Numerical - Fibrocci
Fuzzy logic
Probability
clustring
back propagation
Neural n/w

Unit 1 - Introduction to artifical intelligent techniques.

1. Introduction
2. Search algoriths - types, methodology
3. Mathematical optimization & evolutionary computing
4. Handling uncertainities - fuzzy logic, Bayesian n/w
5. Neural n/w, support vector machines
6. Statistical learning methods

Traditional Techniques (Mathematical optm^n)
1. Linear prgming
2. Non-linear prgming
3. Integer prgming
4. Geometric prgming
5. Quadratic prgming

Non-traditional
- Evolutionary computation
  - evolve in genetic
    - genetic algo.
    - Memetic algo.
  - evolve in social behaviour
    - Artificial bee colony algo
- Non-gradient probabilistic
  - Taby search
  - Simulated

Artificial intelligence - (man-made) (there is some part ... safety)

Simulation of human intelligence process by machines, especially comp. system.

Search algo.

Informed

Cost func^n known (guide process)

Best 1st search, hill climbing

1) Use of heuristics - ISA use heuristics or additional infor to guide process.

2) More efficient - ISA are more efficient than USA algo. such as (BFS)

3) Goal directed - designed to find sol^n to specific problem

4) Cost based - ISA often use cost based esitimates to evaluate nodes.

5) Prioritazation - ISA prioritize n. which nodes to expand based on additional info. available

Uninformed search

Cost func^n not known.

Breadth 1st search, Depth search

1) Systematic exploration. (explor search space systematically)

2) No heuristics - don't use additional information (cost func^n to guide process)

3) Blind Search - USA don't consider cost of reaching goal

4) Simple to implement - USA are simple to implement & understand

5) inefficient in complex problems: with large search

EF
PQ
RC
PM
SCM

Goals of AI in manufacturing -

1. Improving efficiency & productivity -
   ai can use to automate repetative tasks, reduce ~~task~~ waste, which leads improved efficiency & productivity in mfg. process.

2. Enhancing product quality -
   used to monitor & control mfg. process, detect defects & anomalies, improve quality control which result in higher-quality products.

3. Reducing costs - By streamlining process, reducing waste, & optimizing resource utilization, ai can help manufact-ures reduce costs & increase profitability.

4. Predictive maintainance -
   ai use to monitior machines & equipment in real-time, identify potential issues
   → AI improve overall equipment effectiveness & reduce maintainance costs.

5. Supply chain optimization - ai use to analyze data from ~~sensors~~ various sources (such as Sensor, social media & whoather forecast and many more.
   This lead to reduce lead times, better customer service & improved cost efficiency.

Tools for AI such as search algo.

1. Depth 1st Search (DFS) -
   - DFS is search algorithm that explores as far as possible along each branch of tree before backtracking.
   - This algo useful for finding sol^n in large, complex search space.

2. Breadth First Search (BFS)
   - Search algo. that explore all nodes at current depth before moving on to nodes at next depth.
   - useful for finding shortest path bet^n 2 nodes in graph.

3. Best First Search (BFS):
   - search algo. that evaluates each node in search space based on evaluation func^n, then expands node with best evaluation.
   - algo. useful for problems where finding optimal sol^n is not critical.

appn - Path find, ML, optimization (determine best state of process

4. A* Search -:
   - A* search is search algo. that combines advantage of both BFS & Best first search.
   - uses an evaluation func^n f to guide search towards goal node, also considering cost of reaching that node.

Mathematical optimization -

— tool used in AI to solve complex problems with many variables & constraints.

— find best possible sol^n to problem

Optimization technique :

1. **Linear prgming** - LP is optimization technique use to find optimal sol^n to linear obj. func^n, subject to linear constraint
   resource alloc^n & prod^n planning.
2. **Quadratic prgming** - Find optimal sol^n to quadratic obj. func^n, subject to linear constraint
3. **Convex optimization** - find — convex obj. function, subject to convex constraint.
4. **Non-linear prgming** - find optimal sol^n to non-linear obj. func^n, subject to non-linear constraint.
   (used in ML, task such as class^n, regression & clustring)
   — used in engineering, design & control system.

   Same both

5. **Stochastic optimization** - find optimal sol^n to problem that involves random variables
   — used in ML task such as learing & dynamic prgming.

Evolutionary Computation :

— it is branch of AI that draws inspiration from principles of biological evolution. to solve optⁿ & search problems.

1) Genetic Algo → Fittest solⁿ selected to produce next generation of candidate
2) Genetic prgming → use GA to evolve comp. Program.
3) Evolution strategies → use stochastic search & evolution to find optimal solⁿ to problem.
4) Particle Swarm Optⁿ → popⁿ based optⁿ algo. that models behaviour of swarm of particles.

— this techniques applied to wide range of AI problems, including feature selection, control system

— this are useful when tradition optiⁿ methods are unable to handle complexity of problem or search space is very large / nonlinear.

Uncertainly - lack of sureness about something

Reasoning - is a logical / thoughtful way of thinking

Probablistic methods -

incorporate random variables & gives probability distribution to solⁿ.

Crossover probability -

no. of crossover occurs in 1 generatio /

GA =
coding
↓
random generator
↓
reprodⁿ
↓
crossover
↓
mutation
↓
Safe offspring

$$x = x_{min} + \frac{x_{max} - x_{min}}{2^n - 1} \times \text{decoded value}$$

Fuzzy logic - Method of reasoning that resembles human reasoning - way of decision making

logic:
- Propositional (either true / false)
- Predicate (we can't say true/false it depends upon value (app^n))
- Fuzzy (can't clearly say true / flase it is partially true & partially false

1) Prof. Zadeh is writer of fuzzy logic

2) For any process transfer func^n developed by governing eqn (in laplace form) but in fuzzy there is no need of governing eq^n.

3) Fuzzy logic is branch of AI, that deal with reasoning that is approximate / uncertain.

4) Fuzzy logic is based on idea that many real-world situations. (such hot, fast)

5) In fuzzy, machine thinks like human.

6) Fuzzy logic provides way to represent & manipulate fuzzy concepts, allowing us to reason about them in more natural & human like way.

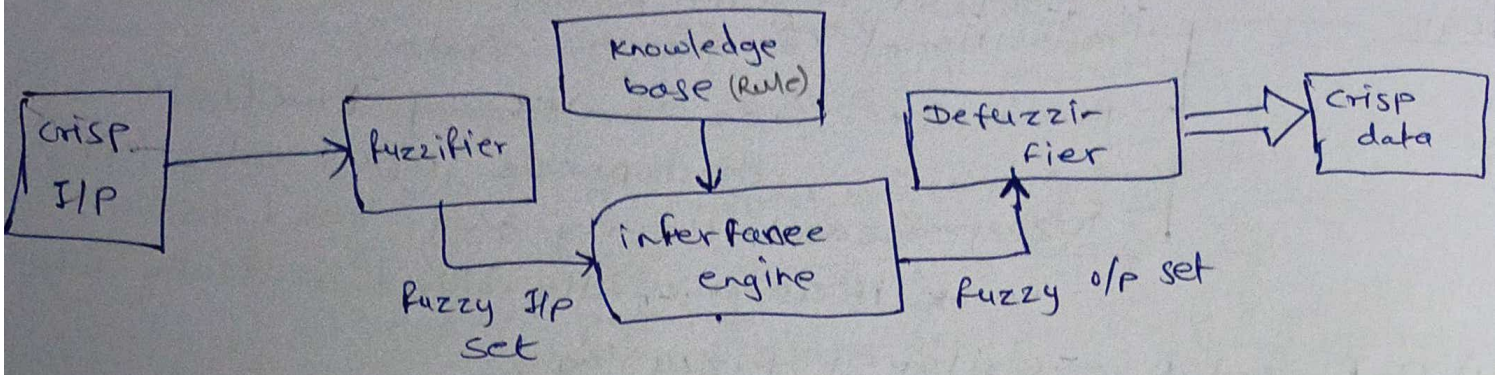
7) Fuzzy logic provides way to perform inference & decision making with fuzzy sets.
rules in fuzzy expressed using if-then statements, where cond^n & conclusion involve fuzzy sets.

8) human decision making includes range of possibilities bet^n yes & no, such as (cannot say, possibly Yes / No, certainly Yes / No)

9) Fuzzy logic is tool which convert imprecise info. (human lang.) to precise information i.e. crisp value (machine characteristics)

- Machine understands only crisp data.

Comp. of fuzzy logic:



Inference engine - convert data into knowledge for

Membership - represents belongingness of character. at some extent.

Knowledge base - if & rules are stored in knowledge (rules)

Fuzzification - crisp i/p (low i/p, high i/p) changes to fuzzy logic i/p.

Inference engines - whatever rules provides which matches to your i/p on basis of that it provides control systen

Defuzzification - control rules (fuzzy rule) changes to crisp o/p.

Rule base - component for storing set of rules & if-then cond^n given by experts use for controlling decision making systems.

fuzzification - is module/component for transforming system i/p i.e. converts crisp no. into fuzzy steps.

(crisp no. are those i/p which measure by sensors & then fuzz^n)
↓acceptable by user

Inference engine - main component in fuzzy logic, becoz all info. is processed here. allow user to find matching degree bet^n current fuzzy i/p & rules.
— After matching, system determines which rule is to be added according to given i/p field.

defuzzification - component which takes fuzzy set i/p generated by inference engine & then transforms them into crisp value.
— last step in^n fuzzy logic system. process

App^n:
— Navigation & avoiding obstacles
— Active navigation in mobile-robot.
— Target loc^n,
— TO control speed
— use where an exact mathematical formulation of problem is not possible / very difficult.

Artificial Bee algorithm - this algo. highly related to bee behaviour while looking for best source of food

— Movement of bees divided in 3 phases:-

ⓐ Employed phase
ⓑ Onlooker phase
ⓒ Scout phase

ⓐ Employed phase (working) -
- generate new soln
- create new fitness
- Apply greedy selection
  ↓
  compare new with old

ⓑ Onlooker phase (watching) -
- calculate probabilities
- produce new soln depending on prob.
- calculate new fitnees
- Apply greedy selection

ⓒ Scout phase -
- find abandoned soln (based on value of limit)
- Generate new soln randomly to replace them

Appn -
1) Robot path planning
2) Path planning of mobile robot
3) Solve path planning problem in 2D & 3D space.

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appn of bayesian n/w in robotics

— for decision making
— robot control
— fault diagnosis

Bayesian Network - / belief n/w

— Bayesian n/w is probablistic graphical model use to represent & reason about uncertainty in system (cond^n dependency)
OR represent probablistic relation bet^n variables

— Main adv. is their ability to handle uncertainty in principle & intuitive way.

— uncertainty arise from several sources, such as
—incomplete or noisy data
—incomplet knowledge of problem domain.

— key idea behind bayesian n/w is to represent joint probability dist^n over all variables

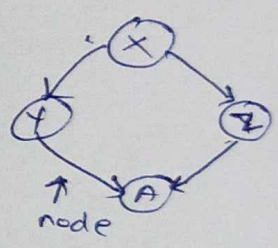
— n/w built from probability distrubution.

Node - each variable represented by ~~directed edges~~ node in n/w. random
(representation of variable in n/w is node)
or corresponds ex. height, age, country
e.x.

Directed Acyclic Graph:

conceptual representation of series of activities / event.

DAG is graph with directed links & one which containeds no directed cycles.



link - represent casual relationship or cond^l probability among random variable

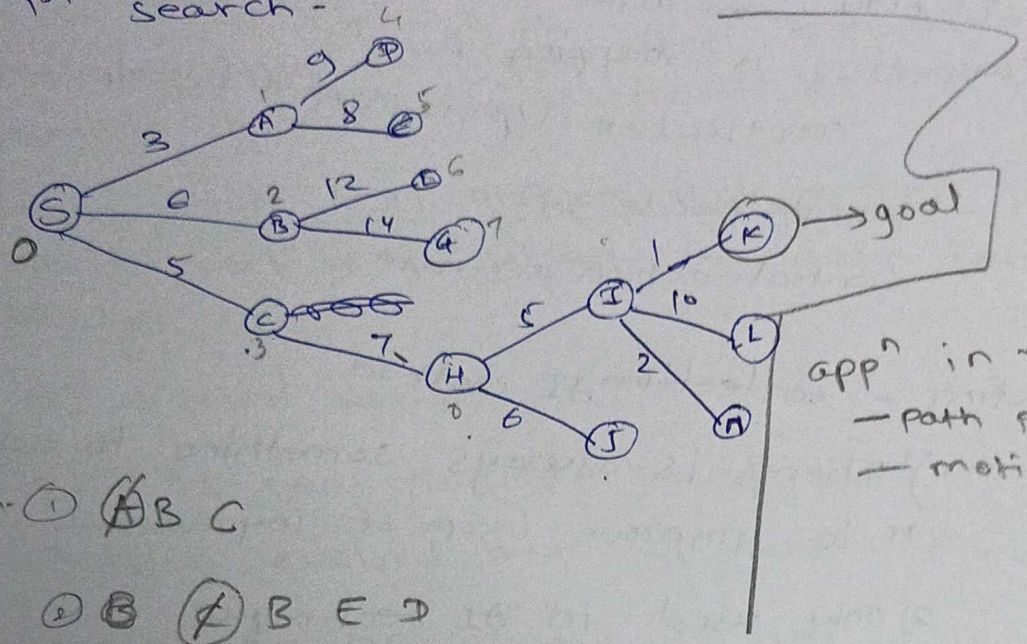
links are added bet^n nodes to indicates that one node directly influeces other

Joint probability distrubution - if we have variable $x_1, x_2, x_3 \ldots x_n$, then probabilities of different comb^n of $x_1, x_2, x_3 \ldots x_n$ known ass joint probability distrubution.

→ Probability of more than 1 variable occuring together,

Informed Search algo.

Best 1st search -



app^n in robotics
- path planning
- motion planning

iteration - ① ~~A~~ B C

② ~~B~~ ~~C~~ B E D

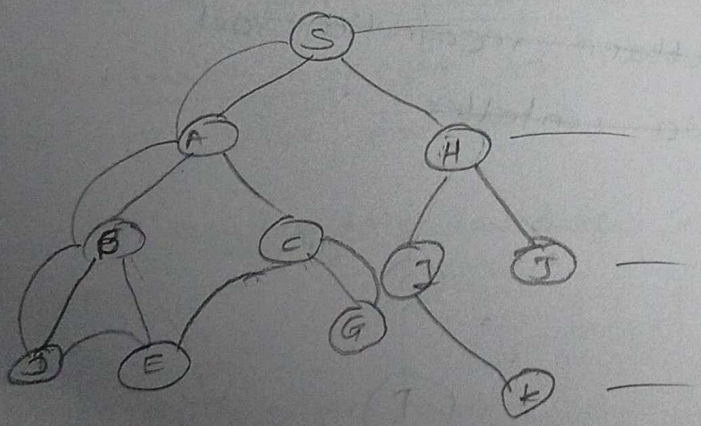
③ ~~B~~ E D H

④ E D F G ~~H~~

algorithm ans:
0 1 3 2

Uninformed Search algo.

Breadth 1st search



app^n - maze solving - find shortest path through maze, allowing robot to navigate

obstacle avoidance.

Robot game playing

Soft Computing -

y = o/p x = i/p
F = mapping

$Y = F(x)$ control action

Computing is mapping func^n particular i/p is mapped by o/p

Computation - provide precise sol^n
control action accurate

Soft computing - ~~collection~~ AI method

1) There is always something to adjust or to improve (scope of improvement.
2) only used in AI technique
3) Soft computing is all about how much best sol^n you get!
4) In these you cannot predict best result there are multiple sol^n.
5) this is based on AI knowledge
~~6) pattern recognition tool~~
~~7) No controller~~

Q.10

Probability of mutation → exchange of 0 & 1
Probability of crossover → should less, sol^n will keep on changing
String length
Population size

selection criteria

7. What is meta heuristics-

→ ~~X~~ Metaheuristic is higher-level procedure to generate heuristic that provide sufficient good sol^n.

— It is high-level problem independent algo. framework provides set of guidelines to develop heuristic optim^n algo.

— AI based method

— It is non-gradient based and this method getting evolved but not genetically.

— Metaheuristic always identify class of problem & then select method.

How they are different

— They fond sol^n very quick than traditional technique

— They eliminate barrier to identify class & decide method to solve problem

— They use asystematic random search for Past sol^n to problem

— but they are less acurate.

what is membership

→ Membership → core of fuzzy

— represents belongingness of that character at some context

— fuzzy set is distinct from crisp set in that it allows its elements to have degree of membership.

— surface / line that defines relationship betn value in set's domain & its degree of memb.

Significance -

— allows us to represent reason about imprecise / uncertain info.

— instead of representin i/p values as crisp, precise values as crisp, precise values we represent fuzzy values that have degree of membership in fuzzy set.

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linear regression - use for quantitive data

statistical method use to analyze relationship betn 2 variables.

dependent — one/more independent

— find best linear relationship betn variable which is use to make prediction about dependent variable based on values of indepen.

— technique use least squares regression,

diff. betn supervised & unsupervised

Supervise	unsupervised
Input data is labelled	i/p data is not labelled.
also known as classification	also known as clustering
Accurate & reliable results	Moderate accurate & reliable results.
uses off-line analysis	uses real-time analysis of data
Less computational complexity	More computational complexity
desired o/p is give	desire o/p not given
training data use to infer model	cannot use
we can test our mode	can't taste model.
ex-optical character recognition	ex. find face in image.
No. of class are known	not known

Parameters are 1. training data
2. testing data

Neural network - (soft computing method)

— it is computational model based on how brain solves certain kind of probleme.

— neural n/w thinks like human, act like human brain

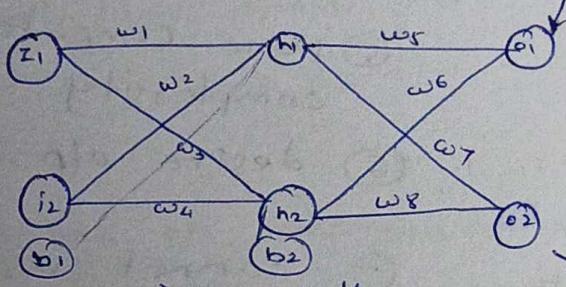
— it is AI method where there is alway something to adjust.

— no controller, key element is ability to learn

— Pattern recognition tool

— It is iterative type of algo.

ANN diagram



here, i1 & i2 are i/p node/layer

h1 & h2 — hidden layer — hidden layer try to establish in some rules in order to corelate output & i/p

O1 & O2 - O/p node/layer

W1, W2 ... W8 - weights

b1 & b2 - additional nodes called "as biased nodes"

— if both i/p zero, out will be '0'. to overcome that we add biased nodes which common offset

↓

maintain constant offset

Algorithm specific parameter - 1) Hidden nodes
2) Hidden layer
3) learning rate

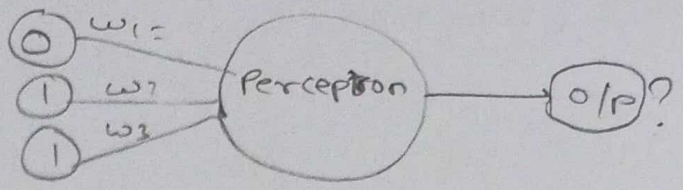
— minimize prediction error on training data.

— Each connection has weight no. that controls signal bet two neurons.

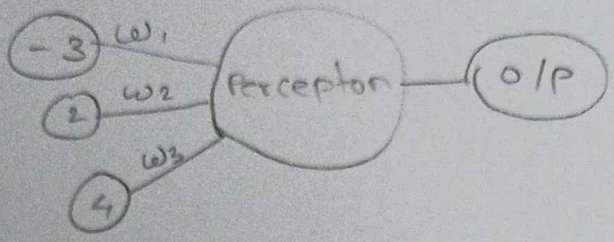
— If n/w generates good o/p no need to adjust weight

— poor o/p - an error, system adpots, alternating weights in order to improve subsequent results.

i/p node pattern 1 - (0, 1, 1)



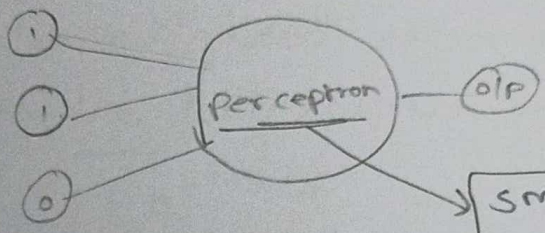
weights are



$$net h_1 = i_1 \times w_1 + i_2 \times w_2 + i_3 \times w_3$$

$$= 6$$

i/p node for pattern 2 - (1, 1, 0)



$net h_2 = i_1 \times w_1$

Note

small version of neuron

$Y = \varphi(v) = 1$ for Parttern 1 = $Y = 6 > 0$ so o/p of $Y = 1$ - using activation rule

for pattern 2 = $Y = -1 < 0$ so, o/p of $Y = 0$

Back propogation -

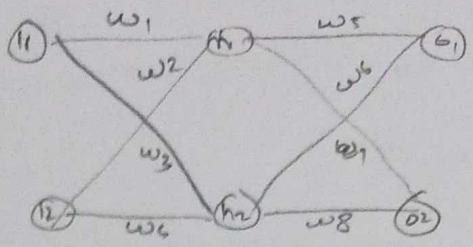
K-clustering : K - define no. of predefine clusters
— no. of classed not decided.
— it is unsupervise learning algo.
— which group unlabelled dataset into diff. clusters.

— it is iterative algo.
— that divides unlabelled dataset into K different clusters. in such a way that similar properties.

— It is centroid based system where each cluster is associated with center.

Task - make attributes unless
if pnt data given no need to normalise fun
— determines best value for K center pnts.
by interative process.

Back propogation algo.



I/P to h_1

$net\ h_1 = w_1 \times i_1 + w_2 \times i_2 + b_1 \times 1$

$= 0.3 \times$

$$Out_{h_1} = \frac{1}{1+e^{-net_{h_1}}}$$

$$net\ O_1 = w_5 \times Out_{h_1} + w_6 \times Out_{h_2}$$

$$Out\ O_1 = \frac{1}{1+e^{-net_{O_1}}}$$

Explain back propo- To update value of weight take partial derivative

- use for training artifical neural n/w ↗ weights changes on real time
- basic idea behind to adjust weight of ~~neuron~~ n/w connections so that o/p produced by n/w is closer to desire o/p for given i/p.

there are 2 pass in back propogation

frwrd pass - decides error.

backward -u- - minimize error.

AIR

endsem

S.A

Q.5.

→ minimization

temp - 100°c

initial value = 35

final value = 50

Probability for new soln $= e^{-\Delta c/T}$

Probability of accepting soln

$= e^{-\Delta c/T}$

ΔC = final value − initial value

$\Delta C = 50 - 35$.

$= 15$

$T = 100°$

$\therefore = e^{-15/100}$

$= 0.8607$

Q.6 minimization

→

Current value, $x_i = 20$

lower bound of $x = 10$

upper $-l\sim$ $= 50$

Random value should be betⁿ

Random no. ~~(0 2)~~ = N = 5 no.s

$\Sigma N = 1.87$

Updated value = $\boxed{x_{i+1}} = x_i + \sigma \left[\sum_{i=1}^{N} R_i - \frac{N}{2} \right]$

σ (sigma) $= \frac{UB - LB}{6} = \frac{50 - 10}{6} = 6.666$

$= 20 + 6.666 \left[1.87 - \frac{5}{2} \right]$

x_{i+1} = ~~29.132~~ 15.80042 — updated value

Ant Colony Optimization

Q.7 distance matrix -

	1	2	3	4
1	0	32	51	28
2	32	0	43	38
3	51	43	0	49
4	28	38	49	0

Pheromen deposited

	1	2	3	4
1	1	1	1	1
2	1	1	1	1
3	1	1	1	1
4	1	1	1	1

efficiency (η) = 1/distance

	1	2	3	4
1	0	0.031	0.019	0.035
2	0.031	0	0.023	0.026
3	0.019	0.023	0	0.020
4	0263	0.026	0.020	0

Probability = pheromen $\times$ (efficiency)^2

2	3	4
9.765×10^{-4}	3.844×10^{-4}	1.275×10^{-3}
3.7044×10^{-7}	1.4582×10^{-7}	4.8368×10^{-7}
3.7044×10^{-7}	5.1626×10^{-7}	9.9946×10^{-7}
		= 1

$\Sigma = 2.636 \times 10^{-3}$

Q. 9:

Total distance travelled = path addition

= 170

100 - 51

Updated Pheromen deposited by ant 1 : $\frac{1}{170}$

= 0.0058

Q.8 = ?

ant colony
region growing

0 2 4 8 2^3 2^2 2^1 2^0

2^0 2^1 2^2 2^3

1 2 4 8

Run length encoding

→

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

4 bits, & addition should be length

run	bit value	length	strength length
1	1	10	4
2	0	14	4
3	1	5	3
4	0	1	1
		Σ = 30	max = 4

8 4 2 1

run	bit	length	Total (bit + length)
1	1	1010	5
2	0	1110	5
3	1	0101	5
4	0	0001	5
			Σ = 20

Compression ratio = $\frac{30}{20}$

= 1.5

Q.16

image

2	7	5	3
2	5	7	1
4	4	3	6
2	9	2	5

template

9	2	8	5
3	6	7	3
0	9	9	8
7	9	1	5

PI : Σ(temp - image)

7	5	3	2
1	1	0	2
4	5	6	2
5	0	1	0

Σ = 44 ⟶ PI

Q.17

2	0	1	0
1	0	1	2
0	0	3	0
4	1	2	0

⟶

x coordinate $= \frac{M_{10}}{M_{00}}$, $M_{10} = \Sigma M_{x'} \cdot M_{y'}$

Region growing : Seed point - original

Seed point → max intensity

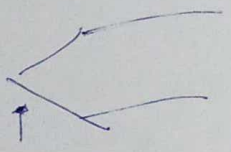
Threshold → $\frac{min + max}{2}$

Seed pnt - intensity of cell

threshold & max value → 1

less than threshol → 2

Probability-



,27

Value

Σ values of 1st row

= 2nd row

2nd row 1st value as it is down

↳ + diagonal

= down

A Star algo.

→

(0,5)	(1,5)	(2,5)	(3,5)
(0,4)	(1,4)	(2,4)	(3,4)
(0,3)	(1,3)	(2,3)	(3,3)
(0,2)	(1,2)	(2,2)	(3,2)
(0,1)	(1,1)	(2,1)	(3,1)
(0,0)	(1,0)	(2,0)	(3,0)

start

end

for (1,3)

g (0-1) + (0-3)
= 4

h (1-3) + (3-5)
= 2 + 2
= 4

Total = 8

for (1,1)

g, (1-0) + (1-0)
= 2

h = (1-3) + (1-5)
= 2 + 4
= 6

Total = 8

for (2,2)

g, (2-0) + (2-0)
= 4

h, (2-3) + (2-5)
= 1 + 3
= 4

Total = 8

for (0,2)

g, = (0-0) + (0-2)
= 2

h (0-3) + (2-5)
= 3 + 3
= 6

Total = 8

1st condition - Select min total cost, if all are same then

2nd cond^n - Select h minimum

17.

	1 (x)	2 (y)	3	4
1	2	0	1	0
2	1	0	1	2
3	0	0	9	0
4	4	1	2	0

x coordinate of centroid - $\frac{M_{10}}{M_{00}}$

M_x =

2	0	1	0
2	0	2	4
0	0	9	0
16	4	8	0

M_y =

2	0	3	0
1	0	3	8
0	0	9	0
4	2	6	0

$M_{10} = \Sigma M'x * M^{\circ}y$

$=$

$2'$	$0'$	$1'$	$0'$
$2'$	$0'$	$2'$	$4'$
$0'$	$0'$	$9'$	$0'$
$0'$	$4'$	$8'$	$0'$
$16'$			

$\times$

2°	0°	3°	0°
1°	0°	3°	8°
0°	0°	9°	0°
4°	2°	6°	0°

M_{10} =

2	0	1	0
1	0	2	4
0	0	9	0
16	4	8	0

$\Sigma = \underline{48}$

$M_{00} = \Sigma M^{\circ}x \cdot \Sigma M^{\circ}y$

$=$

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

$*$

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

$=$

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

$\Sigma = 9$

$\therefore$ x coordinate of centroid $= \frac{48}{9} = 5.333$

Q.18

y coordinate of centroid

$$= \frac{M_{01}}{M_{00}}$$

$$M_{01} = \Sigma M^{0}_{x} \cdot M^{1}_{y}$$

$$= \begin{matrix} 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 \end{matrix} \times \begin{matrix} 2 & 0 & 3 & 0 \\ 1 & 0 & 3 & 8 \\ 0 & 0 & 9 & 0 \\ 4 & 2 & 6 & 0 \end{matrix}$$

$$= \begin{matrix} 2 & 0 & 3 & 6 \\ 1 & 0 & 3 & 8 \\ 0 & 0 & 9 & 0 \\ 4 & 2 & 6 & 0 \end{matrix}$$

$\Sigma = 38$

$$M_{00} = \Sigma M^{0}_{x} \cdot \Sigma M^{0}_{y}$$

$$= 9$$

y coordinate of centroid $= \frac{38}{9}$

$= 4.222$

Normalized cross correlation method

Ex: along $x=1$, $y=2$

Image → will be

2	7	9
0	4	0
9	9	3

template -

0	5	1
8	9	3
8	6	3

(Squaring to both)

Avg intensity of image

4	49	81
0	16	0
81	81	9

$\Sigma = \sqrt{321}$

$= 17.91$

Avg intensity of template

0	25	1
64	81	9
64	36	9

$= \sqrt{289}$

$= 17$

Product of Avg intensity

$= 17.91 \times 17$

$= 304.580$

Product of (template & image ϕ translated) intensity:

0	35	9
0	36	0
72	54	9

$\Sigma = 215$

Efficiency = $\frac{\text{Actual product of intensity}}{\text{Avg. intensity product}}$

$= \frac{215}{304.80}$

$= 0.7053$

(1,1) (2,2)

(1,1) (0,2)

Template matching:

PI →

transl^n (2, 2)

image →

2	7	5	3
2	5	7	1
4	4	3	6
2	9	2	5

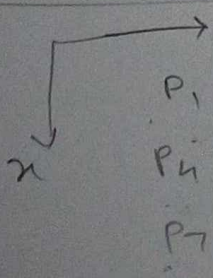
temp →

9	2	8	5
3	6	7	3
0	9	9	8
7	9	1	5

7	5	3	2
1	1	0	2
4	5	6	2
5	0	1	0

$\Sigma = 44$

Prewitt & sobel operator:



$$\nabla = \begin{Bmatrix} \frac{\partial f}{dx} \\ \frac{\partial f}{dy} \end{Bmatrix}$$

$$\nabla f(x) = (P_3 - P_1) + (c \cdot P_6 - c \cdot P_4) + (P_9 - P_7)$$

gradint along x

$$\nabla f(y) = (P_7 - P_1) + (c \cdot P_8 - c \cdot P_2) + (P_9 - P_3)$$

Prewitt = c = 1

$$mx = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

$$my = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

Ex: 7 intensity $\begin{bmatrix} 4 & 6 & 5 \\ 3 & 7 & 8 \\ 2 & 9 & 1 \end{bmatrix}$

$$mx \begin{bmatrix} -4 & 0 & 5 \\ -3 & 0 & 8 \\ -2 & 0 & 1 \end{bmatrix}$$

$$my = \begin{bmatrix} -4 & -6 & -5 \\ 0 & 0 & 0 \\ 2 & 9 & 1 \end{bmatrix}$$

$$\nabla x = \frac{1 + 5 + 1}{3} = 2.33$$

$$\nabla Y = \frac{2 + 6 + 4}{3} = 3$$

$$\text{gradient} = \sqrt{2.33^2 + 3^2} = 3.7985$$

Steps of RCGA:

1) Initialization - intialize ppn size by randomly generating set of individual from search space.

2) Roulette wheel selection - for min take reciprocal of fit value reciprogal & for further solving

3) Cross over probability - where 2 selected parent soln undergoes crossover to produce new offspring.

4) Cross over Siter - refers to locn in parent soln at which info. exchange occurs during crossover oprn

inappropriate → algo. exploration capability & lead to invalid soln generation

select → no. & locn of crossover

5) Mutation - small random changes in chromosome to explore new area.

- in rcga, no. which is repeating we exchange them by no. which is not present in string.

6) Exchange of genes -

- as mention mutation in RCGA we use combn method.

7) Optimum soln -

best soln to problem being optimize with given search space.

- iteratively applying we get better fitness.

Q.1 2 type of algo. use to explore search space to find goal state from starting state:

Uninformed Search Algo.:

- also called as blind search algo.
- It is a class of general purpose algorithm
- In uninformed search algo. cost function is not known to us.
- here, we do not have additional info. abt problem except problem def^n
- These algo. make decisions based on fully current state & available actions, without considering goal / structure of problem.
- This algo. explore entire search space

Ex - 1) Breadth - 1st search
2) ~~Best~~ depth 1st search
3) Iterative deepning search (IDS)

Informed Search algo: - It gives more efficient & accurate soln

- also known as heuristic search algorithm
- cost func^n is known to us
- this algo. uses additional information to increase efficiency of search.
- this info. is provided through heuristics
- this algo use heuristics to prioritize exploration of more promising path.
- By considering distance of goal, algo. can make informed decisions on which nodes to expand next.

Inform search algo. Ex:

1) Best 1st Search -
   - evaluate nodes based on heuristic func^n
   - It expands most promising node 1st, according heuristic func^n

2) A* search:
   - widely used algo. in AI.
   - it combines cost of path from start node to current node & current node to final point

3) Greedy best 1st search -
   - similar to A*

Theory questions:

Quest No. -
1, 2 (DFS), 3, 10 (rcga), 11, 12 (strategy), 14 (robot vision), 15, 21, 22, 23, 24, 25 (rcga), 26, 27, 29, 32, 33, 34, 35

rCGA
Robot vision
Imagined scale sorting

Q.11 Tabu Search

→

~~Tabu search algo. is~~ metheuristic optimization ~~(technique) Algo~~ used to solve optimization problems.

- Tabu Search introduced by fred Glover in late 1980's
- Inspired by human problem-solving behaviour.

  concep of tabu → [forbidden (not to allow)] movements in problem solving.

- Tabu search is metaheuristics optimization Algo. use to solve optimization problems.
- Tabu search maintains search trajectory while exploring sol^ space.
- It uses memory structure to store previous moves & avoids revising them in future,
- (allowing algo. to escape local optima & search for better sol^.)
- Key idea to use ~~me~~ short-memory, called tabu-list
- Tabu-list records recently visited sol^/moves.
- Tabu-list prevents algo. from returning to previously explored area & encourages explorations of new regions.

Applications :

1) Path planning
2) Task allocation
3) Scheduling
4) Conf^n optimization

1) Path planning -

In robotics path planning aims to find optimal or near-optimal path for robot to navigate from start pnt to goal point

2) Task Allocation -

— In multirobot system, tab goal is to assign tasks to robot optimally.

- algo. considers various factors like
  a) robot capabilities
  b) task requirements
  c) comm^n costs
  d) load balancing

3) Scheduling -

- Tabu search utilized for scheduling tasks in robotics systems,
where multiple tasks need to be executed coithin time constraints.

factors to be considered a) task priorities b) deadlines c) resource utilization

4) Conf^n optimization :

— use applied to optimize conf^n of robot, Such as placement of sensors & actuators.

- algo. explore diff. conf^n & evaluate based on factors a) cost b) reliability c) coverage

Q. 22 different methods to deal with moving obstacles

→

Dealing with moving obstacle is challenging task in robotics. it requires real-time perception, prediction & decision making to navigate safely & efficiently

here are some methods which develops to address this problem,

1) Reactive method
2) Predictive method
3) Model-based -lv
4) velocity obstacles
5) comm^n & coordination
6) Learning based (train fast)

1) Reactive Method: (fast & effective)

- this method based on immediate response to detected moving obstacle. it takes (utilize) data in real time.
- once obstacle detected robot adjust its trajectory to avoid collision.
- Not considered to be for long term planning.

2) Predictive Method:

- This method aims to predict future positions & behaviours of moving obstacles.
- This method utilize sensor data & motion Prediction algorithm to guess future trajectory for obstacles.
- By considering predicted obstacle position, robot plan its own trajectories to avoid collision.

3) Model-based methods:

- it involves building models of environment & moving obstacles.
- this include physical properties, motion patterns
- By adding models into planning & decision-making process,
- By taking this data robot can predict & react to movement of obstacles more effectively.

4. Velocity obstacles

- geometric constructs that possible velocities robot can take without colliding with moving

- By calculating velocity obstacles of moving obstacle, robot can plan its own trajectory to avoid intersecting with any obstacle.

5) Learning based -

- this approach uses ML technique to deal with moving obstacles.

- train model to recognize & predict behaviour of moving obstacle base on historical data,

- learnig from past, robot can make decision & take actions ~~based on~~ to avoid collision

23. Robot path planning Robot control in Dynamic environment.

→

Path planning of robot control in dynamic environment refers to process of determining optimal paths for robots to navigate & controlling their movement in real time.

- it is challenging task
- there should be effective & accurate models of dynamic environment. like modeling moving obstae such as human, robots, vehicles in motion.
- Model should capture trajectories, kinematic & behaviour pattern.

Gathering info:- 1) Gathering info about surrounding objects & movements.

2) various sensors use to detect & track obstacles.
↳ camera, radar, proximity, lidar.

3) gathered data then processed & provide i/p

Reactive & predictive approach:

1) it works combination, reactive approach focuses on immediate response & take action in real-time on moving obstacle.

2) Predictive approach predict future obstacle positions, allow Robot to plan its trajector & collisio free.

Motion planning & collision avoidance:

- aim to generate collision free path for robot while considering presence of obstacle.
algo. factors → velocities, trajectories, dynamic & kinematic

Safety considerations:

- Prioritize safety.
- well being of robot, human & other
- safety constraint such as min. distance Speed limits

App^n of GA for path planning: Read before exam from pdf

1) Problem formulation
2) Encoding
3) Population intialization
4) fitness evaluation
5) Genetic operations
6) offspring generations
7) Population update
8) Termination criteria

Q.26 Visibility graph method for robot path planning

→

- This method is popular approach for robot path planning in 2-D environment.
- It involves constructing graph that represents visibility relationships bet^n obstacle & then finding path through graph.
- visibility graph method based on concept of visibility bet^n points in 2D space.

1. Const^n of visibility graph:

① - 1st is to construct visibility based on given enviroment.

[Graph consist of nodes, such as start pnt, goal pnt, & vertices of obstacles]

2. Graph search for path planning:

② once visibility graph constructed, search algo. such as a* algo, find shortest path from starting point to goal point in graph.

(search algo, navigate through edges of graph, considers distance bet^n nodes as edge weights & identifies optimal path that avoid obstacles.)

3. Smoothing path -

③ After finding path in visibility graph,

- Post processing step called path smoothing
- it has aims to remove unnecessary zigzags / sharp turns from path to make it more feasible for robot to traverse

4. Implementing motion control -

(4) once final smooth path obtained robot's motion control algo. can applied to follow this path.

— this algo. determines appropriate velocity & steering commands for robot to traverse path smoothly & accurately.

Advantages :

1) simplicity - due to graph simple to implement & understand
2) Completeness - guarentees soln if exists
3) Optimality - find optimal path from start to goal.
4) gives collision-free path in 2D space

Limitations -

1) computational complexity
2) Lack of consideration for robot dynamics

App^n :

1) Robot Navigation
2) Path planning for autonomous vehicles
3) Motion planning for mobile robots

Q.22

App^ of S.A for robot motion planning

→

- SA is metaheuristic opt^ algo.
- use to solve complex opt^ problems

app^ of SA for robot motion planning as follows:

1) Problem formulation -

- in robot motion planning, goal is to find collision free path for robot to navigate from intial point to target position while avoiding obstacles in evironment.
- This problem is formulated as opt^ problem.
- wher objective is to minimize cost function associated with path, such as distance traveled time taken, / energy consumption.

2) Search space representation:

- search space consists of all possible conf^ / states of robot.
- each conf^ includes robot's position & orientation.
- search space can be contine / discrete depend on specific problem or DOF.

3) Initial Sol^ Generation:

represent candidate path for robot

- SA starts with by generating initial sol^,
- initial sol^ can be randomly generated or by simpler path planning algo.

4) Neighbourhood generation:

- SA explores search space by generating new candidate sol^ through smal modifications to current sol^.
- In robot motion planning, neighbourhood generations involves making local changes to robot's path, such as orientation of specific waypoints or adjusting positions.

5. Cost func^n evaluation:

- cost func^n evaluated for each candidate sol^n to determine fitness / quality.
- cost func^n measures performance of robot's path ~~generate~~ based on relevant factors.
  - distance travelled
  - smoothness
  - clearance from obstacles

6. Acceptance criteria:

- SA employs problistic criteria to decide wheather to accept new candidate sol^n or not.
- SA allows for accepting sol^n worse that current sol^n.

7. Annealing schedule:

- means how temp. parameter decided over time.
- initially temp. set is high, allowing algo. to search broadly.
- As algo. progresses temp. decreases

8. Termination Criteria:

- SA continuous generating new sol^n & updating current sol^n until termination cond^n met.
- Termination cond^n can be max no. of iterations, or acheiving satisfactory sol^n.

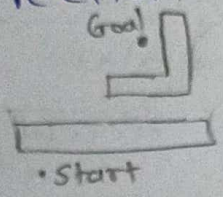
- app^n of SA for robot planing allow algo. to explore search space effectively & resulting in improved sol^n.
- ~~Base~~ By using acceptance criteria & annealing schedul SA balances exploration & exploitation, which enables algo. to find near optimal collision free paths for robot.

29. Write note on bug algorithms for obstacle avoidance

→

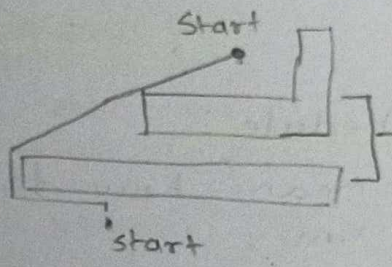
Basic philosophy -

- robots have similar constraints
- Bug algo. require basick knowledge to complete task
- Bug knows euclidian distance betⁿ arbitary points.
- Bugs knows direction to goal just like ant



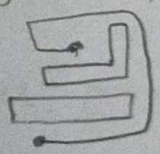
Bug 0 algorithm:

Repeat
1) head towards goal
2) while path to goal is blocked
3) follow obstacle edges
4) end while
5) end repeat



1) Repeat
2) head towards goal
3) while path to goal blocked
4) Follow obstacle edges
5) end while
6) end repeat

Bug trap



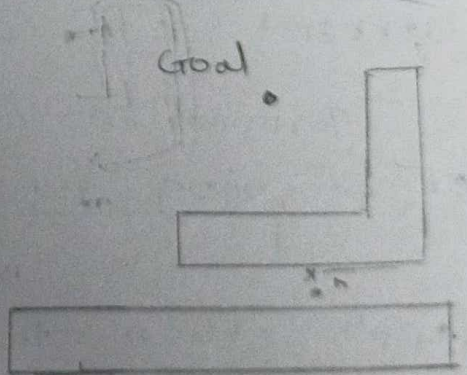
- Bug 0 had no ~~ba~~ way to back trap.
we have to add memory.

Bul 1- algorithm :

consider all choices before progressing

Exhaustive

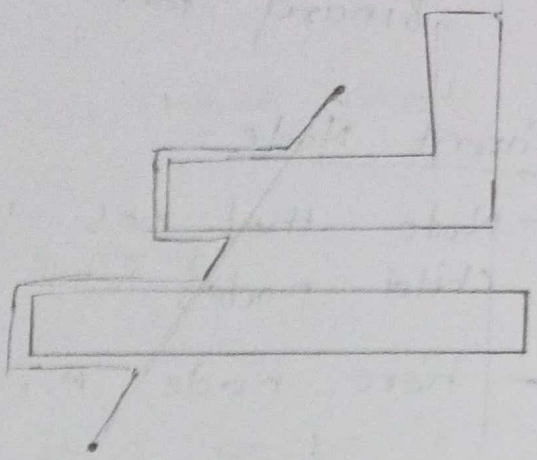
1. Repeat
2. head towards goal
3. while path to goal blocked
4. x := point where obstacle met
5. do
6. Follow obstacle edges all the way aroun
7. n := min. distance to goal
8. while not back at x
9. goto n
10. End while
11. End repeat



1) it's a greedy algo, take 1st thing which looks better
2) less predictable
3) we have to draw fine m-line for short path

Bug 2 – algorithm

1) while not at goal
2) follow m-line
3) while path to goal block
4) follow obstacle edges
5) if m-line met closer goal
6) then break
7) End while
8) End while

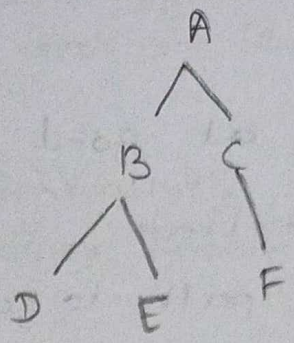


Comparision of performance of bug 1 & distance bug

- Bug1 & distance bug both are robot path planning
- they share some similarities, they also have some distinct char. that affect performance

Q.3

Binary tree :



Parent Node -

- Node that has 1/more child nodes
- here node A, B & C are parent node

A is paret node of B & C

B is parent node of D & E

C ı—ll ll— F

Leaf node : (terminal node) external

- Node that does not have any child nodes.
- or we can say node which is located at end of branch.
- In this example, D, E & F are leaf node

Internal & external node :

- Internal node : (non-leaf node)
  - Any node in binary tree which is not a leaf node.
  - node which has 1/more child node.
  - ~~degree of node can be 0, 1, 2~~
- in ex. A, B & C are internal node

- External node :
  - it is leaf node refer above

4. Degree of node:

- In binary tree, DON refers to no. of child nodes it has.

- in binary tree node. can have max 2 childeren left & righ.

∴ don can be 0, 1 or 2

- In given ex.
  - node A has degree of 2 becoz it has 2 child nodes (B, C)
  - node B has degree 2 becoz it has 2 child D & E
  - node C has degree 1 becoz it has only 1 child F.
  - node D, E, F have 0 DON since they do not have any childeren.

Q.14

Robot Vision system:

- Robot vision system is technology / technique that enable robot to see interpret surrounding visual info.
- Robot will be able to identify, navigate, inspect or handle parts.

Vision System has 2 type of images

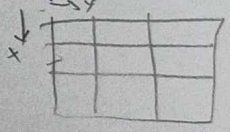
(Binary image) Grayscale image which is in 2D form
- it has 2 colors black & white
- it has 256 Possible shades
- 8 bit color format
- 16 bit color format (~~RGB~~) it has 65536 shades (2^{16})

Color image: RGB color image (0,0,0) (255,255,255)
- it is in 3D format

Red Green Blue channels of image.

Digitalization of image: convert analog → digital

1) Sampling:
- in sampling, divide image in set of sets
- in the form of grid



2) Quantification: assign numerical value
- no. represent intensity of reflected light which is defined in range 0-255.
- intensity of reflected light is also use to know geometry of object.
  ex. find CG of object.

Techniques for image analysis:
1) Template matching
2) Normalised cross coorelation
3) edge detection

a) Template matching-

template is small part of image

1) find transⁿ template.
2) find PI
3) min. value of pereformance index

demerits - 2 image compared should have same avg. intensities.

b) Normalised cross corelation:

- it is unitless, so it is independent of intensity we divide it by normal value it gives normal results.

c) Edge detection:

- at edge gradient of light intensity will be infinite.

Hen grandient operator use to locate edge.

Steps to find edge:

- if surface smooth gradient ~~or~~ zero E
- gradient const - any value ↙
- gradient have large value / infinite ⊥
- grandient of intensity ⟶ is criteria to find edg

it check pixel by pixel to find which pixel is on edge or not

for edge detection we use 2 operator

1) Prewitt
2) Sobel

Q.27 What is AS/RS ? what criteria to define Considerations

ASRS System - Computer controlled system for automactically storing & retrieving goods from storage loc^n

- AS/RS typically consist of comb^n of hlw comp. such as racks, shelves, conveyors & robotic system
- AS/RS uses ~~hig~~ advance technologies such as barcode scanning, RFID & comp. vision to identify track & manage inventory items.

Criteria for automated part storage in AS/RS:
1) Size 2) weight 3) waiting time

1) **Part size** - AS/RS designed to handle various sizes
   - size of part needs to be compatible with dimension of storage system
   - depending on type size varies.

2) **Part weight** - weigh of part need to be considered
   - while designing AS/RS system for particular app
   - System ~~should~~ must be able to handle weight of parts & ensure that store & retrieve safely.

3) **Waiting time** - waiting time for parts stored in AS/RS should be minimal.
   - system must design to ensure that parts or retrieved quickly & efficiently to minimize waiting time.

Techniques for AS/RS :

AS/RS employs on various techniques to automate.

1) Vertical Lift modules (VLMs) :

- VLMs are tall, vertical structure consist of multiple trays / shelves
- system utilizes automated vertical lift mechanism
- fast & efficient access to store & retrieve

ex. Car manufacturing facility to store & retrieve automated parts.

2) Horizontal carousel :

carousel - rotating machine

- consist of series of rotating bing that move horizontantally along track
- maximizes floor space utilization & reduce time req. for item retrieval.

ex :- pharmacian use horizontal carouse to store & retrieve medicines

3) Vertical carousel -

- here shelves rotate vertically only.
- suitable for small parts with high picking freq.

ex. electronics mfg.

Q.15 Imaging based automatic sorting & inspection

→ - These systems are advance technologies used in industries.

- It is imaging based automatic sorting & inspection used imaging technology including camera, sensors, computer vision algo.

due to this sort & inspection of material runs automatically in smooth way.

- This system speed up sorting & inspection but also eliminates errors (that may occur when human carry out this tasks)

- This system increase productivity due to automation & also improves quality of product due to high precision algo.

ex: in industrial mfg. this tech. use to detect & remove defective products from prod^n line reducing waste & maintaining quality.

→ inspection system will prgm to detect defects such as crack chipis and faring parameters accordingly.

- This helps to ensure that only high-quali products are delivered to customers

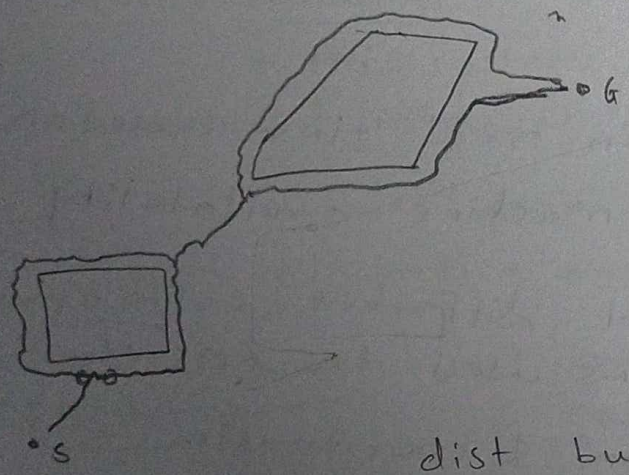
comparision of bug1 & distance bug

Bug 1

merits - complete algo.
(in finite time finds paths if path exist or terminate with failure if it is not)

demerits -

1) large memory & computation required, which leads to less efficiency
2) it is exhaustive.
3) slowest one
4) path length more



dist bug

1) robot visits every edge of obstacle which it faces during its motion.

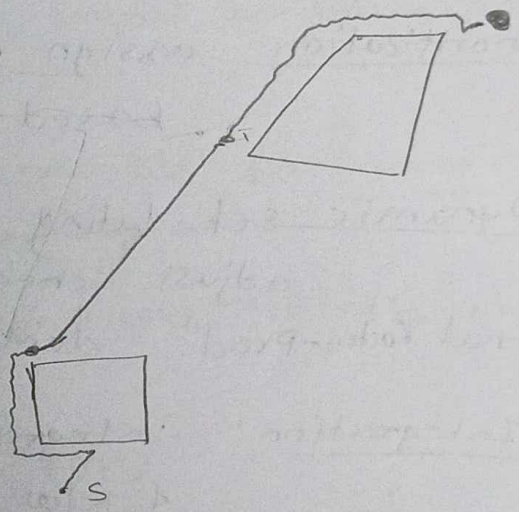
distance bug

merits -

1) traverses less distance than bug1 to reach
2) use use info. coming from range sensors efficiently.
3) shotest path length

demerits.

1) think about obstacle when it encounters one



1) This algo. robots use its sensors efficiently so that it is capable of finding shortes path.
it shoters path efficiently

32. Explain real time scheduling in FMS

→ Real time scheduling (RTS) in FMS refers to process of allocating & manging resources.

- Goal: optimize utilization of equipment & minimize downtime while meeting targets.

Key features of RTS in FMS:

1. Task allocation - which task should allocate to which resource.
2. Control & monitoring: ensures each task executed on time & according to sequence
3. Prioritization - assign priorities to different tasks based on ~~prod~~ & imp. & urgence.
4. Dynamic scheduling: adjust schedules in real-time based on external factors-Prodⁿ demand, machine availability
5. Integration: integration of different softwares & hlw systems used in FMS to improve commⁿ & coordination.

techniques - mathematical optⁿ
Heuristic algo & simulation.

Components of FMS:

- CNC machines
- Robotics system
- AGVs
- Material handling system
- Computer control system

1) CNC machines - programable machines, perform mfg opr^n milling, turning, driling, grinding.

2) Robotic system - to automate tasks that require Accuracy, high speed opr^n.

robots perform tasks such as material handling, assembly, w- . . .

3) AGVs:
- are autonomoles mobile robots that transport material
- Navigate using sensors & follow predefine path

4) Material handling:
- this systems are responsible for movement, storage & retrieval of materials.
- this system has conveyors, lifters, robotic arm for transporting materials.

5) Coputer control system:
- brain of FMS
- manges & coordinate opr^n

includes slw prgm, control algo & interfaces

Write notes on

→

i) Automatic Tool path generation:

- Crucial component of CAM use in mfg. process
- It creates accurate & optimize path for cutting tool to follow when machining a part.

Features:

1) CAM s/w uses algo. & mathematical model to generate tool path. base on design geometry & requirement

~~2) Automatic tool path generation optimizes~~

2) tool path takes into account factors such as cutting tool geometry, material properties, machining opn

3) automatic tool path gereration optimizes tool's movement to minimize machining time, reduce tool wear & avoid collision

factors consider - tool orientation
cutting forces
accessibility
material removal rate.

---

ii) Application of AI technique in FMS:

- plays crucial role
- intelligent decision making algo.

~~Adaptive control~~ -
Predictive maintainance - ai algo. use to predict when machinery may experience breakdown or require maintainance.

Production optimization - ai help optimize prodn process in FMS.

quality control - improve quality control in FMS
ai identify defects which miss by human

material handling - ai help to automate MH in FMS

- ai algo. can optimize material flow & reduce

~~Supply chain mgt~~ need - Fault detection

iii) Flexible mfg. system: Read

- FMS is advance mfg. system that combines computer controlled machines, robots & automated material handling systems to produce wide range of products with high-efficiency & adaptability.
- system handles mfg. operⁿ such as assembly, testing, inspection, allow for versatile prodⁿ
- Benefits - increase productivity
  reduce customization
  market demand quick response.
- industries - automotive
  aerospace
  electronics
  consumer good mfg.

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iv) Role of Artificial intelligence in FMS:

intelligent decision making

adaptive control

predictive maintainance

Robotics & automation

Quality control & inspection

Data analytics & optimization