Editing as an Evolutionary Algorithm: Selection and Exploration

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A modern manufacturing dilemma

John Deere makes tractors, planters, and lots more

The manufacturing complexity is now overwhelming ... thousands of products... billions of possible combinations...

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Problems in mid to late 1980s

In trying to fill hundreds of custom orders each day, John Deere engineers faced:

- Horrific traffic jams in the plant
- Machines in demand at more than one place at a time
- Others remaining idle with nothing to do

What to do?

Engineers couldn't find efficient production schedules, what to build, in which order.

But eventually, Bill Fulkerson had a creative idea: what's more intelligent than the human brain?

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Answer: Evolution

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Evolution: “descent with modification”

- a messy process, depends on selection and exploration

Can evolution be used to design

... manufacturing schedules?

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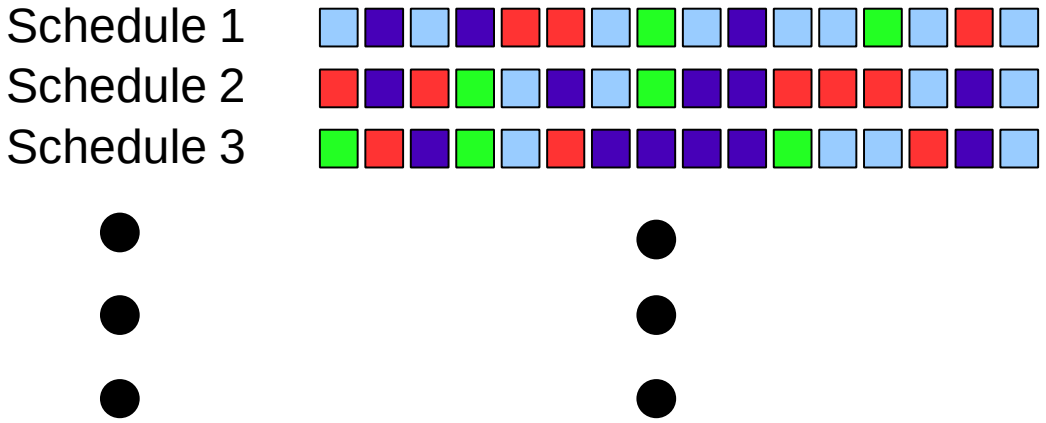
Start with a “population” of random schedules

Make tractor Make planter Make ?? Maintain machines



None of these will be any good, but let them evolve...

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Use computation to let the population

EVOLVE

one generation to the next

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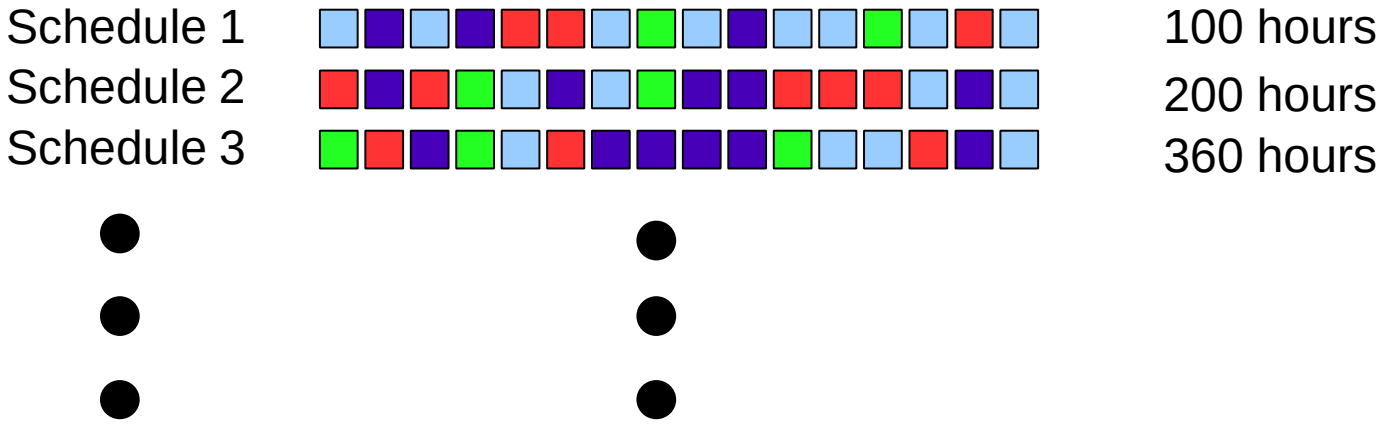
Calculate the “fitness” of each schedule..

faster means fitter



Let SELECTION act: fitter schedules have more offspring in the next generation

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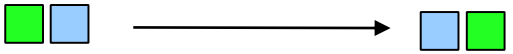
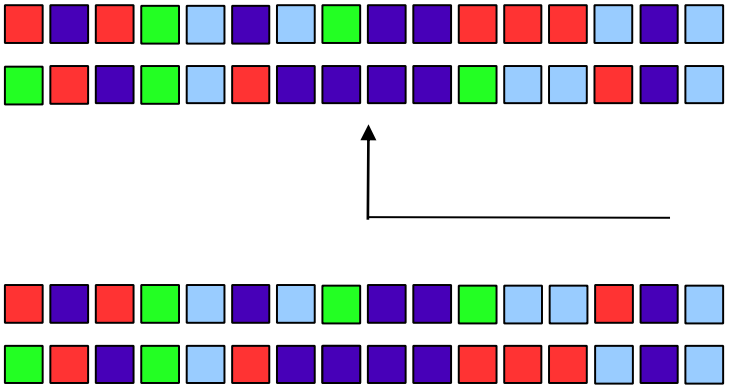
Also include EXPLORATION

- Allow some point mutations:



- Allow “sexual recombination” through crossover:



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Use computation to let the population

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Results?

- Early on, all schedules perform poorly
- After evolution overnight, some schedules outperformed *anything* the engineers could design by 50%
- They work -- but NO ONE really understands why!!

Evolutionary computing

is now applied to:

- aircraft design
- X-ray image interpretation
- drug discovery, etc.

selection + exploration + iteration

=

A powerful and completely random procedure for finding solutions to complex problems

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Now key to fusion energy research:

The Blind Implosion-Maker - Automated Inertial Confinement Fusion experiment design

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The design of inertial confinement fusion experiments, alongside improving the development of energy density physics theory and experimental methods, is one of the key challenges in the quest for nuclear fusion as a viable energy source[1]. Recent challenges in achieving a high-yield implosion at the National Ignition Facility (NIF) have led to new interest in considering a much wider design parameter space than normally studied[2]. Here we report an algorithmic approach that can produce reasonable ICF designs with minimal assumptions. In particular we use the genetic algorithm metaheuristic, in which 'populations' of implosions are simulated, the design of capsule is described by a 'genome', natural selection removes poor designs, high quality designs are 'mated' with each other based on their yield, and designs undergo 'mutations' to introduce new ideas. We show that it takes $\sim 5 \times 10^4$ simulations for the algorithm to find an original NIF design. We also link this method to other parts of the design process and look towards a completely automated ICF experiment design process - changing ICF from an experiment design problem to an algorithm design problem.

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Like evolution, writing is also a messy, iterative process

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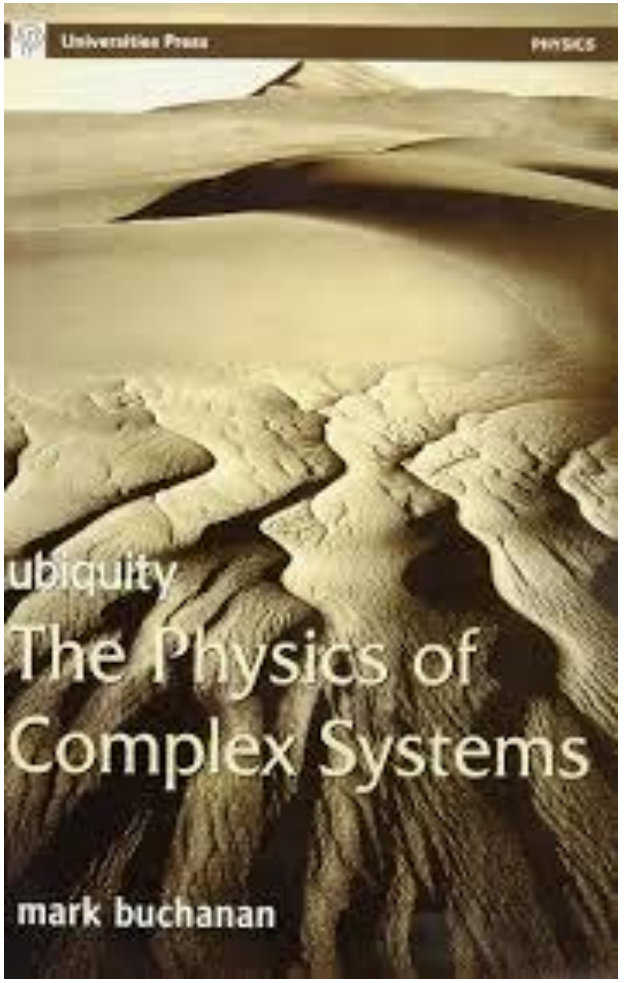

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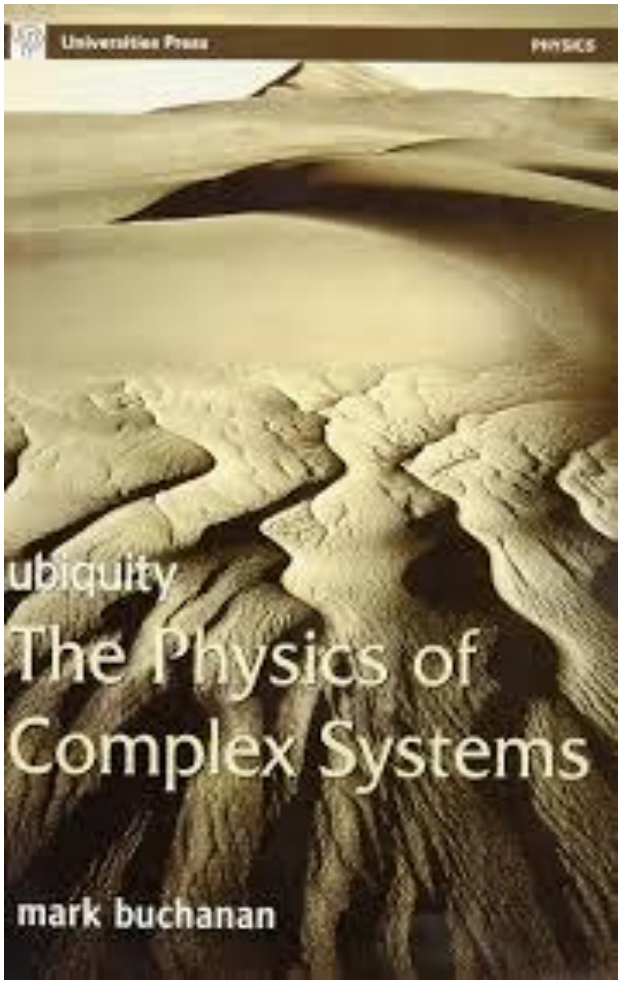

My book is smarter and more creative than I am

Why???

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The evolutionary dynamics of editing:

One draft gives rise to the next through:

Selection:

- keep the better, reject the worse

Exploration:

- expand on incomplete thoughts
- make wrong thoughts less wrong
- try out new ideas
- silly, half-crazy, stupid ideas are all good, as raw matter for further selection

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Stephen King

“I write to find out what I think.”

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selection + exploration + iteration

=

A powerful and completely random procedure for finding solutions to complex problems

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