LA-UR-18-20769
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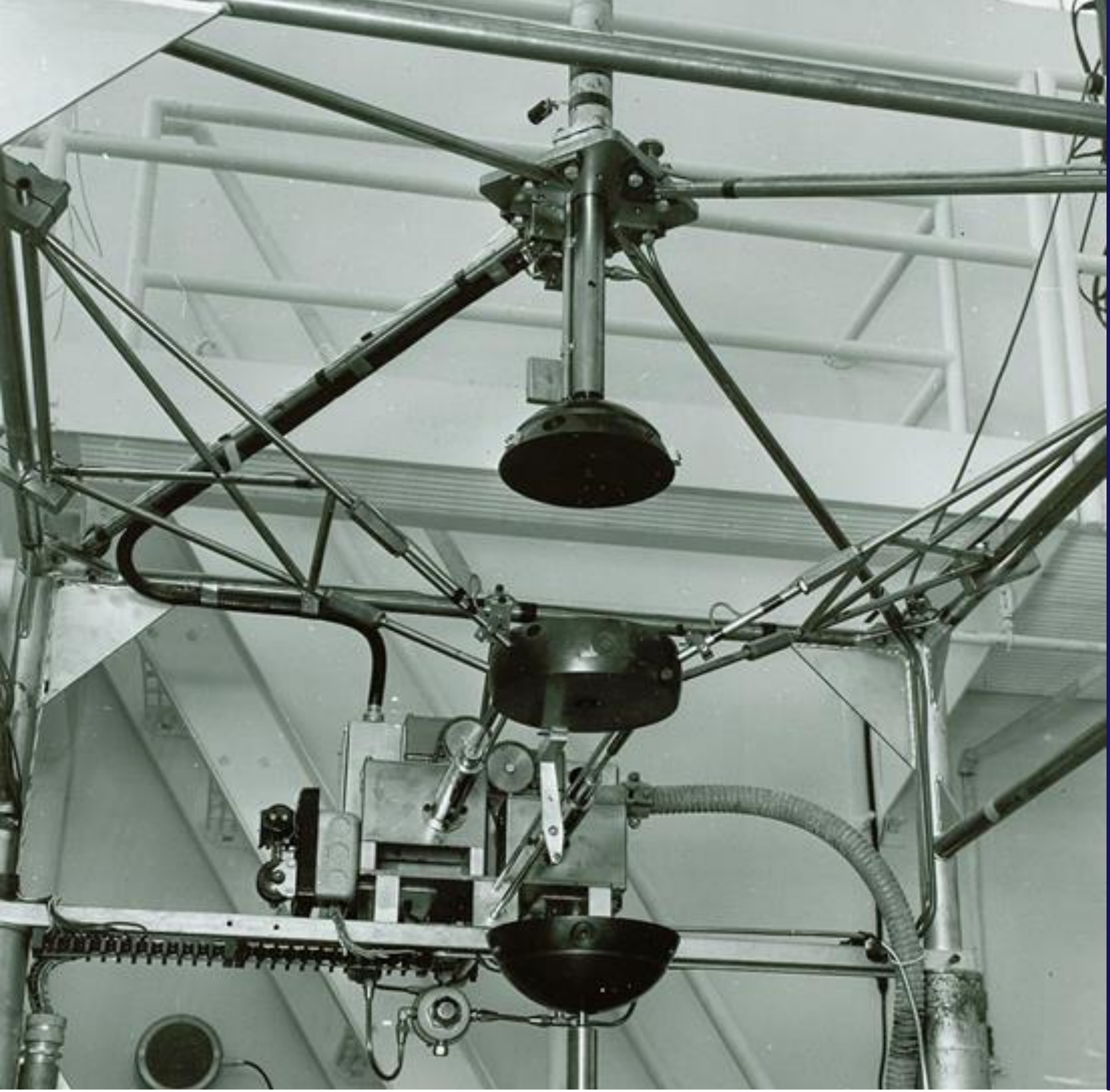
Title: Genetic algorithm for nuclear data evaluation

Author(s): Arthur, Jennifer Ann

Intended for: Research group meeting

Issued: 2018-02-02



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Genetic algorithm for nuclear data evaluation

Jennifer Arthur

Initial population

- **Normally sample μ, σ using uncertainties around the mean N times**
- $$P = \begin{bmatrix} \mu_1, \sigma_1 \\ \mu_2, \sigma_2 \\ \dots \\ \mu_N, \sigma_N \end{bmatrix}$$
- **Each row of P is a member in the population**
  - There are N members total in the population

Fitness (outer loop)

- **Ideal is fitness=0**
- $\boldsymbol{FF = \sum \frac{C-E}{E}}$ **, summed over all configurations of all experiments**
- **Each member of the population has a value of FF (fitness function) assigned to it**
- **Convergence criteria is that min(FF), which is associated with the most fit member of the population, stops changing more than a certain amount (i.e., 1%)**
  - This means that the fittest member of the population is not getting much more fit from generation to generation

Calculate fitness

- **My proposed method:**
- **Input original (C-E)/E values and original μ, σ values**
- **Also input sensitivities such as:** $\frac{d\left(\frac{C-E}{E}\right)_{R_1}}{d\mu}$
    - These sensitivities are each specific to a single configuration of a single experiment

Selection (1st part of inner loop)

- **N times, pick 2 parents and have them reproduce**
  - This creates the next generation of N members
  - There is no limit to how many times a single member can be a parent
- **Pick random # between min(FF) and max(FF)**
  - I.e., the # can be anywhere from the FF value of the most fit member of the population to the FF value of the least fit member of the population
- **1st 2 members that have FF<=random # are the parents**
  - After randomizing population vector of course
- **This makes it so that more fit members of the population are more likely to be chosen, but even members with the worst fitness still have a chance to reproduce**

Reproduction (2nd part of inner loop)

- **Crossover with mutation probability**
- **Reproduce by averaging the μ and σ values of each of the parent pairs chosen in the selection step**
- **Each time an average is taking, there is a 1% chance that a random value is picked instead of the average**
    - Random value (“mutated” value) is generated the same way the initial population was generated

Solution

- The optimized solution is the member of the population that has the minimum (best) value of FF at the time of convergence of the minimum value of FF

Example

- **N=100**
- **Using real μ, μ unc., σ, σ unc., and (C-E)/E inputs**
- **Made-up sensitivities (of (C-E)/E values to a change of a single unc.):**
  - R_1 to μ : .01
  - R_2 to μ : .001
  - M_L to μ : .001
  - R_1 to σ : .001
  - R_2 to σ : .01
  - M_L to σ : .01

  Mutation rate: 10%

  Convergence criteria: .1%

Example

- **Original FF=1.8144**
  - Original nuclear data: 3.182, 4.098
- **New FF=1.2742**
  - New nuclear data: 3.1815, 4.0795