Subject ______ lec 4 Date ______

Evolutionary Algorithms (Genetic Algo.):

Automization → Bio inspired (mostawha men 7aga f env.)

Genetic Algo. (Adaptive heuristic search)

- ↳ used to sole optimization problems.
- ↳ Solve complex prob. (takes a long time)
- ↳ awsal l good sol. f wa2t osayr.

Evolution (lazem ab2a 3arfa 7eta ely gay menha)

↳ reproduce (tatkasar) → bel tazawog result beta3to offspring

↳ chromosome gowa genes beta3ty, el offspring beyaSod genes men om w genes men ab f yekawn chromosome

↳ beye7sal tasyer beset beye7sal f chromosome
↳ mutation

↳ then offspring become part of population

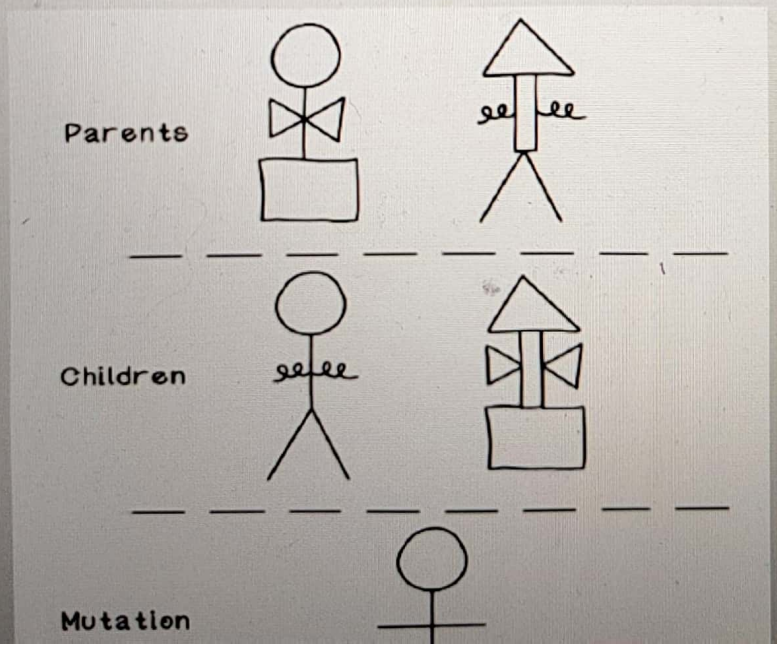
* Survival of the fittest → genes beta3to akwa beye2dar y cope ma3 env. aktar + ye3eesh a7san.

* genes ad3af → no cope + da3ef

EVOLUTION

at the following things happen during the process of evolution:
o individuals in the population reproduce to create offspring.
The offspring created through reproduction contain a mix of
ave slight random changes in their genetic code.

mple of
and mutation



7asl tazawog 3aml 2 offsprings kol wa7ed wakhed 7aga men kol parent w ba3den 7asl mutaion (ta5yer f genes)

Subject _____ Date _____

Kol fe2a leha sefat:

↳ Variety (tanaw3) (Kol wahed mostalef)

↳ Hereditary (werasa) (child beyewras men ab)

↳ Selection (survival of the fittest)

∴ Badl ma a3ad agarb Kol sol. f Search Space Kebeer → Bio inspired Alga (genetic) babda2 b random sol. w akayem sol. de w ba3raf men akwa, w 3ayn3 kaza sol. ma3 ba3d (reproduction) w a2ol3 (generate) sol. geded l-Yad ma awsal l sol. good enough.

global best and local best

afdal sol. f Search Space Kolo (Min of all Min)

afdal sol. f makanha (Min f part)

↳ ba2dar awsal l global best / a2rab mno.

Diversity → ba2dar a2a2a2ha f solutions

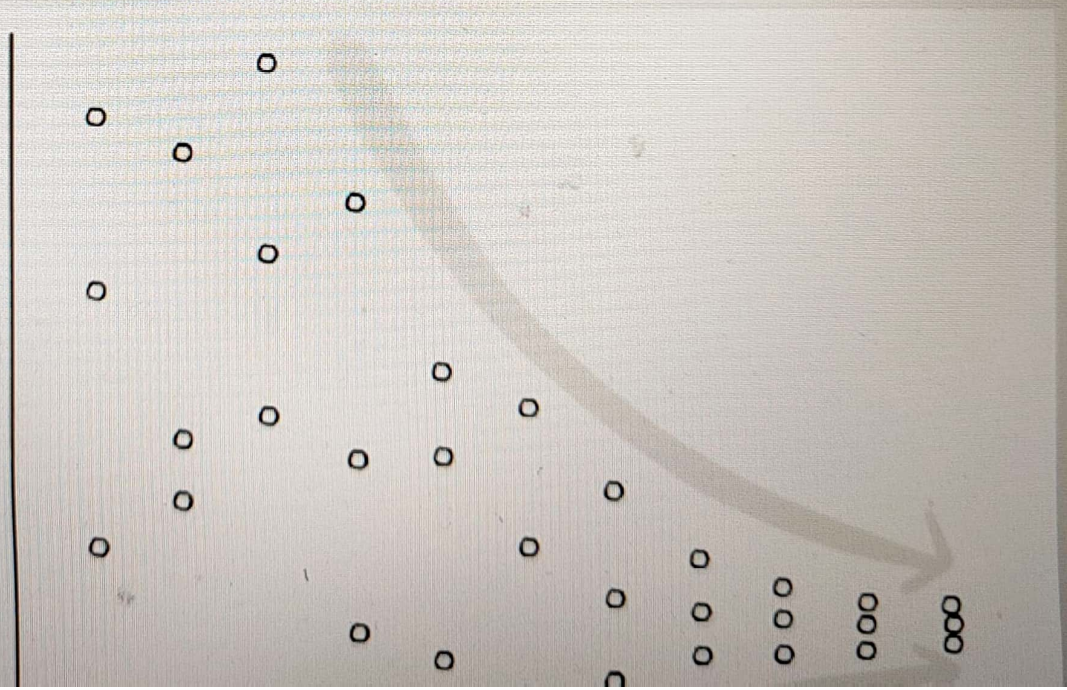
↳ beta3ty (solutions teb2a montashra f Search Space Kolo)

↳ bayssa3dny eny awsal l global best

NETIC ALGORITHMS

ded when
ne algorithm
solutions at
ates toward
neration. At
should vary
attributes.
, the risk of
ases.

bade2 b solutions bo3od 3an ba3d w kol showaya a3od a7asen solutions (convergence) eny awsal l global best



Subject _____ Date _____

→ Kol 7gpa leha 7odod gdida newsal l destruction, wla newsal l 7gpa ma7doda temna3 diversity.

Diversity to convergence → eny baro7 l global best (slide 9)

General life cycle of a genetic algo.

↳ creating (create population)

↳ Measuring (Mesure fitness) (bakayen sol.)
↳ ay mada bey7el sol. probabilistic

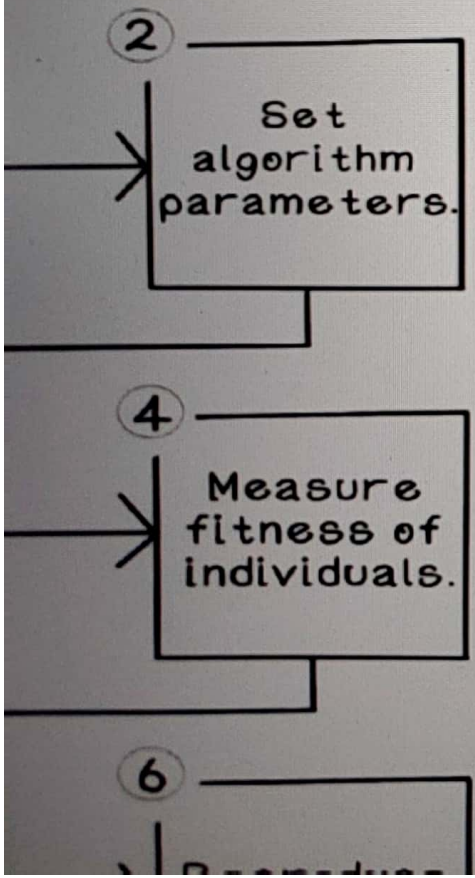
↳ Selecting (selecting parents of new gen based on fitness) (fitness ↑ → forsthom akbar en yeb2o parents)

↳ Reproducing (Reproducing ind. from parents)
↳ Reproduction bet. solutions

↳ populating (populating next generation)

* Flow chart mahya ma3aya f kala.

CHART OF A GENETIC ALGORITHM



encode , set paramters , create inital , mesure fitness , select parents , reproduce , populate , mesure fitness hal weslt l stop condition la2 yeb2a arga3 a select parents tanya

Subject Date

1] creating population

↳ lazem a3mel encoding lel sol. space (representation)

+

↳ condition mo3ayn a3mel beh evalution

→ Ay problem lazem a3melha representation

↓

encoding (shafra)

Binary representation (Sahla f ta3amol)

↳ chromosome magmo3a men genes wara ba3d, zay array, kol gene l'vale → Allele

↳ magmo3et chromosomes te3mely population

→ 1 (Fe) , 0 (Mafesh)

ex: Knapsack → Fe 7agat hatet7at gowa Shanta (1), w 7agat la2 (0)

* features → Feha semat 7a2eziya ely a3raf amayz beha ban2dmen.

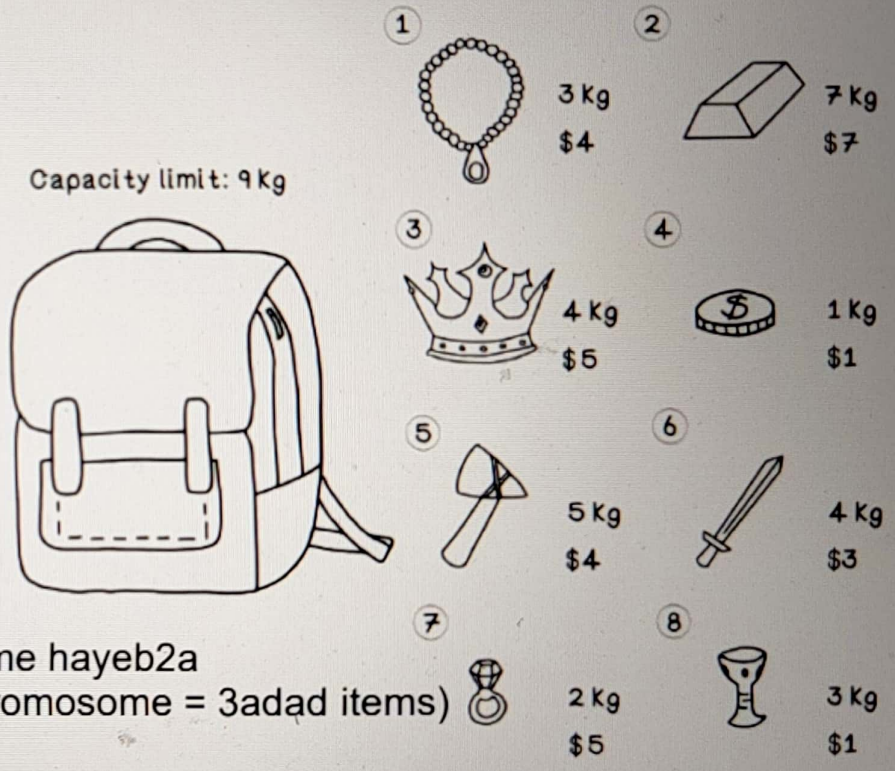
→ teb2a akfa2 w a2al f 3adad.

→ genetic Algo. ely beygarb diff. Combination.

NCODING THE SOLUTION SPACES

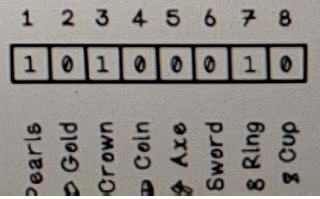
s a crucial step, which
ul design of the
of possible states. The
structure with specific
represents possible
problem. Furthermore,
of states forms a

g is a type of encoding
ts excluded items with
ed items with 1s, for
napsack problem.



3andy 8 items f chromosome hayeb2a
length beta3o 8 (length chromosome = 3adad items)

ha7otha 1 mesh ha7otha 0 w ady l kol gene esm men 7agat ely 3andy ha7ot 3o2dd w ring w crown chromosome da garb talata dol



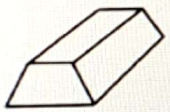
me7aded size 4
ba7seb fitness l kol chromosome men el 7agat ely a5adha
c1 invalid 3ashan over weight fitness= 0 aw -ve
c2 fitness = 7 mesh a7san 7aga bas valid
c3 fitness = 9 valid w wesl l weight belzabt
c4 fitness = 8 valid

EXAMPLE: KNAPSACK PROBLEM

Capacity limit: 9 kg

1 — 3 kg, $4

2 — 7 kg, $7



3 — 4 kg, $5

4 — 1 kg, $1

5 — 5 kg, $4

6 — 4 kg, $3

7 — 2 kg, $5

8 — 3 kg, $1

#	1	2	3	4	5
c1	1	0	1	0	1
c2	1	0	`1	0	0
c3	1	0	1	0	0
c4	0	0	0	1	1

Measure fitness of chromosomes:
Fitness of c1= 3+4+5+4 = 16 overw
Fitness of c2= 3+4 = 7
Fitness of c3= 3+4+2=9
Fitness of c4= 1+5+2=8

here to search

Subject Date

Steps (Slide 13):

1) ↳ 7adet eny hasht8l b binary (Fe w mafesh)
2) ↳ " 3adad items F 7aded length chromosome
3) ↳ " Kol gene beymasel eh 3andy
4) ↳ generate random chromosomes (sol. mostalefa)

↳ F el ghaleb "ba7awel aktar solutions + bakarar 7ogm → 3ashan yeb2a fe diversity.

* lazem Sol. teb2a Valid
↳ me7aze2 condition
↳ Ay Sol. < 9 (V)
↳ Sol > 9 (not Valid) (fitness = 0 / -ve)
↳ 3ashan at7anabo.

* Solution = chromosome

2] Selecting parents based on fitness
↳ Kol chromosome ely f population batshlcham fitness beta3hom w baratbhom men a3la fitness lel a2al.

↳ Sahla bas 3ebha diversity
↳ momken 7agat sol. ely fitness beta3ha 3aly yeb2o Sol. gamb ba3d yasdony l local.

↳ bady foras l Kolo bas foras akbar l chromosomes Kawayesa + bady sa3at foras lel da3ef 3ashan ye7azaz diversity

Subject   Date

↳ Roulette wheel selection
⇓ ↳ mazsoma slices
baratb ch. ↳ spin l7ad ma ashof sahm hayo2f
men kebex l fen 2ala anhy slice, ely hato2f 3ando
so8ayx   howa parent

↳ Slice awsa3 forstha akbar (more fit / fitness↑)
"Sol. more fit forsto akbar".

↳ Slice adyaz (less fit)

→ e2ay b spin wheel f python → Stimulate

↓ steps

1) Calculate total fitness of population

2) Calculate relative fitness l kol individal
(their fitness ÷ total fitness)

3) Calculate cumalative prob. for each individal
(bagma3 ably w kol ely ma3aya)
(total = 1)

4) generate random no. between 0 and 1

5) Select 1st Ind. whose cumaltive prob. >= to random no.
(bakaren b cumulative)

6) Repeat process l7ad ma awsal l stopping cond.
↳ men awel cumulative
↳ bagam3 cumulative geded + random no. gedeed

EXAMPLE FOR ROULETTE WHEEL SELECTION

Suppose we have a population of four individuals with *the following fitness scores:*

Individual A: 12
Individual B: 8
Individual C: 6
Individual D: 4

3andy 4 indivudals (chromosomes)
1) total fitness = 30
2) relative fitness (fitness bta3 kol wa7ed / *total fitness*)

1) Calculate the total fitness:
Total Fitness = 12 + 8 + 6 + 4 = 30

2) Calculate the relative fitness:
Individual A: 12 / 30 = 0.4
Individual B: 8 / 30 = 0.2667
Individual C: 6 / 30 = 0.2
Individual D: 4 / 30 = 0.1333

EXAMPLE FOR ROULETTE WHEEL SELECTION

ate the cumulative probability:

al A: 0.4

ual B: 0.4 + 0.2667 = 0.6667

dual C: 0.6667 + 0.2 = 0.8667

dual D: 0.8667 + 0.1333 = 1

enerate a random number between 0 and 1:

example) Random number = 0.52

elect the parent:

this case, the random number falls between the cumulative probabilities of Individual A (0.4) and dividual B (0.6667). So, Individual B is selected as a parent.

Repeat the process to select another parent.

3) a7seb cumulative l kol wa7ed
4) generate random number between 0 and 1 = 0.52
5)amsek 0.52 w a compare men awel comulative a2of l7ad ma ala2y prob adaha aw akbar menha ha2of 3and indviudal b
6) arga3 agam3 cumulative prob tany w random number tany w ne3ed process

Subject _____ Date _____

3] parents selection

↳ no. of parents is determined by no. of offsprings required
(3adad parents 3ala 7asab 3adad offsprings)

↳ [OR] basod 50% men parents
(handah 3ala wheel 50 marra)
↳ law 100 chromosome.

4] Reproduction

↳ crossover
↳ mutation
} → 2 steps (Kol encoding fe 2 steps dol)

a] Crossover

↳ Mixing part of chromosome of the 1st parent with part of the chromosome of 2nd parent to create one / more offsprings

↳ Single point crossover (inheriting one part)
↳ generate random number (Int) within length chromosome
↳ Rakm da hawa ely ba2sem fe chromosome
↳ batal3 3adatan 2 offsprings (2 sol.)
(Kol parent et2asm nosen)
↳ awel nos ma3 tany nos w vice versa.

Subject ______ Date ______

↳ two point crossover (Inheriting more points from each parent)

↳ batala3 2 random no. w a2ta3ha talat apra2.

↳ gor2 1 w 3 men ab w tany men om (vice verse).

"alternating"

↳ hay7a2a2 diversity aktar (offsprings aktar estelafan).

↳ uniform crossover (Inheriting many points from each parent)

↳ generate mask (hasod arkam f awel offsprings w ba2gar arkam lel offspring tany)

↳ bey2at3 kara mara w awsal l diversity aktar

bataded arkam genes asodha

b] Mutation

↳ Randomly changing offspring slightly to create variation in population. (encourge diversity)

↳ Bit String mutation

↳ a gene in binary encoded chromosome is selected randomly and changed to another valid vale.

(law 0 → 1 / 1 → 0)

Subject _____ Date _____

↳ Constant mutation rate

↳ Rakm ana ely atota (not random) (From 0 to 1), rakm ely beytadeddy el prob. en gene da yet2eleb aw laz.

ex: (rate = 0.6) ⟶ bamshy 3ala chromosome (gene) by gene, ⟶ (generate random no.) f kol gene law (R.N) tel3 as8ar men 0.6, law akbar bayefdal zay ma howa.

↳ ∴ bay5osh f mutation.

Steps:

↳ 1] a7aded mutation rate (bet 0,1)

↳ 2] bamshy 3ala kol gene

↳ 3] generate random no. l kol gene (bet 0,1)

↳ 4] Compare r.n bel mutation rate

↳ 5) r.n < mutation rate ∴ mutation happen

↳ else no mutation.

↳ beyeddy diversity a7san

↳ Mutation rate ↑ ⟶ Diversity ↑

↳ Kol ma (araud rate) ⟶ kol ma araud rate en (gene) ehha tet2eleb ⟶ Diversity a7tar.

law rakm Kebeer forset en R.N yet3a3 as8ar mena akbar.

Subject Date

→ high mutation means more diversity.

∴ Zadet mutation rate 3aly → ∴ genes keteer hatet2eleb
" " " qayel → ∴ genes qayela "

↳ Solution (offspring) → fitness beta3o 3aly → law te3bt feha keteer habawrka.

↳ Solution (offspring) → fitness beta3o qayel → law te3ebt fe keteer hayeb2a atsan.

* mutation 3aly → ta2seer 3ala fitness qayel 7elw.

* " qayel → " " " 3aly 7elwa. (mesh hal3ab feh keteer)

Adaptive mutation

↳ bazes fitness bta3 kol offspring bageeb average fitness beta3hom.
↳ a3la menha high fitness
↳ azal menha low fitness.

Subject _____ Date _____

∴ high fitness 3ayza low rate
low " " high "

↳ da ely beye3melo adaptive

* beygeb offsprings ely tal3a men crossover

↓

yetseb averge fitness (Sat fasel)

↓

bazaded 2 mutation rate (wated olayel, wated 3aly)

↓

ay offspring (high fitness → rakm dayel)
" " (low fitness → " kebeer)

Steps:

↳ 1) Calculate averge fitness value

(F) ↳ 2) for each chromosome calculate fitness value

↳ 3) if F < AVg → low quality sol.
↳ ∴ Rate kept high

↳ 4) if F > AVg → high quality sol.
↳ ∴ Rate kept low.

Subject Date

5] populating next generation:

↳ Mix maben parents w child

↳ next generation ba3melo eray?

a) ↳ Steady state

↳ parents metratben men a3la fitness lel a2al

↳ akamel bazy men offsprings

example: 3andy 100 metratben men highest fitness lel a2al

↳ ba5od awel 50 men parents w a3ed 40 men offsprings

↳ ba3d ma salsthom mutation w kol 7aga.

↳ ba5od percent men parents + percent men offsprings.

highest x% = 100%

highest 100 - x

Subject ________ Date ________

b) generational

↳ termy parents w tasod offsprigs bas.

problem: ↳ Diversity Kebera awy → ∴ ab3ed 3an Min

↓ zeyada 3an ↳ teshhatetny aktar perom

c) Exploration vs Exploitation (best way)

↳ between maben eny aktashef Hagat gedeeda + eny astaghel el adeema

1] ↳ bageb bowl a7ot fe Kol parents w offsprigs ma3 ba3d

2] ↳ arattb fitness beta3hom kolohom ma3 ba3d.

3] ↳ ashtaghl b ay tare2a men selection (zay Rolete)

4] ↳ w astar rakm ely 3ayzo ka pop. size

↳ 7afzt 3ala diversty (foras akwa lel akwa + foras osayra lel ad3af)
(→ akbar; so8ayra ↙)

↳ Kol ma a2awod offsprings ely basadhom
↳ Diversty ↑.

Subject _____ Date _____

Stopping Condition:

↳ 1) Fe 3andy no3 problems en Fitness betа3o yeb2a ma3roF, w ma3 kol sol. bashof fitness wesl kam.

↳ fitness = rakm da [or] Far2 Faga sabaya awy

↳ ∴ terminate.

"Constant vale that indicates no. of generations for which Algo. will run, or best fitness needed to be reached"

↳ 2) law mafesh rakm

↳ a] aSod 3adad mo3ayn men iterations. w ashof solutions.

↳ b] generation ged ed akarno b best ely ablo

law mafesh Faghyer 3ala mada to aw 3adad Iterations w howa Sabet ↳ ∴ best Fitness Sabet → a2ta3 keda Algo. gab aSro

ION OF GENETIC ALGORITHMS

BLEM WHERE THERE ARE 26 ITEMS.

feha 26 items , law 3ayza agarb item item yeb2a 67 alf genetic algorithm hawsal l nafs rakm f 3 secs men 10,000 to 100,000 kol genetic algorithms sha5ala 3ala random numbers f kol mara yetal3 7al mo5talef showaya yedeny nafs 7al ba3d 3adad iterations mo3ayn f 3ashan keda eda range

Brute force	Genetic algorithm
2^26 = 67,108,864	10,000 - 100,000
100%	100%
~7 minutes	~3 seconds
13,692,887	13,692,887