AI Midterm Revision

Chapter 1

- AI Perspective:

✓ artificial intelligence as "**the study and design of intelligent agents**"
where an intelligent agent is a system that perceives its environment and takes actions which maximize its chances of success

- What is AI?

✓ These are our **four** wings for an AI application:

1. Thinking humanly	The exciting new effort to make computers think machines with minds, in the full literal sense
2. Thinking rationally (Correct behavior)	The study of the computations that make it possible to perceive, reason, and act
3. Acting humanly	The art of creating machines that perform functions that require intelligence when performed by people
4. Acting rationally	Computational intelligence is the study of the design of intelligence agents

- AI State of the art:

✓ Deep Blue defeated the world chess champion Garry Kasparov in 1997

✓ Proved a mathematical conjecture (Guising) unsolved for decades

✓ No hands across America (driving autonomously 98% of the time from Pittsburgh to San Diego)

✓ During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people

✓ NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft

✓ Some programs solve crossword puzzles better than most humans

Chapter 2:

- FAQ (EL doctor 3ardhom 2al enha mohma)
- LFR and Its applications

- **Robot Components (What makes a Robot)**
  1. Power Supply
  2. Movable Physical Structure
  3. Sensors
  4. Effector Actuators
  5. Motion System
  6. On-Board computer system
  7. Controllers for all the above
- **What are Robots good at?**
  - ✓ What is hard for humans is easy for robots.
    1. Repetitive Tasks
    2. Continuous Operations
    3. Complicated Calculations
    4. Refer to huge database
  - ✓ What is easy for humans is hard for robots.
    1. Reasoning
    2. Adapting to new situations
    3. Flexible to changing requirements.
    4. Integrating multiple sensors
    5. Resolving conflicting data
    6. Synthesizing unrelated information
    7. Creativity
- **What Tasks Would You Give the Robot?**
  - ✓ Dangerous (space exploration-chemical spill cleanup-disarming bombs -disaster cleanup)
  - ✓ Boring or Repetitive (welding car frame-part pick and place -manufacturing parts)
  - ✓ High Precision or High Speed (Electronics testing -surgery -precision machining)

- **Actions of Robots can be categorized as:**
  1. Actuators(pneumatic :working by air,- Hydraulic: use of pressurized liquids – electric solenoid)
  2. Motors(Analog: continuous-Stepping: discrete increments)
  3. Gears ,belts ,screws and levers
  4. Manipulations
  - **Actions of Robots can be classified according to movement as:**
    1. **Pick and Place: Move items between points.**
    2. **Continuous Path: Moves along a programmable path**
    3. **Sensory: Employs sensors for feedback**
  - **How do Robots Move?**
    1. Simple Joints (2D):
       - Prismatic (Sliding along one axis)
       - Revolute (Rotating about one axis)
    2. Compound Joints (3D)
       - Ball and Socket= 3 revolute points
       - Round cylinder in tube=1 prismatic,1 revolute

Degrees of Freedom = Number of independent Motion

e.g. 3 degrees of freedom:2 translation,1 rotation

6 degrees of freedom:3 translation,3 rotation)

MOBILITY

Legs

Wheels

Tracks

Crawls

Rolls

- **<u>What Sensors Might Robots Have and its uses?</u>**

Sensor Types

1. Optical (Laser/Radar – 3D- Color Spectrum)
2. Pressure
3. Temperature
4. Chemical
5. Motion and Accelerometer
6. Acoustic (Ultrasonic)

Sensors Use

Used for feedback.

Uses sensors for Control - the Brain

- Open loop, i.e., no feedback, deterministic(Instructions and Rules).
- Closed loop, i.e., feedback (Learn and Adapt).

MEASURES OF PERFORMANCE

- **Speed and acceleration**
  - Faster speed often reduces resolution or increases cost
  - Varies depending on position, load.
  - Speed can be limited by the task the robot performs (welding, cutting)
- **Resolution(measure of movement)**
  - Often a speed tradeoff
  - The smallest movement the robot can make
- **Working volume (measure of theatre of operation)**
  - The space within which the robot operates.
  - Larger volume costs more but can increase the capabilities of a robot

Performance (cont.)

- **Accuracy of Implementation**
  - The difference between the actual position of the robot and the programmed position
  - Repeatability
    - ➢ Will the robot always return to the same point under the same control conditions?
    - ➢ Varies depending on position, load?
- **Cost**
  - Typically a tradeoff – improved performance on other metrics vs lower cost

WHAT ARE SOME PROBLEMS WITH CONTROL OF ROBOT ACTIONS?

Joint play, compounded through N joints.

Accelerating masses produce vibration, elastic deformations in links.

Torques, stresses transmitted depending on end actuator loads.

Feedback loop creates instabilities.
- **Delay between sensing and reaction.**

Firmware and software problems
- **Especially with more intelligent approaches**

WHY IS ROBOTICS HARD?
(TECHNOLOGY LIMITATIONS)

- **Sensors are limited and simple**
- **Manipulators (Effectors) are limited and simple**
- **State (internal and external, but mostly external) is partially-observable**
- **Environment is *dynamic* (changing over time)**
- **Environment is full of potentially -useful information**

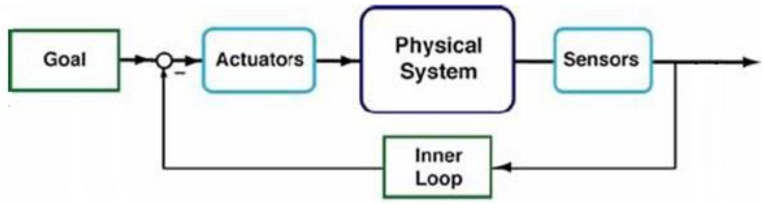
WHAT SUBSYSTEMS MAKE UP A ROBOT?

Action
- **Stationary base**
- **Mobile**

Sensors

Control

Power supply



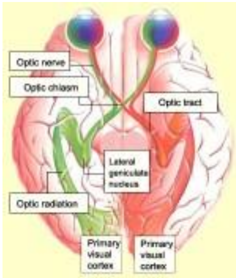
ROBOT ACTUATORS

Beep

Motors

LED Lights

WHAT DOES BUILDING ROBOTS TEACH US ABOUT HUMANS?



How do our sensors work?

- eyes
- brain

How do we integrate sensors?

How does our muscular-skeletal system work?

- How do we grab and hold an object?

How does our brain process information?

What is nature of intelligence?

How do we make decisions?

Chapter 3

Intelligent Agents

- **What is an agent?**
  Is anything that can be viewed as perceiving its environment through sensors and acting through actuators.
- **What are types of agents?**

  Human agent:

  - eyes, ears, other organs for sensors
  - hands , legs, mouth, and other body parts for actuators

  Robotic agent:

  - cameras and infrared range finders for sensors
  - various motors for actuators

What are capabilities of Intelligent Agents

Capabilities of Intelligent Agents

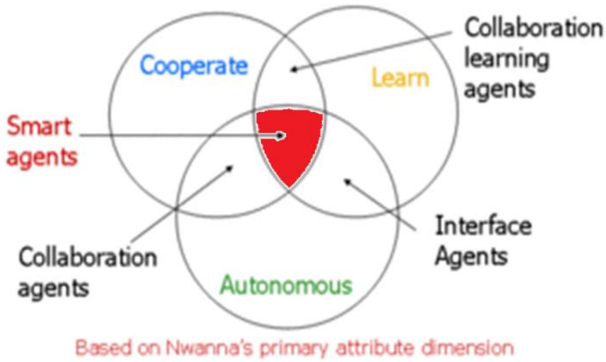
• **ability to *adapt***

Adaptation implies sensing the environment and reconfiguring in response.

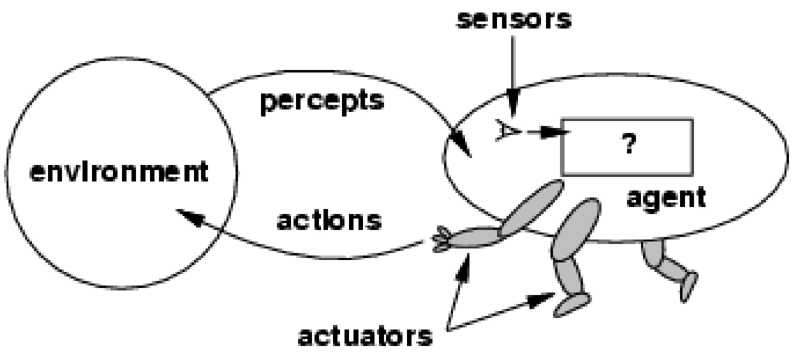
- **This can be achieved through:**
  - **the choice of alternative problem-solving-rules or algorithms**
  - **the discovery of problem solving strategies.**
  - **other aspects of an agent's internal construction, such as recruiting processor or storage resources.**

• **ability to *learn***

- **Learning may proceed through trial-and-error, then it implies a capability of introspection and analysis of behavior and success.**
- **Alternatively, learning may proceed by example and generalization, then it implies a capacity to abstract and generalize.**

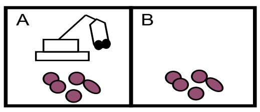


• Agents and Environments



agent = architecture + program

A Vacuum-cleaner agent



- **Percepts**: location and contents, e.g., *(A,dirty)*
  - *(Idealization: locations are discrete)*
- **Actions**: move, clean, do nothing: *LEFT, RIGHT, SUCK, NOP*

Vacuum-cleaner world: agent function

Percept sequence	Action
$[A, Clean]$	$Right$
$[A, Dirty]$	$Suck$
$[B, Clean]$	$Left$
$[B, Dirty]$	$Suck$
$[A, Clean]$, $[A, Clean]$	$Right$
$[A, Clean]$, $[A, Dirty]$	$Suck$
⋮	⋮

```
function REFLEX-VACUUM-AGENT([location,status]) returns an action
   if status = Dirty then return Suck
   else if location = A then return Right
   else if location = B then return Left
```

• Rational Agents

- The right action is the one that will cause the agent to be most successful
- Performance measure: An objective criterion for success of an agent's behavior
- e.g., performance measure of a vacuum-cleaner agent could be:
    - amount of dirt cleaned up,
    - amount of time taken,
    - amount of electricity consumed,
    - amount of noise generated

2.3 PEAS (Task Environment Description)

- **PEAS: Performance measure, Environment, Actuators, Sensors**
- **Must first specify the setting for intelligent agent design**
- **Consider, e.g., the task of designing an automated taxi driver:**
    - **Performance measure**
    - **Environment**
    - **Actuators**
    - **Sensors**

PEAS: Specifying an automated taxi driver

*P*erformance measure:

- safe, fast, legal, comfortable, maximize profits

*E*nvironment:

- roads, other traffic, pedestrians, customers

*A*ctuators:

- steering, accelerator, brake, signal, horn

*S*ensors:

- cameras, sonar, speedometer, GPS

PEAS EXAMPLE 2
Agent: Medical Diagnosis System

- **Performance measure: Healthy patient, minimize costs, lawsuits**
- **Environment Patient, hospital, staff**
- **Actuators: Screen display (questions, tests, diagnoses, treatments, referrals)**
- **Sensors: Keyboard (entry of symptoms, findings, patient's answers)**

PEAS EXAMPLE 3
Agent: Part-Picking Robot

- **Performance measure**: Percentage of parts in correct bins
- **Environment**: Conveyor belt with parts, bins
- **Actuators**: Jointed arm and hand
- **Sensors**: Camera, joint angle sensors

PEAS EXAMPLE 4
Agent: Interactive English tutor

- **Performance measure**: Maximize student's score on test
- **Environment**: Set of students
- **Actuators**: Screen display (exercises, suggestions, corrections)
- **Sensors**: Keyboard

Agent	Performance measure	Environment	Actuators	Sensors
Medical Diagnose	- Healthy patient - Minimized cost	- Patient - Hospital - Staff	- Tests - Treatments	Keyboard Entry of symptoms, findings, patient's answers
Vacuum Cleaner	- Cleanness - Efficiency - Battery life - Security	- Room - Table - Wood floor - Carpet - Various obstacles	- Wheels - Brushes - Vacuum Extractor	- Camera - Dirt detection sensor - Cliff sensor - Bump Sensor - Infrared Wall Sensor
Part - picking Robot	- Percentage of parts in correct bins.	- Conveyor belt with parts, - Bins	- Jointed Arms - Hand	- Camera - Joint angle sensors.
Refinery Controller	- Purity - Yield - Safety	- Refinery - Operators	- Valves, Pumps - Heaters - Displays	- Temperature - Pressure - Chemical Sensors
Interactive English Tutor	- Student's score on test	- Set of Students - Testing Agency	Display of exercises, - suggestions - corrections	- Keyboard Entry

- **Environment types**

1) **Fully Observable:** An agent's sensors give it access to the complete state of environment at each point in time.
   (3ks fully observable ,howa partially observable)
2) **Deterministic:** The next state of the environment is completely determined by current state and the action executed by agent.

(3ks fully deterministic ,howa stochastic)

3) **Periodic:** Agent's experience divided into loosely connected modules.

(3ks fully Periodic ,howa sequential)

4) **Static:** The environment is unchanged while an agent is studying its decision about action.

(3ks static howa dynamic)

5) **Discrete:** A limited number of distinct, clearly defined percepts and actions.
   (3ks Discrete howa Continous)
6) **Single Agent:** An agent operating by itself in an environment.
   (3ks single agent howa multivalent)

- **Agent types**

1. **First Vision**
   - Physical Agents: Is an entity which *percepts* through sensors and *acts* through actuators(as a traditional agent).
   - Temporal Agents: A temporal agent may use time based stored information to offer instructions or *data acts* to a computer program or human being and takes program *inputs percepts* to adjust its next behaviors.
   - Believable Agents: An agent exhibiting a personality via the use of an artificial character for the interaction to practically express believes (believes against characters).
2. **Second Vision**

[Hena mohm hett enk ezay hat7wl simple reflex agent to model based]

2.5.1Simple reflex agents

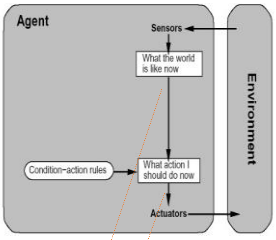
- **Acts only on the basis of the current percept. The agent function is based on the *condition-action rule*:**

  if condition then action rule

- **This agent function only succeeds when the environment is fully observable.**

- **Some reflex agents can also contain information on their current state which allows them to disregard conditions whose actuators are already triggered (self filtering).**

Simple reflexagent-contn



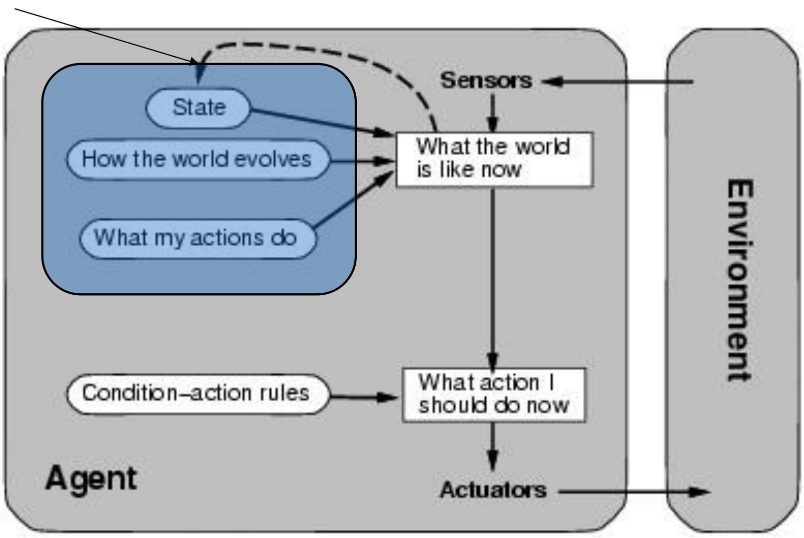

```
function REFLEX_VACUUM_AGENT( percept )
    returns an action

    (location,status) = UPDATE_STATE( percept )

    if status = DIRTY then return SUCK;
    else if location = A then return RIGHT;
    else if location = B then return LEFT;
```

Simple reflex agent-contn

- **Implementation and properties**
  - function *ReflexAgentWithState* (*percept*) returns action
    - static: *state*, description of current world state;
      rules, set of condition-action rules
    - *state* ← *Update-State* (*state, percept*)
    - *rule* ← *Rule-Match* (*state, rules*)
    - *action* ← *Rule-Action* {*rule*}
    - return *action*
- **Advantages**
  - Selection of best action based only on current state of world and rules
  - Able to reason over past states of world
  - Still efficient, *somewhat* more robust
- **Limitations and Disadvantages**
  - No way to express goals and preferences relative to goals
  - Still limited range of applicability

Model-based reflex agents-contn

New

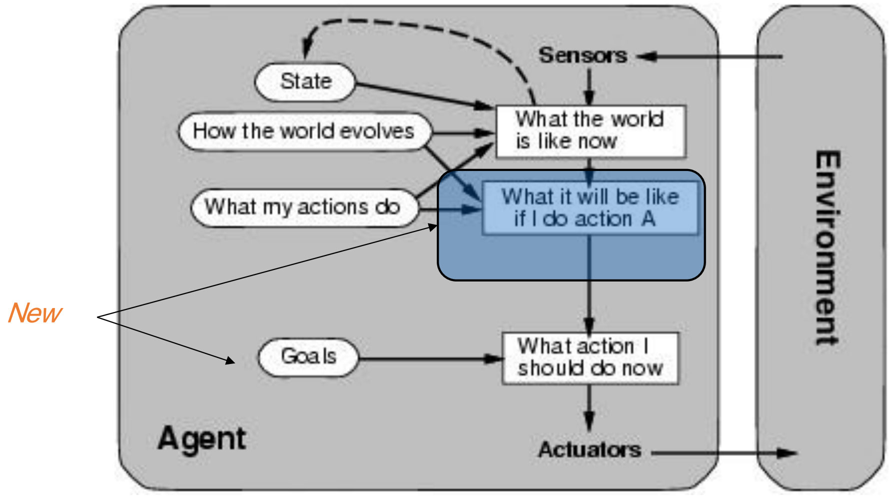


- Model-based agents can handle partially observable environments.
- Its current state is stored inside the agent maintaining some kind of structure which describes the part of the world which cannot be seen.
- This behavior requires information on how the world behaves and works. This additional information completes the "World View" model.

2.5.3 Utility-based agents

- **Goal-based agents only distinguish between goal states and non-goal states.**
- **It is possible to define a measure of how desirable a particular state is.**
- **This measure can be obtained through the use of a *utility function* which maps a state to a measure of the utility of the state.**

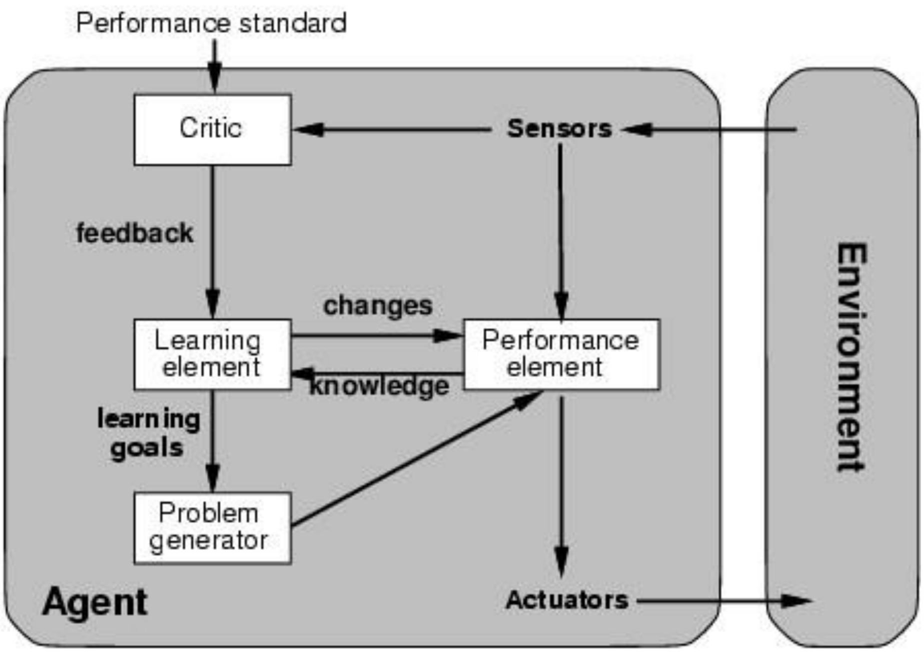
Goal-based agents-contn



Goal-based agents-contn

- Implementation and Properties
  - Functional description
    - Complete description using classical planning
    - Requires more formal specification
- Advantages
  - Able to reason over goal, intermediate, and initial states
  - Basis: automated reasoning
    - One implementation: theorem proving (first-order logic)
    - Powerful representation language and inference mechanism
- Limitations and Disadvantages
  - Efficiency limitations: can't feasible solve many general problems
  - No way to express preferences

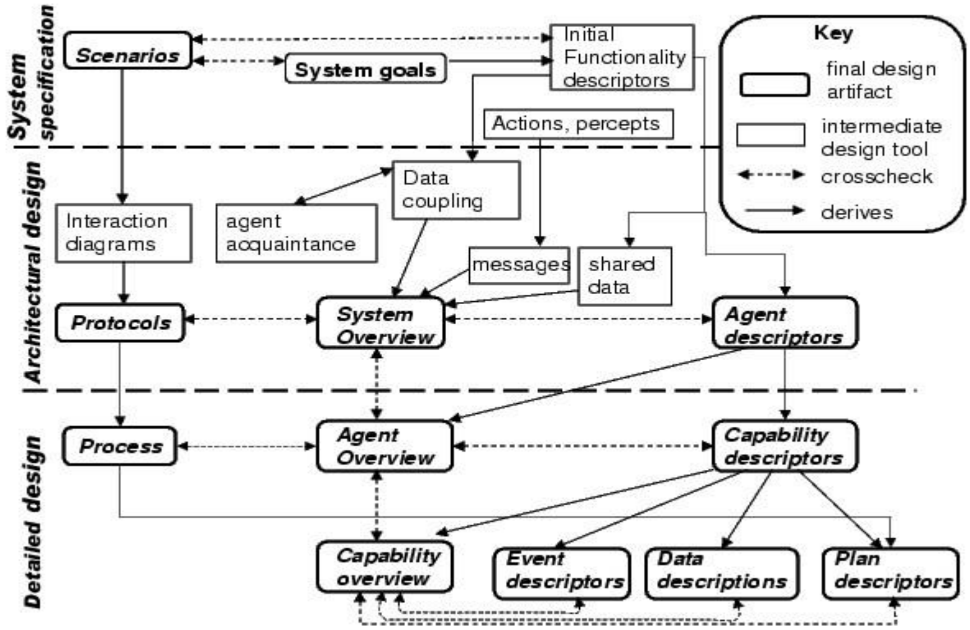
2.5.5 Learning agents



Learning Agents Components

- New components:
  - Learning element – Makes improvements to performance element
  - Performance element – Selects actions – Previously this was the whole agent
  - Critic – Gives performance feedback to learning element – Needed because precepts don 't capture performance
  - Problem generator – Suggests innovative actions

2.8 Intelligent Agent Design

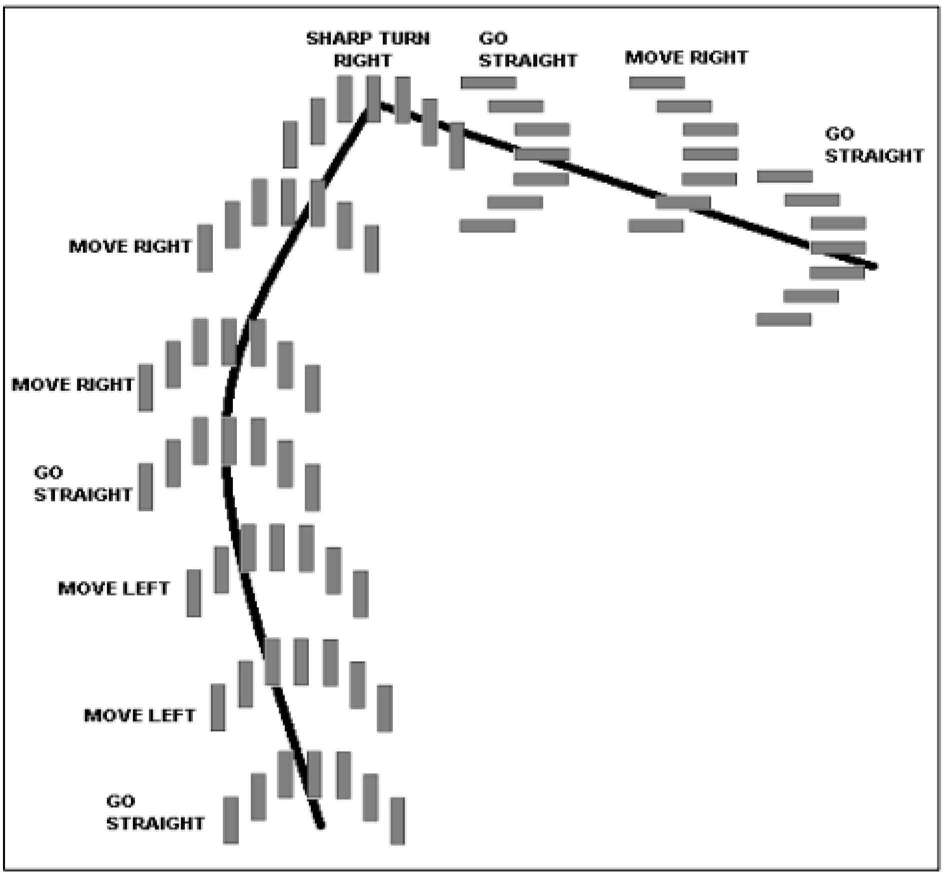


Intelligent Agent Design issues

- how tasks are scheduled and how synchronization of tasks is achieved ?
- how tasks are prioritized by agents ?
- how agents can collaborate, or recruit resources?
- how agents can be re-instantiated in different environments, and how their internal state can be stored?
- how the environment will be probed and how a change of environment leads to behavioral changes of the agents?
- how messaging and communication can be achieved?
- what hierarchies of agents are useful (e.g. task execution agents, scheduling agents, resource providers …)?

Exam Questions

- **LFR (Line Following Robot):[Exam 2021-2022-2018]**



Requirements:

1) Robot must be capable of following line.
2) Should be capable of taking various degrees of turns.
3) Must be prepared for a situation that it runs into a territory which has no line to follow.
4) Must be capable of following a line even if it has breaks.
5) Must be insensitive to environmental factors (lighting and noise).
6) Must allow calibration of lines darkness threshold.
7) Scalability must be a primary concern in design.
8) The color of line mustn't be a factor as long as it is darker than surroundings.

LFR Applications

(Industrial automated equipment carriers, automated cars, tour guides in museums and other similar applications and second wave robotic reconnaissance. operations).

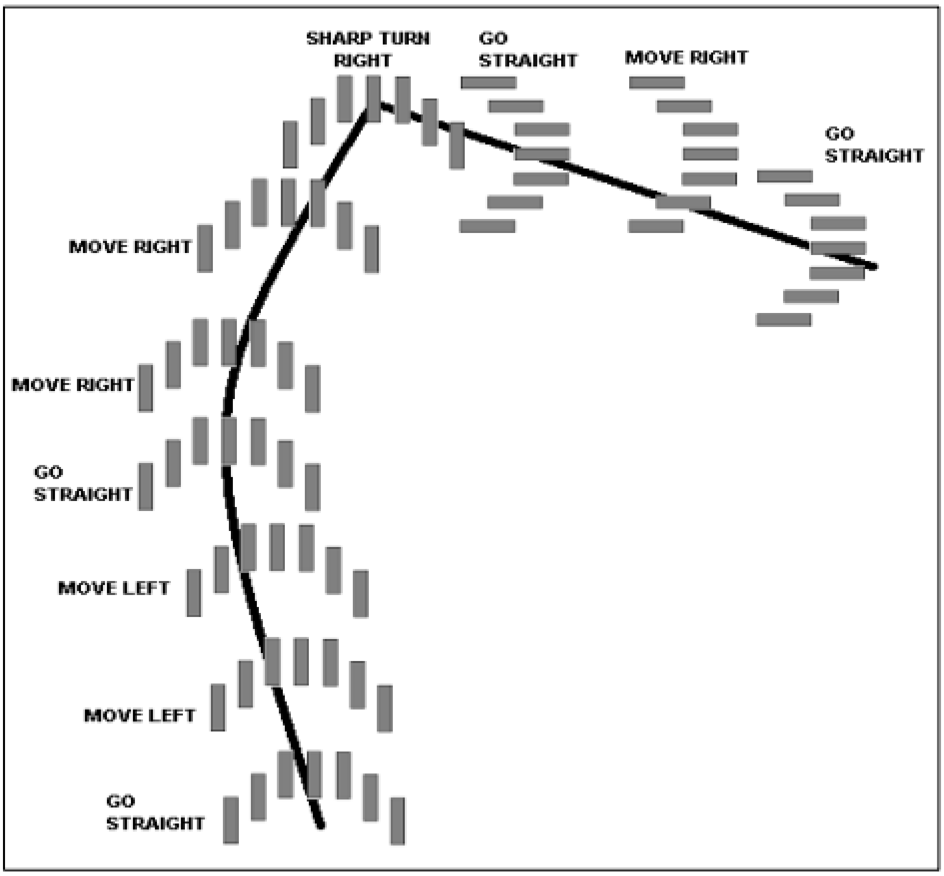
Questions:

a) Is this type of robot could be considered as LFR? why?

Yes,

- Robot must be capable of following line.
- Should be capable of taking various degrees of turns.
- Must be prepared for a situation that it runs into a territory which has no line to follow.
- Must be capable of following a line even if it has breaks.
- Must be insensitive to environmental factors (lighting and noise).
- Must allow calibration of lines darkness threshold.
- Scalability must be a primary concern in design.
- The color of line mustn't be a factor as long as it is darker than surroundings.

b) Draw the trajectory on earth for it



c) What are these robots good at?

LFR used for tour guides in museum will be good at doing repetitive guides without getting tired or missing anything, like humans.

d) What are other applications would you give to this robot?

Industrial automated equipment carriers, vacuum cleaner and automated cars.

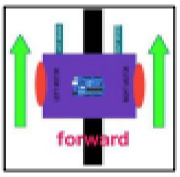
e) What Does building these robots teach us about humans?

Building LFR robots teach us :how our muscular-skeletal system work, how our sensors work(eyes, brain) and how do we make decisions.

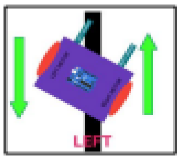
f) How do these robots move?

(d) A typical line follower robot has two sets of motors, let's call them left motor and right motor. Both motors rotate on the basis of the signal received from the left and the right sensors respectively. The robot needs to perform 4 sets of motion which includes moving forward, turning left, turning right and coming to a halt. The description about the cases are given below.

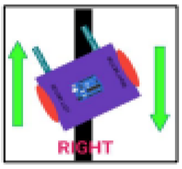
1. **Moving forward:**
In this case, when both the sensors are on a white surface and the line is between the two sensors, the robot should move forward.



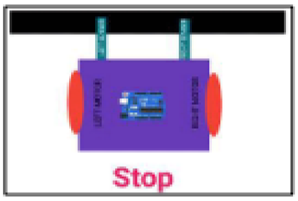
2. **Turning Left:**
In this case, the left sensor is on top of the dark line, whereas the right sensor is on the white part, hence the left sensor detects the black line and gives a signal, to the microcontroller. Since, signal comes from the left sensor, the robot should turn to the left direction. Therefore, the left motor rotates backwards and the right motor rotates in forward direction. Thus, the robot turns towards left side.



3. **Turning Right:**
This case is similar to the left case, but in this situation only the right sensor detects the line which means that the robot should turn in the right direction. To turn the robot towards the right direction, the left motor rotates forward and the right motor rotates backwards and as a result, the robot turns towards the right direction.



4. **Stopping:**
In this case, both the sensors are on top of the line and they can detect the black line simultaneously, the microcontroller is fed to consider this situation as a process for halt. Hence, both the motors are stopped, which causes the robot to stop moving.



g) What sensors might these robots have?

LFR will need optical sensors to know where he is guiding,motion and accelerometer sensor to move wisely.

h) **What are some problems with control of these robot actions?**

- Joint play, compounded through N joints.
- Accelerating masses produce vibration, elastic deformations in links.
- Torques, stresses transmitted depending on end actuator loads.
- Feedback loop creates instabilities.
    - Delay between sensing and reaction.
- Firmware and software problems
    - Especially with more intelligent approaches

i) How do you measures performance of such robot?

MEASURES OF PERFORMANCE

- Speed and acceleration
  - Faster speed often reduces resolution or increases cost
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  - Speed can be limited by the task the robot performs (welding, cutting)
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Performance (cont.)

- Accuracy of Implementation
  - The difference between the actual position of the robot and the programmed position
  - Repeatability
    - Will the robot always return to the same point under the same control conditions?
    - Varies depending on position, load?
- Cost
  - Typically a tradeoff – improved performance on other metrics vs lower cost

Question 2: [6 Marks]

Assume you have a **simple reflex agent** behave as follows:

```
function REFLEX_VACUUM_AGENT( percept )
        returns an action
        (location,status) = UPDATE_STATE( percept )
        if status = DIRTY then return SUCK;
        else if location = A then return RIGHT;
              else if location = B then return LEFT;
```

1

(a) Analyze the relation between the **code** and the **design** to accomplish the job of the Reflex Vacuum. **(2 Marks)**

(b) Determine the Task Environment Description for this agent in form of (**PEAS**): Performance measure, Environment, Actuators, Sensors. **(2 Marks)**

(c) Add your convenient **modification** to the design and the code to accomplish **Model-based** reflex Vacuum agents. **(2 Marks)**

a) Algorithm:
Percepts: location & content (location sensor, dirt sensor)
Actions: Left, Right, Suck, NoOp

Percept	Action
[A, clean]	Right
[A, dirty]	Suck
[B, clean]	Left
[B, dirty]	Suck

b)

PEAS:

Performance: amount of dirt cleaned up,

amount of time taken,

amount of electricity consumed,

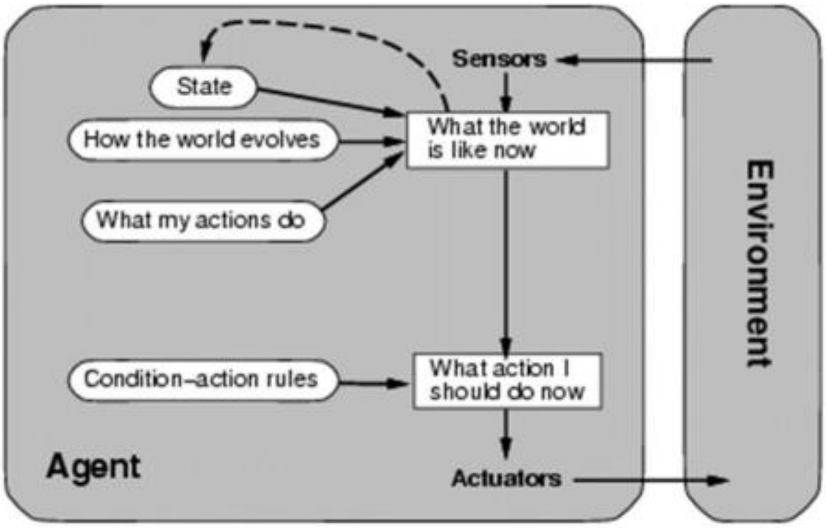
amount of noise generated

Environment: Room, Table, Wood floor, Carpet, Various obstacles

Actuators: Wheels, Brushes, Vacuum Extractor

Sensors: Camera, dirt detection sensor, cliff sensor, bump sensor, infrared wall sensor

c)



Function MODEL-BASED-REFLEX-AGENT (*percept*) **returns** an action

Persistent: *state*, the agent's current conception of the world state

model, a description of how the next state depends on the current state and action

rules, a set of condition-action rules

action, the most recent action, initially none

state<- UPDATE-STATE (state, action percept, model)

rule <- RULE-MATCH(state, rules)

action <- rule.ACTION

return action

Question 3: [4 Marks]

As a result of the difficulties brought by COVID-19 and its associated lockdowns, many individuals and companies have turned to robots in order to overcome the challenges of the pandemic using the Artificial Intelligence applications.

(a) Illustrate how the Artificial Intelligence applications can support facing this challenges? **(2 Marks)**

(b) Do you think AI applications could outperform the human being in the "Testing Capacity & Biological Lab Automation" process? How? **(2 Marks)**

a)

1. Diagnosis & screening
2. Surgery & telehealth
3. Social & care
4. Logistics & manufacturing [package delivery]
5. Drones

b) Yes, since it has greatly saved time & costs & kept the lab workers safe. The system can increase the throughput to 4000 samples a day.
In Italy, the "pipetting" process is automated to reduce the human tester's fatigue from processing the pipette repeatedly. Thus, samples are analyzed up to 450 samples/hour.

China, has developed a dual-arm robot that could handle hazardous biomaterial sampling, this has increased testing Capacity to 100 of samples daily.