



AI Implementation in Digital Micro Fluidics

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Introduction:

Digital Micro Fluidics (DMF) is a technology which allows a grid to manipulate liquid using electric diodes which pull droplets on surrounding grid points to it. While this can be controlled manually, it would be very beneficial to automate the process. There are many challenging factors that arise in a DMF environment, such as droplets needing to avoid each other and some needing to be mixed. This constantly changing environment makes it a possible candidate for applying self learning AI that can easily adapt to the different conflicts that could occur. The specific type of self learning AI that was chosen was reinforcement learning AI, which chooses the most fit neural net (the one that receives the highest reward) to be evolved in the next iterations. This process is very similar to biological evolution.

Goal:

How can self learning AI be applied to DMF Grids? For this portion of research, the ability for an AI to route one droplet to a spot without colliding with an obstacle was it's focus.

Methodology:

In order to train the AI, the software Tensorflow, Keras, and OpenAI Gym were used in conjunction with the Python programming language. These programs assisted in creating an environment which emulated a DMF grid. These programs were also used to interface the neural net with the emulation, allowing it turn grid points on and off and observe the state that the grid is in. The AI was trained and its average reward over the course of an interval (10,000 simulation steps), was recorded and graphed.



Figure 1

Results:

The results obtained from this research are graphed below (Figure 1). While it shows a quick increase in reward, signifying that the AI is improving, it plateaus afterwards, showing that improvement has slowed down. While this may mean that the AI is no longer improving, it could also be that it needs more training to get over a specific problem it has run into.

Conclusion:

While the results obtained weren't exactly desired, there is further research to be done to get a better conclusion on whether this implementation of AI is effective or not, the early results of the research show that the AI has learned, but it is still not known how much the AI will evolve after that first jump. There are multiple areas which could be observed further to get a better idea of why the AI had stopped improving.

Further Research:

For further research, an expansion into having more droplets on the grid would be beneficial, as most likely, in a DMF grid, there will be multiple droplets at once moving around. Another expansion that would be good is to add in mixing of droplets, as that is a key feature of what sets DMF apart from other technologies. There is still much more work that can be done with this as DMF evolves and new techniques and uses come out that could all be researched on.