EXAM

Course: Artificial Intelligence – Algorithms and Applications with Python

Date: *tba*

Name: _____

Matr.-Nr.: _____

Section	1	2	3	∑ (90 P)
Points				

SECTION 1: BASIC CONCEPTS AND THEORETICAL BACKGROUND (20 P)

1.1 Many people have tried to define the concept "artificial intelligence". The most popular one is from McCarthy. Please give his definition of *Artificial Intelligence* we have discussed in lecture. (1 P)

1.2 What is/are the potential problems of his definition (1 P)

1.3 Please explain briefly the problem of <u>overfitting</u> and <u>underfitting</u> in machine learning. Explain in this context the relationship between bias, variance and total error. (2 + 1 = 3 P)

1.4 What tends to happen with the training error in a linear model as the degree of polynomial increases? (2 P)

1.5 Please explain the k-fold-cross-validation procedure to compute model performance. Explain its benefits compared to other procedures and illustrate it with a simple sketch (2 + 2 + 2 = 6 P)

1.6 What is the Google File System? Please explain its concept and application (1 + 1 = 2 P)

1.7 What is a data.frame in Python. Is there a comparable concept in database theory? (2 + 1 = 3 P)

1.8 What is the difference between central version-control and distributed version-control. Please name an example for each case! (2 + 2 = 4 P)

1.9 A friend of you has a small startup that sells premium e-bikes online (about 100-200 per year). Your friend wants to start to make more databased management decisions, and hence you suggest him to use a dashboard to visualize his sells and user data. However he has never written one single line of code in his life and plans to hire you for that job. In the near future, he wants to

update his dashboard by himself. Analyze this problem based on the framework we used in lecture for tool selection (2 + 2 + 2 = 6 P)

1.10   What is a decision rule? Please construct a rule, or a rule set to predict "Buy = yes" based on the dataset in table 1. (2 + 2 = 4 P)

Tab. 1: Dataframe

#	Brand	Quality	Engine	Buy
1	Porsche	A	Electric, Gasoline	Yes
2	Ferrari	A	Gasoline	Yes
3	Tesla	B	Electric	Yes
4	Audi	B	Electric, Gasoline	No

1.11   Imagine your task is to classify a text to a language. Which one of the following approaches is a generative one, and which is the discriminative one. Why? (1 + 1 = 2 P)

a) learning each language, and then classifying it using the knowledge you just gained

b) determining the difference in the linguistic models without learning the languages, and then classifying the speech

---

1.12   What can you do if your NLP model suffers from overfitting due to high variance? (2 P)

You can remove features. Another solution is to obtain more training examples (if you can). Or use regularization.

1.13   Please explain the relationship between the three factors that influence contextual complexity in machine learning. Why is there no optimal "model" /always a trade-off in applied machine learning? (4 P)

1.14   Give an example for an inductive decision (case, result, and rule). (1 P)

1.15   What is a "knowledge base" in the context of an expert system? (1 P)

SECTION 2: APPLYING THEORY TO PRACTICE (? P)

Consider the following scenario for the section's tasks:

Suppose you recently started to work as a data scientist for the well-known restaurant chain "Bravocado" that focuses on avocado-based meals. Over the last few years, the high demand for food with avocados, such as the beloved avocado toast, led to skyrocketing profit at Bravocado. As a result, Bravocado considers expanding its business to the global market and aims to explore innovative services that can help it to further differentiate itself from other restaurants. As Bravocado has collected massive datasets over the last few years, its business manager Mr. Fool wants you to help reaching both objectives with the use of artificial intelligence.

2.1 Mr. Fool wants you to implement an AI that clusters Bravocado customers. For your analysis, you want to consider *k-means clustering*, *density-based clustering*, and *hierarchical clustering*. When visualizing Bravocado's customer data, you see the following scatter plots. Under each plot, you have outlined the clusters that you would expect your algorithms to find. Please check the algorithm(s) that can be used to find these expected clusters for each of the three plots. (4P)
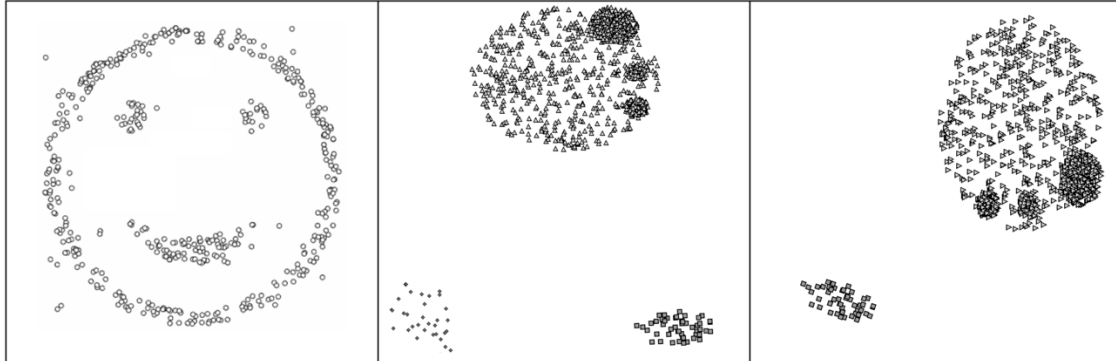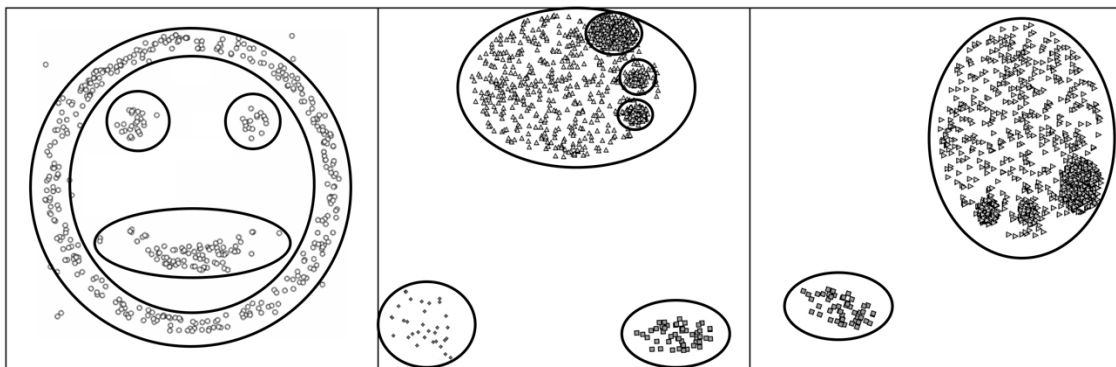
…

	Data Set A	Data Set B	Data Set C

Raw data plots:

Your desired clustering:

Expected clusters: 4	Expected clusters: 6	Expected clusters: 2

Potential clustering algorithms:

Data Set A	Data Set B	Data Set C
❑ k-Means Clustering	❑ Agglomerative Hierarchical Clustering (Linkage criterion: Single)	❑ Divisive Hierarchical Clustering (Linkage criterion: Single)
❑ Density-based Clustering	❑ Density-based Clustering	❑ k-Means Clustering

2.2 After showing your cluster results to Mr. Fool, he wants you to explain when to use *k-means clustering* and when to use *hierarchical clustering*. Please compare the two algorithms based on the type of cluster that they produce and their respective (dis-)ability to detect outliers. (4P)

...

2.3 To illustrate your comparison above, you decide to compute a *hierarchal clustering* by hand.

a) Please compute *agglomerative clustering* using the "single" linkage criterion with the Manhattan distance ($= L_1$ Norm) for the following data. Indicate each step of your computation and draw the resulting clusters into the chart. (5P)

Examplary coordinate:
A = (1, 4)

...
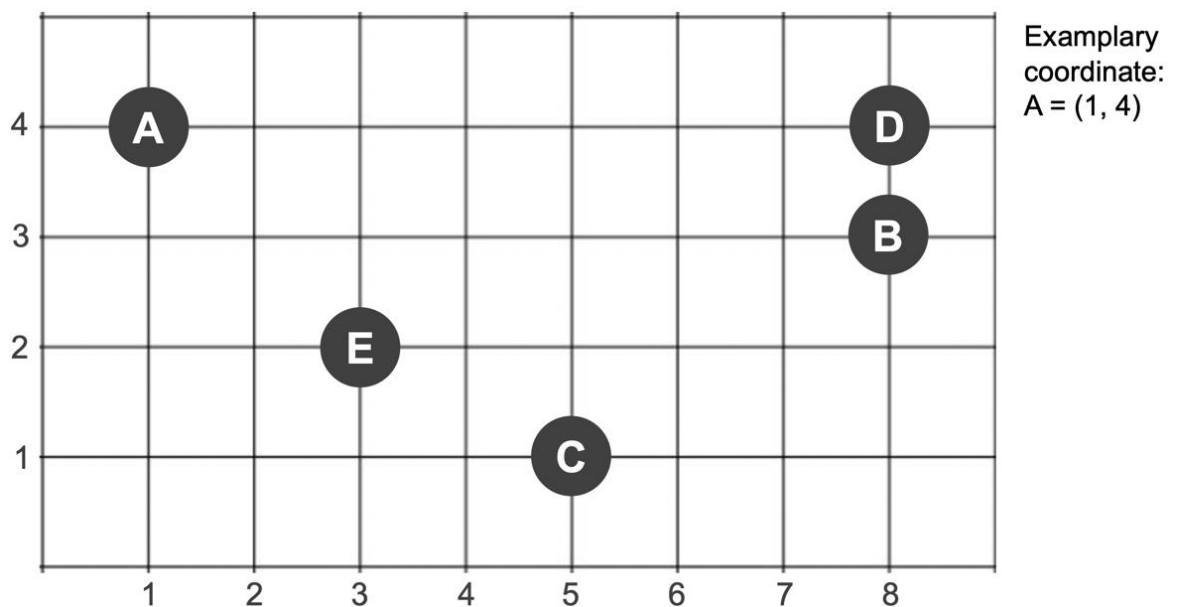
b) In the data of task 2.3 a), the point A can be regarded as an outlier. Depending on your description in task 2.2, please answer either (2P):

- Does the outlier point A negatively affect the clustering algorithm and, if yes, how?

Or:

- Can this clustering be used to handle the outlier point A and, if yes, how?

...

2.4 As a next step, Mr. Fool wants you to create an AI that can predict whether a new customer will order an avocado toast. Please identify a suitable set of *machine learning type*, *task*, *performance measure*, and *experience* for the machine learning problem behind such an AI. Also, which issue can arise if you only use data of Bravocado's current customer base to solve this problem while Bravocado expends its business to other countries? (5P)

Machine Learning Type:

Task:

Performance measure:

Experience:

Potential Issue:

2.5 You decide to implement the requested AI for predicting whether a customer will order an avocado toast using a *neural network*.

a) First, Mr. Fool wants to understand basic designs of neural networks. Please visualize the structure of a *Single Layer Feedforward Network, Fully Recurrent Network*, and a *Jordan/Elman Network*. (4.5P)

Single Layer Feedforward Network:

Fully Recurrent Network:

Jordan/Elman Network:
...

b) Mr. Fool wants to further know which *neural network structure* fits best for the following use cases. Please check the best fitting structure for each use case (2P):

**Use Case 1:** Predict the number of future avocado sales based on past sale trends of avocados.

- ❑ Single Layer Feedforward Network
- ❑ Recurrent Network

Use Case 2: Identify the type of an avocado based on some of its characteristics (e.g., size and weight).

- ❑ Single Layer Feedforward Network
- ❑ Recurrent Network

c) Assume that you have the following data available to train a artificial neuron for predicting whether a customer will buy an avocado toast or not (0 = "no" and 1 = "yes"). Please compute the learning of the below defined initial perceptron based on this data for one epoch (i.e., learning the weights using each example once). Please indicate the resulting weights (8P).

Name	x_0	x_1	x_2	Buys Avocado Toast
Peter Parked	0	1	1	1
Kanye East	1	0	1	0
Harry Otter	0	1	0	1
Justin Bieberlake	1	1	0	0
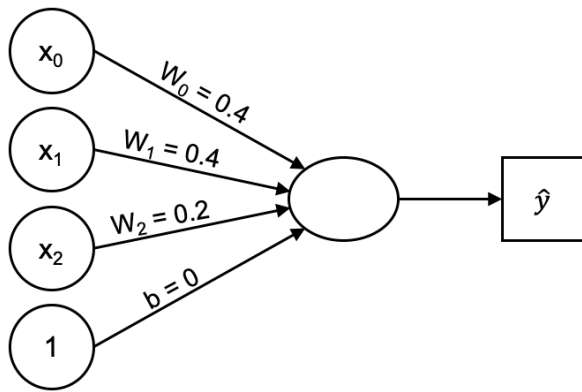
Activation function:

$$f(y_{in}) = \begin{cases} 0 & if \ y_{in} < \ 0 \\ 1 & if \ y_{in} \geq \ 0 \end{cases}$$

...

2.6 Please compute the accuracy of the perceptron before and after training it for one epoch with regard to the training data. How much has its accuracy improved? (4P)

...

2.7 As an alternative to your neural network, you also train a *kNN* algorithm with k=1 using the following data. Unfortunately, you accidentally use a dataset that solely consists of half of your training data to test your trained model. Which accuracy will your trained *kNN* achieve? (1.5P)

...
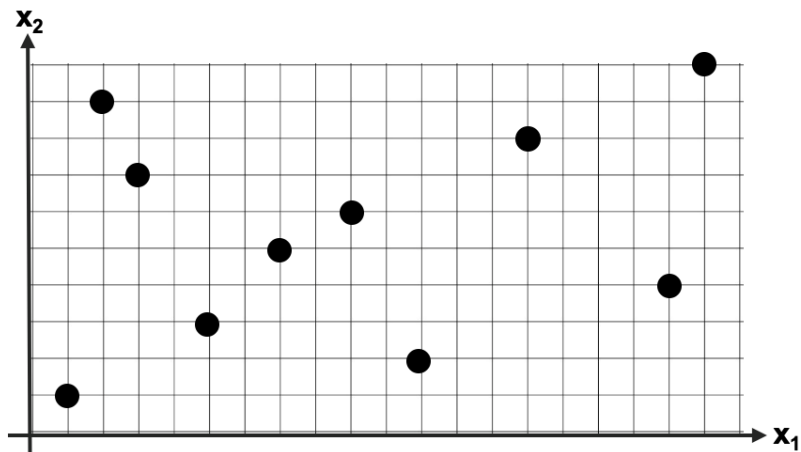
SECTION 3: PROGRAMMING WITH PYTHON (10 P)

Consider the following Python-Code (Code 1) in this section. Please answer the following questions by referring to this code snipet.

Code 1 – Simple implementation of an artificial neuron

<table>
<tr>
<td rowspan="1">Python Code</td>
<td>

```python
class Perceptron(object):
    def __init__(self, num_runs, start_weights):
        self.weights = start_weights
        self.num_runs = num_runs  # run through the dataset X
        print("Init       perceptron        with        weights
{}".format(self.weights))


    def activation_function(self, y_in):
        return 1 if y_in >=0 else 0


    def train(self, X):
        self.X = X
        for run in range(self.num_runs):
            for i in range(len(self.X)):
                x = self.X[i, 0:3]  # select input vector
                y = self.X[i, -1]  # select class
                print("Try   to   predict   input   {}   with   class
{}".format(x,y))
                y_in = self.weights.T.dot(x)
                y_estm = self.activation_function(y_in)
                print("Perceptron guess: {}".format(y_estm))
                if(y_estm != y):
                    print("Estimate    {}    does    not    equal
{}".format{y_estm,y})
                    if(y_in < 0): self.weights = self.weights + x
                    else: self.weights = self.weights - x
```

</td>
</tr>
</table>

2.1 Please give python code to start and initialize the perceptron with the dataset start_weights? (1 P)

2.2 After you run your code to start your perceptron, the console returns the following error: "NameError Traceback (most recent call last) <ipython-input-1-4c443302c04f> in <module> ----> 1 start_weights = np.array([0, 0.5, 0.5]) … NameError: name 'np' is not defined". How do you solve this error? (2 P)

2.3 Please identify and describe the three functions of the perceptron object. What is their task? What are they good for? (6 P)

	Component and Description	Python-Code
1		
2		
3		

2.4 Which type of learning rule does the Perceptron use? (1 P)