Q: Consider a robot that can pick crates off a shelf and deliver them to a packing area in a warehouse.

1. List two sensors and two actuators this robot may have
   1. Optical sensor (Camera); Inertial Measurement Unit (Accelerometer, Gyroscope, Magnetometer)
   2. Electric actuator(for transportation); Pneumatic actuator(for load lifting)
2. What internal system disturbances may be present?
   1. Short-Term: Warehouse electrical outage (no visual orientation possible); Server outage (no task update); Packing area outage(traffic clogging);
3. What external environmental disturbances may be present?
   1. Await for robot’s repairment details; Robotics usage policy changes; Disaster crisis of drought and flood;
4. Name one safety concern there may be with this robot, and explain how you would mitigate it
   1. As for a self-driving robot the biggest safety concern is optical sensor malfunction in object detection, specifically, unintended collision. Hence, I would recommend using a LiDAR in order to check for nearby objects and distance to them, so that a robot doesn’t run into/over an obstacle like human being.

(5 marks)

Q: When selecting parents in a genetic algorithm, we want to preserve some small chance that parents with a low fitness may be chosen. Explain why this is, using a relevant example.

A: In order to prevent the premature convergence, some of the parents should have lower fitness levels. This way the solution stays diverse and does not follow one extremely fitting pattern. GA’s are all about optimization and in case with premature convergence, even if the solution is correct it will probably not be the most optimal one, hence, it is crucial for GA to maintain adequate diversity within its pool.

(5 marks)

Q: Explain what a linearly separable problem is. You may make use of an example in your explanation.

Linearly separable problem is pretty self-explanatory by its name already. This is a problem with two data sets that can be separated by at least one line. The best way to visualize it is to put two input classes on a 2D plane and colour them in two different colours. Let’s take OR activation problem as an example, take a look at the graph below:

As you can see sets of values that activate this function can be easily separated from the values that don’t activate this function by a single straight line. This is what a linearly separable problem is.

(5 marks)

Q: What is sensor noise? Choose a relevant sensor to use in your explanation.

Sensor noise produced by Optical Sensor such as Camera is the result of the information transfer from sensor to the computer. Digital image or frame undergoes a series of picture correction processing’s such as light, colour and frame stabilization/normalization, those processes could lead to some noises in the picture output.

(5 marks)

Q: Consider a neural network that is trained to accept a 128-by-128 pixel image and determine whether or not a face is present in it.

1. How might the image be represented to the network?
   1. The image might be edited into a greyscale and put into a sequence of numbers starting from the top left and ending with the bottom right pixel. The input would be a 128D vector.
2. Describe two ways the output might be presented by the network
   1. Output image having isolated face
   2. Boolean answer containing info about location in the picture as well as its bounding box.
3. What is the minimum number of layers needed to solve this problem?
   1. 4 layers: in the first layer computer identifies pixels of light and dark; in the second layer computer learns to identify edges and simple shapes; in layer three computer learns to identify more complex shapes and objects; in layer four computer learns which shapes and objects can be used to define a human face.
4. What type of neural network would be best for solving this problem?
   1. Convolutional Neural Network would be the best option as it is most commonly used to analyse visual imagery.

(5 marks)

Q: Describe the similarities and differences between sonar and lidar. Your answer should include (at minimum): the type of sensor, the purpose, and the fidelity.

First of all there’s a fundamental similarity in two, both are considered to a remote sensor. LiDAR is an active sensor that uses laser beams in order to determine distance between the sensor and the object, whereas the sonar uses sound waves. Application area for sonars is a lot narrower than it is for LiDAR. Due to a very high level of sensor noise sonars are mostly used to find actual sea depth or underwater objects detection. On the other hand the LiDAR is a very pragmatic and quick technology that allows to save a lot of money when used in large-scale applications. It has a higher measurement accuracy, however, unlike sonar, LiDAR is adversely affected by external factors such as smoke fog or rain. As already mentioned above, LiDAR has a higher application rate, as it is used to not only distance measurements but also atmospheric densities and currents measurements as well as obtaining 3DHR images.

(5 marks)

Q: A long short-term memory network (LSTM) is a type of recurrent neural network. What types of problems are they good at solving, and why? You may use an example in your explanation.

LSTM are good at solving any type of problems that require processing of data sequences like videos and speech. It could be applied to a task like recognition of connected, unsegmented handwriting. The reason why LSTM are so good at such tasks of continuous pattern recognition is due to it’s feedback connections. Unlike vanilla RNN’s that use back-propagation, LSTM RNN’s allow you to partially circumvent the ‘vanishment’ of the long-term gradients, meaning those gradients won’t tend to zero over time, because LSTM allows them to flow unchanged, keeping that in mind the LSTM has similar to the back-propagation through time’s method (used in vanilla RNN’s) complexity of O(1).

(5 marks)

Q: Explain what an “adversarial sample” is, using a relevant example.

Adversarial samples are specifically engineered samples that are applied to a fully trained model in order to be misclassified. This method, associated with security risks, exploits weaknesses of deep learning technologies by purposely feeding biased inputs to the network. This is done to find and neutralize possible weak spots of crucial modern-day technologies such as facial-recognition, biometrical-recognition, self-driving cars etc. Such topic is an important field for research and consideration due to its tendency of transformation from one common model to another. Simply put, if at least one model type has been exploited with an adversarial attack, there’s a big probability that similar-purpose models can be exploited with if not the same than rather similar adversarial samples. There are two types of attacks on DNN possible: white-box and black-box attacks. White-box attacks ate based on known architecture, weights and training algorithm, on the other hand Black-box attacks works as an oracle, where the attacker can only see model’s outputs. For this reason it is possible to avoid any Black-box attack if a prior adversarial testing has been done with White-box method. One of the examples of adversarial sample usage on DNN/NN is when an attacker attempts to impersonate another person by substituting their face with printed or cut-out version of their face. A possible solution for such a problem would be training your model on a custom data set of real and spoof photos.

(5 marks)

Q: What is data bias? Choose one source of societal bias to explain how data bias is preserved in a system.

Data bias is type of data that has been affected by external or internal factors, preventing it from being accurate or even close to truth. Bias in data analysis may occur due to various reasons, here are some of them: [propagating the current state](https://www.cnbc.com/2018/10/10/amazon-scraps-a-secret-ai-recruiting-tool-that-showed-bias-against-women.html), inaccurate training goals, population’s under-representation, cognitive and analytical biases, faulty data interpretation. Examples of data bias are frequently spotted during social data collection. In India the male population percentage among the nation is at 52% (48% is female). While the overall internet penetration of the population is at 49%, the Facebook insight on the population ratio of India is 76% male and 24% female. This very simple example shows you what the data bias is and moreover proves that it is a field to explore and advance on.

(5 marks)

Q: What is neural network convergence? Explain how we check for network convergence.

Convergence is the final state of the network when it is either optimized to its global or local optima. In order to check the network for convergence you should check either the weights or the objective’s value, after convergence it isn’t supposed to change a lot. You should also check the error rate dynamics, it shouldn’t drop much lower than where it is at already.

(5 marks)

You have been asked to create a fuzzy representation of child development goals, for the age of 6 months old. The two development goals to be represented are child weight and child length.

The minimum weight is 12 pounds, the maximum weight is 23 pounds, and the mean weight is 17 pounds. The minimum length is 23 inches, the maximum length is 29 inches, and the mean length is 26 inches.

1. Each fuzzy set should have 3 membership functions – what linguistic variables might these correspond to?
2. Sketch the fuzzy membership sets for child weight and child length
3. Define 3 membership functions for your output fuzzy set
4. Provide a table of the fuzzy rules in your system for your two input fuzzy sets and your output fuzzy set
5. Consider a child who is 25 inches long and weighs 19 pounds. According to your ruleset, which output fuzzy set are they in?

(10 marks)

You have been asked to develop a system that will schedule police officers’ shifts, so that more police can be present in high-crime areas. They want the input to the system to be labelled CCTV footage and historic crime reports, and the output to be a set of postcodes where they should increase officer patrols.

1. What are the potential causes of data bias in this system?
2. What mitigations would you recommend if this system were to be put in place?
3. If you were satisfied that all ethical concerns were mitigated, which CI system would you choose for this problem? Justify your choice

(10 marks)

You have been asked to develop a genetic algorithm that can design a complex plumbing solution for a new city, which can deliver clean water to homes and businesses. The city planner wants an efficient solution, but also wants to keep costs as low as possible.

1. List 3 physical elements you will need to model in order to apply your GA
2. Explain how you would define your fitness function, and provide a justification
3. Choose a stop condition for your GA, and explain why it is appropriate in this situation

(10 marks)

You have been asked to develop a delivery robot for a fast-food company. Their only stipulations are that the robot must be ground-based, and it must have a temperature-controlled pod to keep the food at a suitable temperature.

1. What actuators might you choose for such a robot?
2. What sensors might such a robot need?
3. What safety concerns should be addressed in your design, and how would you address them? You should consider the safety of the robot and the safety of the system users
4. For the temperature-controlled pod, what type of control system would you use and why?

(10 marks)

You have been asked to develop a cruise control system for a new model of car.

1. List the system inputs, outputs, and three potential causes of disturbance
2. What type of feedback controller would you use, and why?
3. What safety concerns might you have, and how would you mitigate them?

The car is reported to have difficulty when travelling near the set-point speed, which causes the car’s engine to rev and then the brakes to be applied in quick succession.

1. Explain what is causing this, in relation to the set-point speed
2. Explain how you might mitigate this, with relation to the controller you chose in the first half of the question

(10 marks)