Adding Genomic Complexity And Multi-level Selection
Lab Assignments: 35% (ISE-483), 25% (SSIE-583)
- Complete 4/5 assignments based on algorithms presented in class
  - Lab 4: April 12th (Wednesday after Spring break)
    - Evolutionary Algorithms, (Lab 4 in Brightspace Assignments)
    - Due April 24th
  - Lab 5: May 1st
    - Ant Clustering Algorithm, (Lab 5 in Brightspace Assignments)
    - Due May 8th

SSIE – 583 - Presentation and Discussion: 35%
- Present and lead the discussion of an article related to the class materials
  - Enginet students post/send video or join by Zoom
- All presentations completed?
readings
until now

- **Class Book**
    - Chapters 1 and 4.

- **Lecture notes**
  - Chapter 1: What is Life?
  - Chapter 2: The logical Mechanisms of Life
  - Chapter 3: Formalizing and Modeling the World
  - Chapter 4: Self-Organization and Emergent Complex Behavior
  - Chapter 5: Reality is Stranger than Fiction
  - Chapter 6: Von Neumann and Natural Selection
    - posted online @ http://informatics.indiana.edu/rocha/i-bic

- **Papers and other materials**
  - Optional
      - Chapter 2, 7, 8
      - Chapter 3, sections 3.1 to 3.5
      - Chapters 10, 11, 14 – Dynamics, Attractors and chaos
      - Chapter 20
Projects

- Due by **May 8th 12th** in Brightspace, “Final Project Paper” assignment
  - ALIFE 2023
    - Not to submit to actual conference due date (March 13th)
    - [https://2023.alife.org/](https://2023.alife.org/)
    - 8 pages, author guidelines:
      - [calls/call-for-papers-extended-abstracts](https://2023.alife.org/calls/call-for-papers-extended-abstracts)
      - MS Word and Latex/Overleaf templates
  - Preliminary ideas by **March 27**
    - Submit to “Project Idea” assignment in Brightspace.
- Individual or group
  - With very definite tasks assigned per member of group

ALIFE 2023

Tackle a real problem using bio-inspired algorithms, such as those used in the labs.
artificial genotype/phenotype mapping

Search algorithms based on the mechanics of Natural Selection
Based on distinction between a machine and a description of a machine
Solution alternatives for optimization problems

Traditional Genetic Algorithm

Genotype

Variation

Selection

Phenotype

Genotype

DNA

RNA

transcription

selection

amino acid chains

development

environmental ramifications

phenotype

organism

Inherited variation

Solution alternatives for optimization problems based on the mechanics of Natural Selection. Based on the distinction between a machine and a description of a machine, these algorithms offer solution alternatives for optimization problems.
artificial genotype/phenotype mapping

Search algorithms based on the mechanics of Natural Selection
Based on distinction between a machine and a description of a machine
Solution alternatives for optimization problems

Traditional Genetic Algorithm

Genotype

Variation

Phenotype

Much more complex!

Search algorithms based on the mechanics of Natural Selection
Based on distinction between a machine and a description of a machine
Solution alternatives for optimization problems
RNA Editing: post-transcriptional alteration of genetic information
- can be performed by ncRNA structures and proteins (i.e. enzyme cascades).
- U-Insertion/deletion RNA Editing (mitochondria of kinetoplastid protozoa)
  - Involve small guide RNAs (gRNA) complementary to the target mRNA, and editosome (multi-protein complex)
    - gRNA is a template for editing
  - insertion/deletion of Uracil (U) residues, usually in coding regions of mRNA transcripts
    - e.g. creation of open reading frames

Including transcription regulation and translation

RNA Editing

Ser    Gly    Glu    Lys
AuGuuuCGuuGuaAuuuAuuAuuuuAuuA
MerPhe Arg Cys Arg Phe Leu Leu Phe Phe Leu Leu

Gln    Glu    Gly    Arg    Gly    Lys
CAGGAGGGCCGUGGAuAAG
Gln    Glu    Gly    Arg    Gly    STOP

is there a **general principle** at play?
Agent-based models of evolutionary dynamics

RNA Editing

Agent-based models of evolutionary dynamics

RNA Editing

**Simple fitness function**

$$F(x) = \sum_{s_i \in S} c_i \sigma_{s_i}(x)$$

- **Miniature of "Royal Road" function (Forrest and Mitchell, 1993)**
  - Schemata $S = (s_1, ..., s_8)$
  - $c_i$ is a value assigned to each schema $s_i$
  - $\sigma_{s_i}(x) = 1$ if $x$ is an instance of $s_i$ and 0 otherwise
  - Fitness of the global optimum string (40 1's) is $10 \times 8 = 80$
Simple example

50 runs for small royal road testbed
De Jong F3 function
example run: Schwefel function
Agent-based models of RNA Editing

ABMGE on oscillatory fitness landscapes

Agent-based models of RNA Editing

ABMGE on dynamical environments

Genomic complexity and multi-level selection

Multi-level complexity

Landscape

Patchwork of regimes

Niches (novelty)

selection between groups within a population

selection between individuals within a group

selection between genes within an individual
altruism and selection

uniﬁed selection

Moral men might not do any better than immoral men but tribes of moral men would certainly “have an immense advantage” over fractious bands of pirates. (Charles Darwin)

- Multilevel selection theory
  - Selection occurs in multiple levels simultaneously
  - No general-case scenario, each organism on a case-by-case basis
    - David Wilson and E.O. Wilson
- Experiments with *Pseudonas ﬂuorescens*
  - Oxygen-exhausting bacteria in liquid
  - Groups with enough altruists survive
- Kin-selection as special case of group selection
  - Leading to various, diverse (selectable) groups with high genetic similarity
- Sociobiology
  - Selfishness beats altruism within groups. Altruistic groups beat selﬁsh groups.

“Morality is herd instinct in the individual”. (Friedrich Nietzsche)
altruism and selection


"Morality is herd instinct in the individual." (Friedrich Nietzsche)

moral men might not do any better than immoral men but tribes of moral men would certainly "have an immense advantage" over fractious bands of pirates. (Charles Darwin)

Sci. American, Jan 2009 (Steve Mirsky)
**Class Book**
  - Chapter 7

**Lecture notes**
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- Chapter 5: Reality is Stranger than Fiction
- Chapter 6: Von Neumann and Natural Selection
  - posted online @ casci.binghamton.edu/academics/i-bic

**Papers and other materials**
- Optional
    - Chapter 5, 7.7, 8.3.1, 8.3.6,