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P1)

1- Do no harm: A robot may not injure a human being or, through inaction, allow a human being to come to harm.

2- Obey humans: A robot must obey the orders given to it by human beings, except where such orders would conflict with the first law (Do not harm).

3- Self preservation: A robot must protect its own existence as long as such protection does not conflict with the first law (Do not harm) or the second law (obey humans).

Zeroth law: A robot may not harm humanity or, by inaction allow humanity to come to harm.

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(2)

P2) a)

```
male(alexanderII).
male(AlexanderIII).
male(Vladimir).
male(george).
male(nicholasII).
female(mariaAlexandrovna).
female(mariaFedorovna).
female(olga).
Parent(alexanderII, alexanderIII).
Parent(alexanderII, Vladimir).
parent(mariaAlexandrovna, alexanderIII).
parent(mariaAlexandrovna, Vladimir).
Parent(alexanderIII, olga).
Parent(alexanderIII, nicholasII).
Parent(alexanderIII, george).
Parent(mariaFedorovna, olga).
Parent(mariaFedorovna, nicholasII).
Parent(mariaFedorovna, george).
```

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P2) a)

```
father(X,Y) :- Parent(X,Y), male(X).
mother(X,Y) :- Parent(X,Y), female(X).
grandfather(X,Y) :- father(X,Z), Parent(Z,Y).
grandmother(X,Y) :- mother(X,Z), Parent(Z,Y).
brother(X,Y) :- Parent(Z,X), Parent(Z,Y), male(X), X\=Y.
sister(X,Y) :- Parent(Z,X), Parent(Z,Y), female(X), X\=Y.
uncle(X,Y) :- Parent(Z,Y), brother(X,Z).
aunt(X,Y) :- Parent(Z,Y), sister(X,Z).
```

b)

~~was Alexander~~

Query: ?- Parent(alexanderII, alexanderIII).

Answer: true

Query: ?- Parent(X, nicholasII).

Answer: X = alexanderIII
X = mariaFedorovna

Query: ?- ~~uncle~~ male(X), (uncle(_,X) ; aunt(_,X)).

Answer: X = george
X = nicholasII

Query: ?- Parent(X,Y), male(X), female(Y).

Answer: X = alexanderIII Y = olga

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P3) GBEST: in this swarm all the particles are neighbors of each other. So, the position of the best overall particle in the swarm is used in the social term of the velocity update equation. It is assumed that GBEST swarms converge fast, as all the particles are attracted ~~to~~ in the same time to the best part of the search space.
However, if the global optimum is not close to the best particle, it may be impossible to ~~the~~ the swarm to explore other areas; which means they will be trapped in local optima

LBEST: in this swarm, only a specific number of particles (neighbor count) can affect the velocity of a given particle.
The swarm will converge slower but can locate the global optimum with a better chance

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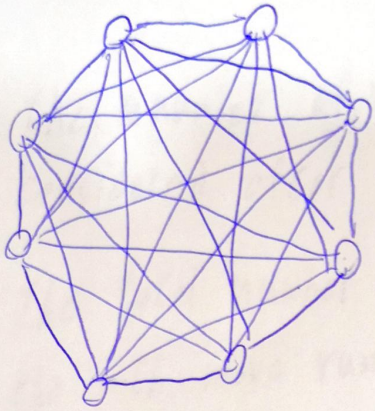
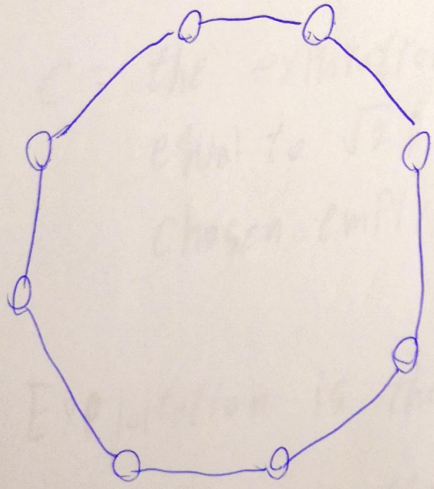
P3) GBEST:



LBEST:



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(6)

P4)

formula : $\frac{w_i}{n_i} + c\sqrt{\frac{\ln N_i}{n_i}}$

w_i = the number of wins for the node considered after the i-th move

N_i = the total number of simulations after the i-th move run by the parent node of the one considered

n_i = the number of simulations for the node considered after the i-th move

c = the exploration parameter - in theory equal to $\sqrt{2}$; in practice often chosen empirically

Exploitation is the first term

Exploration is the second term

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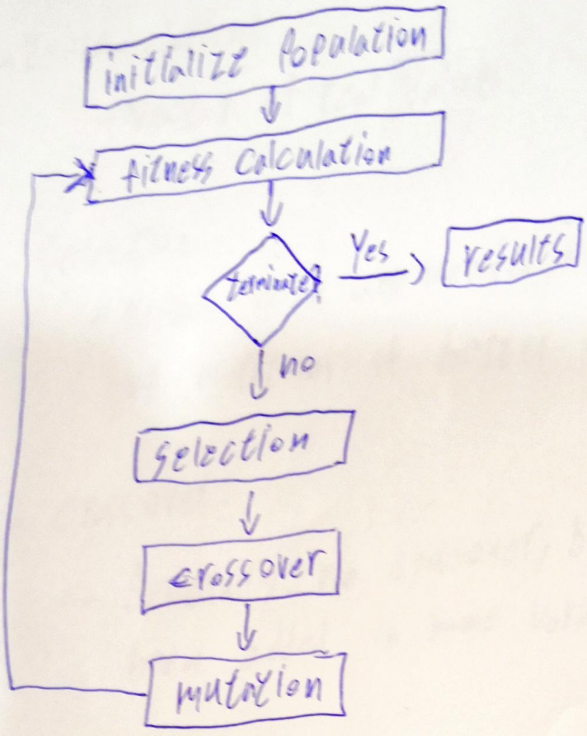
P9) a)



pseudo-code:

- Create a random population consisting of chromosomes (data structer which encode a potential solution).
- until <done> based on a stopping criteria (e.g. max generations or fitness wanted was achived).
  - find fitness score for each member of the population.
  - select members to act upon using variation operators (could be done with various methods e.g. tournament)
    - apply variation operators:
      - crossover and/or mutation
  - replace some members with children from variation ops.
  - keep some members from previous population (elitism/inheratince)

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(2)

P5/ b) 1- representation:
- Vector of real values

2- Selection:
- replace with a member of a sample of mutations if better than parent

3- crossover:
- generally no crossover, but it has been added in some variants

4- mutation
- Yes. add a small normally distributed parameter to a value

Variants:
- (1+1)-ES = a mutant is tested against its parent and the fittest wins.
- (1+λ)-ES = λ mutants are tested against their parents ~~with~~ the fittest wins the Parent wins if he's the fittest
- (1,λ)-ES = same as (1-λ)-ES but the Parent is never retained and only one mutant continues.
- (μ/ρ+, λ)-ES = A population is used where a group of mutants is made for each and compete with the set of Parents, this may have a crossover operation

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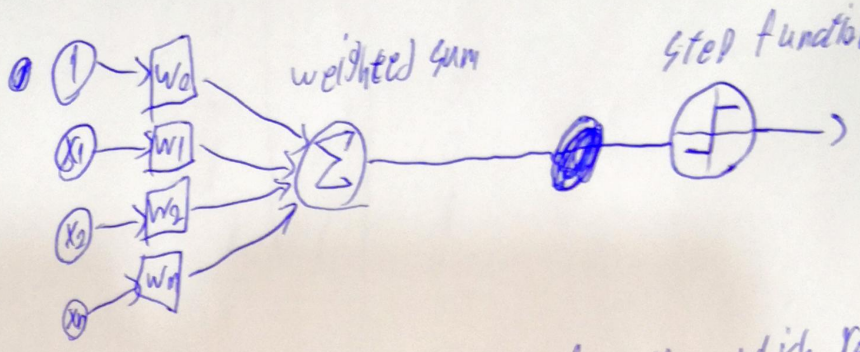
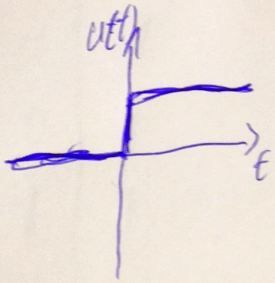
P6) output = step($\sum w_i x_i$) where step(n) = $\begin{cases} 1 & \text{if } n>0 \\ 0 & \text{otherwise} \end{cases}$



activation function is a step function which returns 1 for inputs > 0 and 0 otherwise



a) AND:- y = step(bias + w1 x a + w2 x b)

bias = -1 w1 = 1 w2 = 1

y = step(-1 + a + b)

b) OR:- y = step(bias + w1 x a + w2 x b)

bias = -1 w1 = 2 w2 = 2

y = step(-1 + 2xa + 2xb)

c) NOT:- y = step(bias + w1 x a + w2 x b) ← ignored

bias = 1 w1 = -1 w2 = 0

y = step(1 - a + 0xb)

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P6) AND :-

a	b	output
0	0	0
0	1	0
1	0	0
1	1	1

OR :-

a	b	output
0	0	0
0	1	1
1	0	1
1	1	1

Not :-

a	output
0	1
1	0

Step function for >0 :

	weight1	weight2	bias
AND	1	1	-1
OR	2	2	-1
NOT	-1	0	1