Optimization

Given a function $f(x_1, \ldots, x_n)$, find values of $x_1, \ldots, x_n$ to max/min value of f

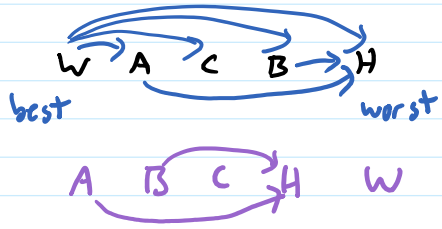
find x, y to maximize $4x + 5y - 2xy - x^2 - y^2$

TSP find ordering of SEA, DEN, ABE, BWI, BDL, DCA to minimize total distance of the resulting tour

find assignment of classrooms to minimize student conflicts

find ordering of teams to minimize upsets during previous season

X	A	B	C	H	W
A		W	W	L	W
B			W	L	W
C				W	W
H					W



A B C H W

Solitaire Yahtzee: Estimate value of anchors by adding expected score in unused categories

$f(x_1, \ldots, x_{13})$ = expected score when playing using heuristic w/ $x_1, \ldots, x_{13}$ as parameters

x_1	3	if	1's	unused
x_2	6	if	2's	unused
	⋮			
	18	if	6's	unused
	20	if	3K	unused
	10	if	4K	unused
	15	if	FH	unused
	⋮			
x_{13}	10	if	Yahtzee	unused

Play each turn to maximize score for turn + score for next anchor

play each turn to maximize score for turn + score for next another

1's, 3K, 4K, FH unused...
3-3=0 9-20 0-10 0-15
=-11 -10 =-15

Hill Climbing: start somewhere
go uphill until at peak
↳ how to determine direction that is uphill

Genetic Algorithms

mimic natural selection — nature-inspired — ant colony optimization, particle swarm optimization

Individuals have genes

genes determine phenotype (physical characteristics / behavior)

phenotype contributes to fitness

fitness contributes to propagation

start with random population — collection of individuals w/ random genes

while not done (out of time, no improvement, ...)

evaluate each individual — genes → inputs to f → evaluate f → fitness (fitness function)

select for crossover — bias towards individuals w/ higher fitness (Gibbs distribution, tournaments)

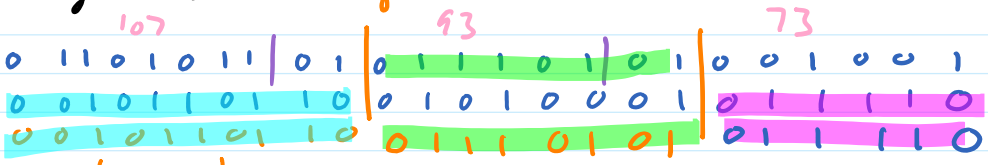
crossover — randomly select genes from parents

select for survival — replacement — fitness based

mutate — randomly change genes in some individuals (low rate)

Representation: what is genetic code? — sequences of bits

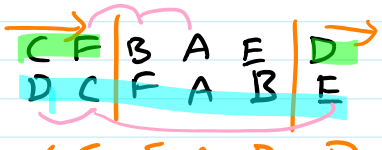
$f(x, y, z)$



Crossover: bitstrings — two-point crossover

0 1 1 1 0 1 0
1 1 0 1 1 0 0

permutation



not a permutation — infeasible

change rep so everything is feasible

A	B	C	D	E	F	
60	70	100	20	10	80	→ C F B A E D
37	30	50	75	26	40	
50	70	50	75	26	80	→ F D B A C E

Genetic Programming:

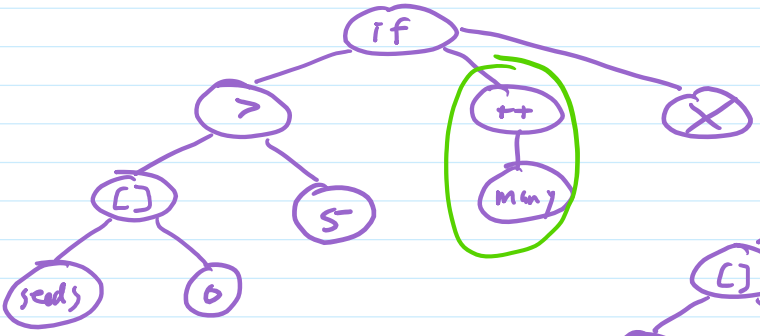
Genetic Programming:

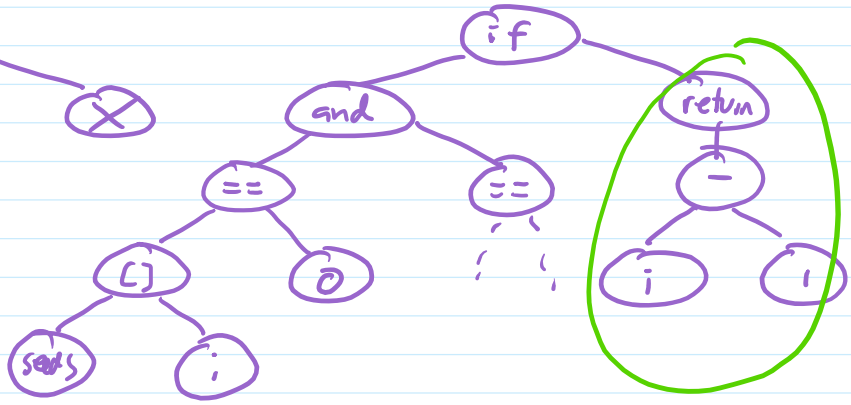
evolving programs

```
if seeds[0] > 5
{
    many++
}
```

```
if seeds[i] == 0 and seeds[i - 1] == 1
{
    return i-1
}
```

representation: syntax trees






```
if seeds[0] > 5
{
 return i - 1;
}
```