Inducing Unpredictable Behavior in a Walking Fly by Destroying Neurons in Its Neural Network

Masaki Hayashi
Department of Game Design
Faculty of Arts
Uppsala University
Visby, Sweden
masaki.hayashi@speldesign.uu.se

***Abstract*— The rise of AI technology, especially neural networks, has earned significant attention as a powerful tool capable of solving a wide range of problems. However, I am intrigued by the idea of utilizing neural networks in a less practical direction. Specifically, I aim to simulate the aimless walk of a fly on a window glass using a neural network. Instead of relying on random values, I have implemented a technique called "neurodrug" where I deliberately destroy neurons in a neural network to generate unpredictable behaviors. Through this experiment, I delve into philosophical questions related to purpose, decision-making, randomness, motivation, intelligence, and instinct.**

Keywords—AI, neural network, simulation, artificial life

I. INTRODUCTION

AI technology based on neural networks has been dominating the headlines, especially in recent times. It is undeniable that AI technology serves as a solution for a wide range of problems. Notably, platforms like ChatGPT, Midjourney, and numerous others have captivated individuals by utilizing AI to respond to queries, generate images from verbal instructions, and provide solutions to a wide range of issues. These services quickly gained global attention and became the subject of numerous discussions. However, here, I would like to present a different problem, possibly in the opposite direction of the current trending AI, and report on an experiment I conducted.

For several years now, I have been focusing on how intentionally destroying neurons in a neural network (NN) trained with meaningful data causes the output results of that NN to behave in various "crazy" ways [1]. I named this technique *neurodrug*. I have applied this method to generate unpredictable, "crazy" drum beats and character animations interactively by introducing destruction to neural networks designed for specific actions, aiming to use it for slapstick content generation.

In this pursuit, I embarked on a challenge to tackle a specific problem using the *neurodrug* technique. The problem involves creating the movement of a single fly casually walking on a glass window, which may seem terrifyingly mundane. By using *neurodrug* to generate the aimless movement of the fly, I intend to delve into various philosophical questions such as purpose, decision-making, randomness, motivation, intelligence, and instinct.

II. WHEN WILL THE WALKING FLY STOP?

I like to observe a small insect crawling on a glass window or wall. Unless there is something particularly noteworthy in its surrounding, it walks aimlessly. It walks for a while, stops, changes direction after some time, and then starts walking again. Sometimes, it remains motionless for a while.

Let's focus on a fly as an example of an insect. Now, considering a fly walking on a glass window, when will it stop? Will it stop after moving 1 centimeter, 2 centimeters, 10 centimeters, or only when it collides with the window frame? In the absence of obstacles or stimuli like food in the surroundings, it becomes unpredictable. Even if it were to stop at 5 centimeters, the question arises: why specifically 5 centimeters?

From the perspective of artificially generating the fly's movement, one might assume that setting the walking distance randomly would make it appear realistic. Alternatively, a Gaussian distribution centered around 5 centimeters could be used. Alternatively, a more sophisticated approach could involve assuming the internal energy of the fly, which decreases as it walks, and it stops to rest once it exceeds a certain threshold.

However, even when considering the generation process of movement, there would invariably be some introduction of random elements. If we were to write a computer program to simulate the walking of a fly, it would require calls to a random number generation function. Performing this walking simulation on a computer is relatively straightforward, and the resulting fly movement would appear remarkably authentic.

However, what about the real fly? If randomness is necessary, does a fly have a random number generator somewhere? Let's assume that it's the fly's small brain that controls its movements. In that case, if there is something that exhibits random behavior, it would likely be the chemical reactions in the brain cells. In reality, the behavior of brain cells is entirely analog and is carried out through complex chemical reactions. In computer neural networks, this process is simplified by utilizing sigmoid functions to determine firing and non-firing. However, the behavior of actual neurons in the brain is significantly more intricate and enveloped in mystery. And within this intricate analog process, wouldn't it be possible for random elements, which are currently under discussion, to come into play?

Based on these assumptions, this paper presents a simple attempt using a computer neural network.

III. FLY SIMULATION WITH NEURODRUG

Based on the approach submitted in Chapter 2, I attempted to simulate the walking of a fly on a computer. It's important to note that my goal is not to mimic the movement of a real fly more accurately. Once we gather the movement of real flies, modeling it through feedforward techniques is relatively straightforward, and it's neither novel nor interesting. Instead, I intend to simulate the movement in a completely different way, diverging from modeling the fly's actual motion.

Through this, I aim to demonstrate the ability to observe phenomena in the realm of real-life organisms from a completely different perspective.

Now, the approach is simple: I employed the neurodrug technique described in Chapter 1. This technique is achieved by deliberately manipulating the sigmoid function of the neural network's neurons from external sources. In this case, I used a recurrent neural network (RNN) suitable for handling temporal sequences, trained it on the fly's walking, and made the fly walk according to what it learned. Furthermore, in real-time and interactively, I destructively manipulate the neurons, eliciting unpredictable movements from the fly.

The RNN used in this study is depicted in Fig. 1. The input consists of a single input indicating whether the fly is currently walking or stopped. The hidden layer consists of a single layer with 20 nodes, and the output consists of five output nodes: indicating whether to continue walking, stop, and the direction to move when starting to walk. Training data was created with a pattern of stopping for 2 rounds and walking for 10 rounds, and the model was trained on this data. After training, by simply providing the current status as input, the fly walks aimlessly according to what it has learned.

During the execution of this learned movement, the sigmoid functions of these hidden layer nodes are dynamically controlled in real-time by multiplying coefficients. In other words, the threshold of determining firing is adjusted. The location within the hidden layer, the range of manipulation, and the extent of manipulation can be set in real-time using three sliders. The experimental results of the fly's movement created in this way are shown in Fig. 2. I have provided a video below showcasing the experiment.

https://youtu.be/vnk3LLEqBjM

IV. Philosophical Meaning

So, what does this humble attempt signify?

Firstly, it is well observed that when organisms are subjected to some form of external stimulation, they react in response to the stimulus. For instance, they flee when poked or approach when there is food available. These actions are driven by clear purposes or motivations.

On the other hand, the behavior of organisms when they are not being stimulated remains a mystery. When organisms lack purpose or motivation, it is commonly assumed that they randomly engage in actions based on chance. Moreover, it is typical not to even consider the unproductive state of such organisms as a matter of concern.

However, is that sufficient? In reality, I find the behavior of organisms in that unproductive state to be more important. Thus, in the previous chapter's experiment, I attempted to create the random movements of a fly by manipulating the sigmoid function of the NN. So, what specifically was this neuron manipulation simulating?

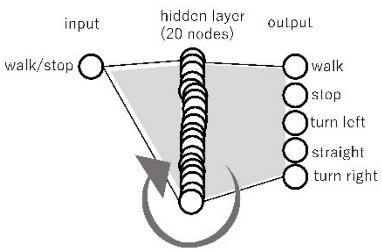

Fig. 1.
RNN used to simulate the movement of a fly.

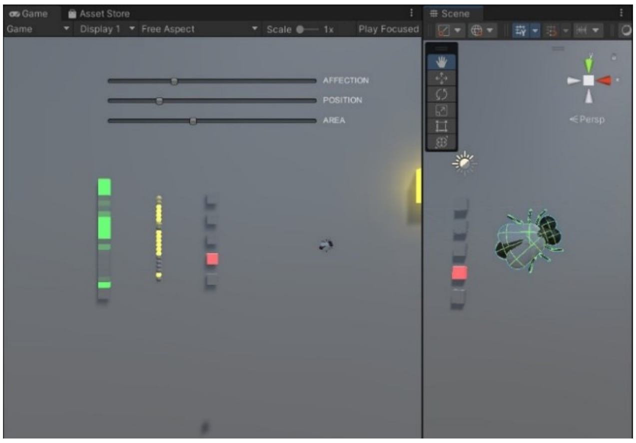

Fig. 2. A walking fly in the Unity Game Engine. The center-left section displays neuron firing, while the upper three sliders allow for controlling the manipulation of neuron destruction.

At the end of Chapter 2, I presented a hypothesis regarding what occurs in the brain of a real fly. This attempt aligns with that hypothesis. In other words, it explores the possibility of generating random behavior by simulating the interaction between the bodily fluid surrounding the neural cells responsible for fly locomotion and the neural cell circuitry.

Through this experiment, it was demonstrated that it is plausible for this assumption to produce fly-like movements. If this assumption holds validity, it can be inferred that these analog fluid dynamics manifest as phenomena influenced by the entire physicality of the fly's body and its external environment, such as temperature and humidity, etc. It is possible that the vast analog fluctuations present in the world physically affect the neurons in the fly's brain, giving rise to seemingly random movements.

Following philosopher Henri Bergson's idea that "Intellect designates the totality of the material interconnections in the world, and instinct emerges from the sense of being both a part of the world and a constituent of the world" [2] we can perceive this attempt as an endeavor to simulate that "instinct."

V. Future

In this experiment, I control a neural network (NN) that has learned the walking pattern of a fly using three sliders. The key point is that I achieve the seemingly random fly movement without using a random number generator. The movements I manually apply through the sliders are based on some intention. However, the intended manipulations ultimately generate the fly's walking pattern in an unexpected, random-looking manner.

The next important step is to connect the manipulation of these neurons to the environment, not through manual sliders. I plan to directly manipulate the neurons using analog environmental factors such as temperature, humidity, light, and other sensing data.

There is no specific "useful" purpose to this work. It is meant to experience the mysteries of life, as discussed in the previous chapter, regarding instinct and intelligence.

References

[1] Masaki Hayashi. "Neurodrug: Slapstick Effects by Destroying Neurons in a Neural Network." 2018 IEEE 7th GCCE. IEEE, 2018.

[2] Henri Bergson, Creative Evolution (1911) tr. Arthur Mitchell, Henry Holt and Company