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Sex as an algorithm The Theory of Evolution Under the Lens of Computation

Motivation

After near century of research and scientists trying to understand sex and its role in evolution, its purpose remains shrouded in mystery. Nearly every living organism takes part in sexual reproduction and very few organisms are asexual. Scientists are baffled as to why this is the case. Asexual reproduction produces the most fit alleles whereas sexual reproduction does not, but rather the best “average” population. As other questions about evolution would slowly be unraveled and eventually explained sex remained as confusing and difficult to explain as trying to answer the question “Which came first, the chicken or the egg?”. By understanding sex’s role in evolution, we get one step closer to understanding nature and how it works.

Problem Statement

In Livnat’s and Papadimitriou’s article “Sex as an Algorithm The Theory of Evolution Under the Lens of Computation”, they tackle multiple questions surrounding sex, evolution, and mutations. While they try to answer questions such as “What is evolution optimizing exactly, if anything?”, and “Are mutations really random?”, the main question that Livnat and Papadimitriou’s article tries to answer is “What is the role of sex in evolution?”.

Approach

By reading the article, Livnat and Papadimitriou clearly do different approaches when trying to answer each of the questions proposed in their article. For their main question, they take a mathematical approach. Their approach was by taking the equation that reconciled Darwin and Mendel's theories and findings of evolution and algebraically manipulating that equation until they found something very familiar, which in this case was the multiplicative weights update algorithm which is used in neural networks. For their other questions that they posed, they took a more logical approach by using current understandings of evolution and challenging them a little bit in hopes to guide the discussion and search for answers in a different direction.

Results

The main takeaways that should be noted when reading the article are the following: one is that sex's role in evolution is to behave as either a randomized algorithm, or a host for a coordination game between alleles where the learning strategy to reach equilibrium is the exact same if not is very similar to a function called the Multiplicative Weights Update Algorithm. It should be noted as well that mutations may not be truly random but more probabilistic. As such, using this probabilistic idea, mutations may be using this information of biased randomization to better choose a mutation down into the future. Or in other words, sex may be allowing mutations to process and transmit information of genetic combinations into the future.

Related Work and Background Material

To understand this magazine article better, it is best to understand the algorithm that is described in their magazine article, the Multiplicative Weights Update Algorithm. The Multiplicative

Weights Update Algorithm is a general name for a broad class of methods for decision making in game theory. While all variations of this algorithm do have the decisionmaker make choices that were more successful in previous rounds in the game, the algorithm does not lend itself to any Nash equilibrium of the games that it gets used in.

After these findings there has been a paper done that backs up their findings however with more of a mathematical proof behind their findings. Reshef Meir's and David Parkes's research paper "On Sex, Evolution, and the Multiplicative Weights Update". What they found is that while yes, the algorithm strongly correlates with population dynamics, the algorithm itself is not the main contributing factor but rather an accurate description and depiction of the behavior sex plays in evolution.

Conclusion and Future Work Directions:

What Livnat's and Papadimitriou's article "Sex as an Algorithm The Theory of Evolution Under the Lens of Computation" tries to answer is the answer what sex's role in evolution is, what evolution is trying to optimize, and whether mutations are truly random. What they discover is that sex can be seen in two ways: One way is that it is playing a coordination game with alleles using the Multiplicative Weights Update Algorithm, or as a randomized algorithm. Mutations may not be entirely random, and mutations may be communicating with other mutations in the future. By algebraically manipulating Mendel and Darwin equation they were able to make such a breakthrough discovery.

While this reading was quite fascinating, much of it was difficult to parse through. A main problem we had was time management, or lack thereof. What could have been done was a more careful and thorough reading of it and reading more secondary sources that covered this article.

Perhaps a better note taking strategy could have been implemented to better prepare and deliver the ideas presented in the magazine article. Better time management is quite in order if we were to present this project again. If we were to do this project again, a better use of time management by using that time to better prepare the slides, communicate better with each other and rehearse what would be discussed during the presentation. As the presentation for this project was done by and articulated by Joe Luna, the changes that he would immediately perform if he were to do it again would be better preparation to present, much better time management with less words on the slides, and with more comprehensive articles relating to the work.