History



Trends:

- Incremental extensions
  - DQN
  - A3C
- Parallelization
  - A3C
  - Evolutionary algorithms

Open Challenges

- Agent modelling
  - General game playing
  - Human-like behaviour
  - Delayed/sparse rewards, multi-agent learning, dealing with large action spaces
- Game industry Adoption
- Developing model-based algorithms
- Improving computational efficiency

Conclusion

Recent Advances:

- Model-Based Reinforcement Learning for Atari (Kaiser et al, 2019)
- AlphaStar (DeepMind, 2019)
- OpenAI Five (OpenAI, 2019)

Future Work:

- Survey focusing on a single class of deep learning algorithms
- Survey focusing on a single genre of video games