1 Connectionism

> For this section, you might want to take another look at lecture 6. Recommended readings: Connectionism - Stanford Encyclopedia of Philosophy [Buckner19] Rosenblatt's perceptron, the first modern neural network [Loiseau19]

Task 1.1: What are some key characteristics of connectionist approaches?

Some key characteristics:

- The connectionism tries to explain the intellectual abilities.
- They are represented as an artificial neural network.
- It has some input-values that have a connection with hidden units that all have weights that are connected to some output units.
- The central goal in connectionist research is to find the right set of weights to accomplish a given task.

Task 1.2: Optional Explain some ways connectionist approaches are inspired by human biology?

Some inspirations:

- Cognitive systems based on artificial neural networks.
- Cognitive system modeled on the macroscopic organization of the brain.

1.1 Artificial neural networks

Task 1.3: What is meant by the statement that artificial neural networks are universal function approximators?

This statement's meaning is that the artificial neural network can generate an algorithmically generated class of functions that operate within the function space of interest. This means that the neural network can have a set of training data and derive a function that (hopefully) gives an output value valid for a set of input values.

A universal function approximator depends on that the neural network can represent a wide variety of functions given the correct weights to function correctly.

Task 1.4: Explain, also using a formal description, why image classification can be addressed by a universal function approximator.

The reason why a universal function approximator can address image classification is by using *convolution*. A neural network takes an image as input and reads it as a digitized scene, with red, green, and blue values for each pixel in the image. These values are again fed to a set of filter units. These units can detect specific, local features using the said *convolution* operation.

When the universal function approximator has reduced the image into a *feature map* (A feature map consists of all of the unique features found in an image.), this feature map is then further processed to be able to detect

features and activates even more nodes depending on the weights in the neural network.

Finally, the neural network reaches a fully connected classification layer where it assigns the label that fits the given weights from the input values.

Task 1.5: Optional Explain some characteristics of a problem domain (e.g. the form of the input data) that would encourage the use of neural nets

Task 1.6: What is the most important difference between a sigmoid activation function and the ReLU activation function?

ReLU - Rectufued Linear Units: This is a kind of filtering system. IT takes in different output values and only pass along activations that exceed a given threshold. After this, the ReLU sends the signal to a pooling layer, which again collects data from several ReLU-units and only passes along the most significant activations. In short, the ReLU picks the max value.

Sigmoid activation function - Is a function that calculates the different values and gives it an activation value between 0 and 1. However, as the values get increasingly large, the difference between the values gets closer. They are making it vanish when using it in deep learning.

Task 1.7: Explain the" association black box" analogy of artificial neural networks.

The *association black box analogy* is that the whole neural network is inside a "black room," which is where the computations are happening. The only thing that we can perceive is the input value, and the values returned from the box. So for all of the input inserted, the black box returns a value.

Task 1.8: Optional What are the reasons why there has been a considerable increase in the use of deep neural in the last years?

One of the reasons it has been a considerable increase in the use of the deep neural network is that the neural nets have many more hidden layers. It is proved that this additional depth can increase the representational and computational power of a neural network.

The main reason is that computers are more vital than ever, which again makes it possible to use these kinds of solutions.

Task 1.9: Optional Explain the biological inspiration for Convolutional Neural Networks.

The hidden units of the network are only connected to a local receptive field. This is inspired by the brain by looking at how the auditory Corex is activated when using sight.

1.2 Perceptron

Task 1.10: Give an example of a problem that can be solved by a perceptron. You might sketch this.

A problem that can be solved by a perceptron is every linearly separable problem. Solving a problem related to the OR-operation is an example of a problem that can be solved by a perceptron.

Task 1.11: Give an example of a problem that cannot be solved by a perceptron.

XOR (exclusive or) - operations cannot be solved by a perceptron since they are not linearly separable.

Task 1.12: Implement the perceptron model using python. Test your model with the AND and OR functions. Provide your code and explain your results

Task 1.13: Optional Plot the learnt decision boundary for both the AND and OR functions.

1.2.1 XOR

Task 1.14: Optional What happens when run with the XOR function? Plot the decision boundary and explain what is happening.

1.2.2 IRIS

Task 1.15: Optional The Iris data sets consists of 3 different types of irises' (Setosa, Versicolour, and Virginia) petal and sepal length. We have grouped the Virginica and the Versicolor in one class and the Setosa one class. The task is to use the perceptron to separate the Setosa from the other flowers using only the Sepal Width and the Petal Width with your perceptron model. The data is provided in the data.csv and the true classes in the target.csv. Plot the learned decision boundary.

1.3 General discussion

Task 1.16: Do ANN's use symbols? Explain how or how it is not possible.

ANN uses "distributed representations," Which means that a state is represented by activating a set of neurons. An idea is not stored in a single neuron; it has to be represented by several neurons. This is possible since the neural network is a connectionist.

Task 1.17: Optional In your opinion, is association making the same thing as real intelligence? If not, how do they relate to each other? Motivate your view.

Task 1.18: Is there something that coarsely resembles production rules in ANNs?

Looking at the ANN's different neurons, we can see that all of them have a specific weight given the input values. Therefore each of them can resemble a production rule based on what kind of information they were

given.

Task 1.19: Some connectionists argue that the brain's neural net indeed implements a symbolic processor. How do they argue for this claim?

Some connectionists claim that information is stored non-symbolically in the weights or connection strengths between the nodes in the network.

Others claim that the brain implements a symbolic processor. The brain is still a neural network, but the processors are higher and more abstract. So they mean that we could learn how the machinery needed for symbolic processing can be forged from a neural network.

Task 1.20: Optional In your own words, what do you believe are the main challenges that the connectionist perspective has to face in the coming decades?

2 Belief-Desire-Intention (BDI) architecture

> For this section and the following sections, you might want to take another look at lecture 7. Recommended readings: Belief–desire–intention software model – Wikipedia [Wikipedia contributors20a]

Task 1.21: Explain the different architecture components in the BDI architecture.

BDI consists of 4 different components.

1. Beliefs: This is what the agent believes about its environment.
    - Belief-set: This is a set of beliefs that are stored in a database.
2. Desires: This is what the agent wants to achieve.
    - Goals: A goal is a desire that is pursued continuously by the agent.
3. Intentions: This is what the agent has chosen to do. A representation of actions committed.
    - Plans: A sequence of actions that it can perform in order to achieve its intention.
4. Events: These are activities performed by the agent as a reaction to perception. This could lead to a change of belief, goals...

Task 1.22: Comment on the view of' practical reasoning' as referred to in the context of BDI?

It seems like the architecture is dynamic and does not necessarily remember or take learning from earlier knowledge to a more significant extent. When it is presented with a new event, it will try to change its components. However, it is fascinating to see how a rational software agent is combined with mental attitudes.

3 Subsumption

> Recommended readings: Elephants don’t play chess [Brooks90] Subsumption architecture – Wikipedia [Wikipedia contributors20b] > Optional A robust layered control system for a mobile robot [Brooks86]

Task 1.23: What are the key ideas behind the subsumption architecture?

The key idea is to avoid having to use symbol manipulation to achieve human intelligence. Instead, it is aimed at real-time interaction and responses to a dynamic lab/office environment. It consisted of 4 key ideas:

- Situatedness - It should be able to react to its environment within a human-like time-frame. Perception of action.
- Embodiment - the agent should be embodied. This forces the designer to test and create a physical control system.
- intelligence - The architecture needs to be able to develop perceptual and mobility skills.
- Emergence - Individual modules are not considered intelligent by themselves. It is by looking at the agent and the environment that determines whether an agent is operating intelligence. (Determined by the observer.)

Task 1.24: Optional Many cognitive architectures make use of an explicit model of the world to be used for cognitive tasks, e.g. problem solving and learning. Does that also include Brooks' Subsumption Architecture? How does this architecture relate to the Physical Symbol Systems Hypothesis and the Heuristic Search Hypothesis?

Task 1.25: Describe the layered structure of the Subsumption Architecture. How are the layers related to each other? How are their dependencies? How are the layers linked to sensor data in and actions out?

Each of the layers is made up of a set of processors that works as finite-state machines. Each of the layers is responsible for a single behavior goal. There is no central control, and all of the augmented finite state machines send and receive information asynchronously. They communicate an action through the suppression of signals from the other layers. This is all communicated to an Actuator, which will do the output and percept new inputs.

4 Hybrid architectures

Task 1.26: What is the benefit of combining reactive and deliberative sub-components to create a hybrid architecture?

The benefit of combining reactive and deliberative sub-components is that it balances both aspects but at the cost of complexity. *The reactive sub-components* would be able to respond to environmental changes without any complex reasoning and decision-making. While *deliberateive sub-system* would be responsible for conceptual planning and decision making using symbolic representations.