Leveraging World Models in RL for Circuit Design Optimisation

R244: Large Scale Data Processing and Optimization
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Background

- Circuit design: arrange electronic components to form a functional and optimized circuit.
- It is critical to create efficient and powerful computer systems.
- However, it is an intricate and time-consuming process, often requiring extensive human expertise and iteration.
- **Solution:** Reinforcement Learning (RL) lets systems learn optimal behaviors by trial and error, automating and enhancing circuit design.
- **New Approach:** Experiment with World Models in the RL pipeline, enhancing an agent's ability to make informed decisions.
World Models (1/2)

- Inspired by how humans develop mental models of the world, understand and predict the environment using limited sensory input.
- Agent will benefit from abstract space and time representations.
- Predictive model of future = better experience-based decision-making
- World Models have 2 main components:
  - Vision model (V) = Variational Autoencoder to encode observations
  - Memory model (M) = Recurrent Neural Network for predictions
def rollout(controller):
    """env, rnn, vae are """
    """global variables """
    obs = env.reset()
    h = rnn.initial_state()
    done = False
    cumulative_reward = 0
    while not done:
        z = vae.encode(obs)
        a = controller.action([z, h])
        obs, reward, done = env.step(a)
        cumulative_reward += reward
        h = rnn.forward([a, z, h])
    return cumulative_reward

Figure 2: Flow diagram showing how V, M, and C interacts with the environment (left). Pseudocode for how our agent model is used in the OpenAI Gym [5] environment (right).

Figure 1: We build probabilistic generative models of OpenAI Gym [5] environments. These models can mimic the actual environments (left). We test trained policies in the actual environments (right).
• Open-source platform to experiment with RL for computer systems.
• Abstracts away the complexity of running experiments in real systems.
• Support 12 different computer system environments:
  • Switch Scheduling
  • Server Load Balancing
  • Adaptive video streaming
  • Circuit design
  • ...
Contribution

• State-of-the-art models for RL in circuit design uses Graph Convolutional Neural Networks.
• Apply World Models to circuit design problems.
• VAE to encode circuit schematics into compact latent variables.
• RNN to predict how latent space changes given component tweaks.
• Output fed to evolutionary control network (decision-making).
Expected Results

• World models able to accurately emulate circuit simulations in training.
• Evolution finds competitive policies using learnt model.
• Hopefully: outperform black-box Bayesian Optimisation in same or smaller amount of number of steps.
• Leverage Park’s standardized benchmarks to compare techniques.
Progress

• Literature review, both on current approaches to optimizing circuit design and implementations of World Models.

• Explored Park’s documentation and existing benchmarks.

• To Do:
  • Implementation + Evaluation
  • If given the time, try combine GCNN with World Model or/and expand the Controller model beyond a simple evolution-based optimization strategy.
  • Write up.