Research Proposal for Bachelor Thesis Simulating the Double Slit Experiment Using Propagating Neural Cellular Automata

1 Introdcution

The double slit experiment is a classic demonstration of the wave-particle duality of light and has been an important topic of study in quantum mechanics. The purpose of this project would be to explore the possibility of simulating this experiment through the modeling of "wavelike" cellular automata (CA) with Convolutional Neural Networks (CNNs).

2 Goals

- Investigate the feasibility of using CNNs to model wavelike cellular automata.
- Developing a CNN-based model that recreates the interference pattern of self-propagating cellular automata waves.
- Exploring the relationship between CNNs and cellular automata and their potential to simulate wave-like behavior.

The successful completion of this thesis will result in a new computational approach to simulating the double slit experiment, using the latest advances in machine learning, and cellular automata theory. This will provide insight into the wave-particle duality and open up new avenues for future research in quantum mechanics.

3 Related Work

Waves and CA

The main underlying idea that CA can show wavelike properties has already been discussed in the scientific literature:

Isotropic wave-like behavior in CA has already been established here Cole et al. [1993] and here Makarenko et al. [2022a].
The behaviour also emerges intrinsically via a propagation rule that allows for the creation of a branched multiway graph as seen here URL. I also discovered that this idea was already discussed and shown to uphold here Makarenko et al. [2022b] thus giving scientific merit.

Machine Learning

There exists a close connection between CNNs and CA Gilpin [2019]. Another related paper where machine learning is combined with CA and builds the practical foundation for my approach: IMordvintsev et al. [2022] that works on 2-d cellular automata with CNNs.
So in a sense, the novelty is that the CNNs would learn wave-like behaviour similar to how it learned to regrow in the aforementioned paper. The idea is to modify these growing neural CA such that they behave like waves when the limit of their classical particle size goes to zero.

4 Approach

I would start by reviewing the existing work on wave-like cellular automata and their behavior. The second step will involve developing a proof of concept model of a 2-D cellular automata simulation using CNNs, based on the approach presented in the aforementioned "Growing CA" paper Mordvintsev et al. [2022]. The final step will involve modifying the model to recreate the interference pattern of self-propagating waves, similar to the double slit experiment.

The proposed approach has the potential to provide a new and innovative perspective on the wave-particle duality, making a potentially relevant contribution to the field of machine learning or physics. Before I work out a more detailed proposal or a proof of concept I just wanted to check if this topic even comes into question or needs to be modified to be considered. Thank you for your consideration.

References

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