01418362 INTRODUCTION TO MACHINE LEARNING

WATER QUALITY CLASSIFICATION

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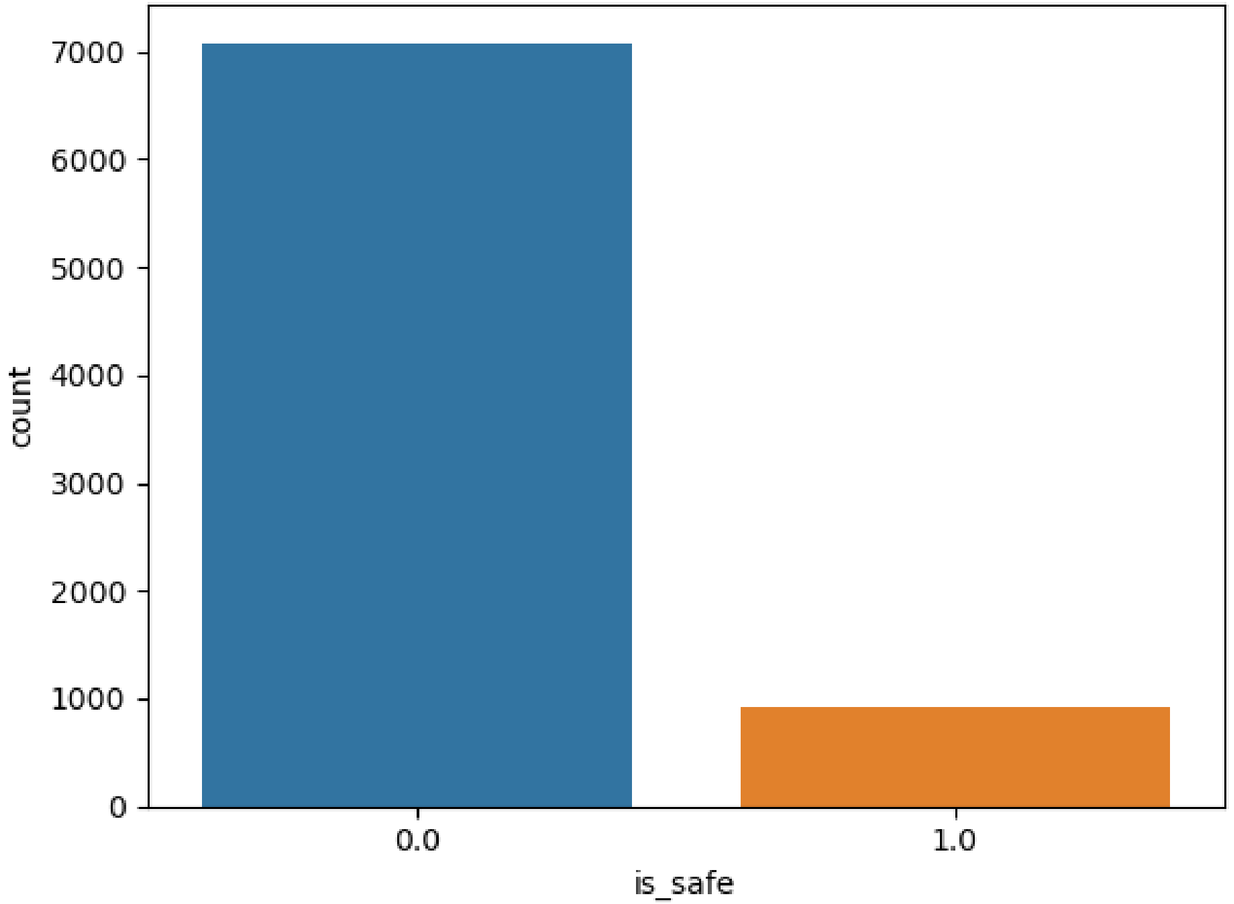
DATASET

```
df = pd.read_csv('waterQuality1.csv')
df
```

	aluminium	ammonia	arsenic	barium	cadmium	chloramine	chromium	copper	flouride	bacteria	...	lead	nitrates	nitrites	mercury	perchlorate	rad
0	1.65	9.08	0.04	2.85	0.007	0.35	0.83	0.17	0.05	0.20	...	0.054	16.08	1.13	0.007	37.75	
1	2.32	21.16	0.01	3.31	0.002	5.28	0.68	0.66	0.90	0.65	...	0.100	2.01	1.93	0.003	32.26	
2	1.01	14.02	0.04	0.58	0.008	4.24	0.53	0.02	0.99	0.05	...	0.078	14.16	1.11	0.006	50.28	
3	1.36	11.33	0.04	2.96	0.001	7.23	0.03	1.66	1.08	0.71	...	0.016	1.41	1.29	0.004	9.12	
4	0.92	24.33	0.03	0.20	0.006	2.67	0.69	0.57	0.61	0.13	...	0.117	6.74	1.11	0.003	16.90	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
7994	0.05	7.78	0.00	1.95	0.040	0.10	0.03	0.03	1.37	0.00	...	0.197	14.29	1.00	0.005	3.57	
7995	0.05	24.22	0.02	0.59	0.010	0.45	0.02	0.02	1.48	0.00	...	0.031	10.27	1.00	0.001	1.48	
7996	0.09	6.85	0.00	0.61	0.030	0.05	0.05	0.02	0.91	0.00	...	0.182	15.92	1.00	0.000	1.35	
7997	0.01	10	0.01	2.00	0.000	2.00	0.00	0.09	0.00	0.00	...	0.000	0.00	0.00	0.000	0.00	
7998	0.04	6.85	0.01	0.70	0.030	0.05	0.01	0.03	1.00	0.00	...	0.182	15.92	1.00	0.000	1.35	

7999 rows × 21 columns

DATASET



SPLITING DATA

```python
def train_test_split(X, y, test_size=0.20, random_state=None):
    if random_state is not None:
        np.random.seed(random_state)

    indices = np.arange(len(X))
    np.random.shuffle(indices)

    test_samples = int(len(X) * test_size)

    test_indices = indices[:test_samples]
    train_indices = indices[test_samples:]

    X_train, X_test = X[train_indices], X[test_indices]
    y_train, y_test = y[train_indices], y[test_indices]

    return X_train, X_test, y_train, y_test
```

K-NEAREST NEIGHBORS

Assumption : similar data points should have similar labels

```python
class KNNClassifier:
    def __init__(self, n_neighbors=5, p=2):
        self.n_neighbors = n_neighbors
        self.p = p

    def fit(self, X, y):
        self.X_train = X
        self.y_train = y

    def predict(self, X_test):
        predictions = []
        for x_test in X_test:
            x_test = np.array(x_test)

            distances = np.power(np.sum(np.power(np.abs(self.X_train - x_test), self.p), axis=1), 1/self.p)

            k_neighbors_indices = np.argsort(distances)[:self.n_neighbors]
            neighbor_labels = [self.y_train[i] for i in k_neighbors_indices]
            prediction = np.bincount(neighbor_labels).argmax()
            predictions.append(prediction)

        return np.array(predictions)

    def score(self, X_test, y_test):
        predictions = self.predict(X_test)
        accuracy = np.sum(predictions == y_test) / len(y_test)
        return accuracy
```

Minkowski distance

$$D = \left(\sum_{i=1}^{n} |p_i - q_i|^p \right)^{1/p}$$

K-FOLD CROSS VALIDATION

```python
def k_fold_cross_validation(X, y, model, k=5):
    n = len(X)
    fold_size = n // k
    scores = []
    for i in range(k):
        # Split data into training and validation sets
        start = i * fold_size
        end = min((i + 1) * fold_size, n)
        X_test = X[start:end]
        y_test = y[start:end]

        X_train = np.concatenate([X[:start], X[end:]], axis=0)
        y_train = np.concatenate([y[:start], y[end:]], axis=0)
        model.fit(X_train, y_train)
        # Evaluate the model on the validation data
        score = model.score(X_test, y_test)
        scores.append(score)

    return scores
```

DATA PREPROCESSING

```
df.dtypes
```

```
aluminium      float64
ammonia         object
arsenic        float64
barium         float64
cadmium        float64
chloramine     float64
chromium       float64
copper         float64
flouride       float64
bacteria       float64
viruses        float64
lead           float64
nitrates       float64
nitrites       float64
mercury        float64
perchlorate    float64
radium         float64
selenium       float64
silver         float64
uranium        float64
is_safe         object
dtype: object
```

```
df['ammonia'] = pd.to_numeric(df['ammonia'], errors='coerce')
df['is_safe'] = pd.to_numeric(df['is_safe'], errors='coerce')
```

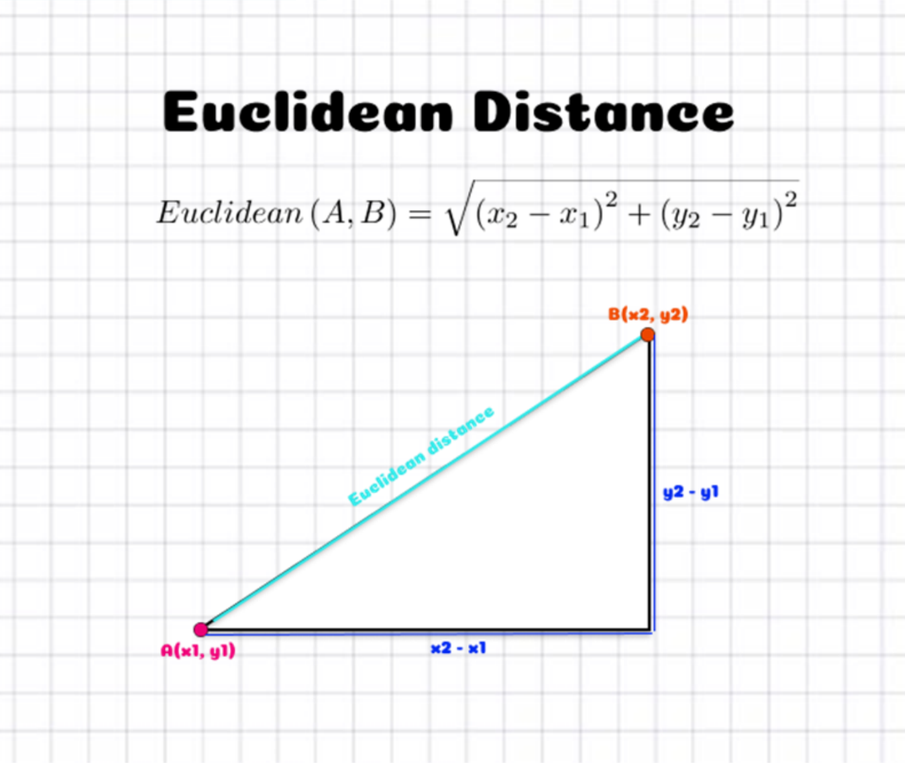
```
x = np.array(df.drop(['is_safe'], axis=1))
y = np.array(df['is_safe'])
```

```
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.2, random_state=42)
```

```
# Convert training data to float
x_train = [[float(value) for value in sample] for sample in x_train]
y_train = [float(label) for label in y_train]

# Convert test data to float
x_test = [[float(value) for value in sample] for sample in x_test]
y_test = [float(label) for label in y_test]
```

EUCLIDEAN DISTANCE




```
model_euclidean = KNNClassifier(n_neighbors=5, p=2) #Euclidean distance
model_euclidean.fit(x_train, y_train)
model_euclidean.score(x_test,y_test)
```

```
0.8586616635397123
```

```
n_neighbors_list = list(range(1, 25, 2))  # List of values for n_neighbors
accuracy_scores = []

for n_neighbors in n_neighbors_list:
    knn_classifier = KNNClassifier(n_neighbors=n_neighbors, p=2)
    knn_classifier.fit(x_train, y_train)
    accuracy = knn_classifier.score(x_test,y_test)
    accuracy_scores.append(accuracy)

# Find the highest accuracy and its corresponding n_neighbors value
max_accuracy = max(accuracy_scores)
best_n_neighbors = n_neighbors_list[accuracy_scores.index(max_accuracy)]

print("Highest Accuracy:", max_accuracy)
print("Corresponding k value (n_neighbors):", best_n_neighbors)
```

```
Highest Accuracy: 0.8736710444027517
Corresponding k value (n_neighbors): 21
```

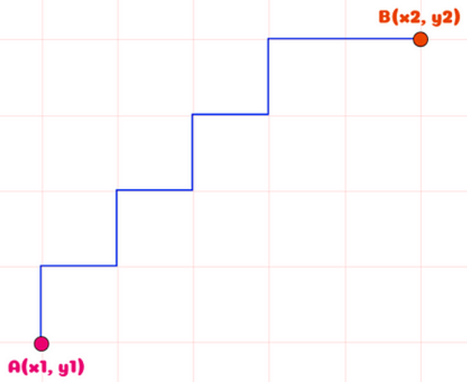
```
model_euclidean = KNNClassifier(n_neighbors=21, p=2)
scores = k_fold_cross_validation(x, y, model_euclidean, k=5)
print("Cross-validation scores:", scores)
print("Average score:", np.mean(scores))
```

```
Cross-validation scores: [0.5766103814884302, 0.8524077548467792, 0.9443402126328956, 0.9687304565353346, 0.991869918699187]
Average score: 0.8667917448405253
```

MANHATTON DISTANCE

Manhattan Distance

Manhattan(A,B)= |x1-x2| + |y1-y2|




```
model_manhattan = KNNClassifier(n_neighbors=5, p=1) #Manhattan distance
model_manhattan.fit(x_train, y_train)
model_manhattan.score(x_test,y_test)
```

```
0.8730456535334584
```

```
n_neighbors_list = list(range(1, 25, 2))  # List of values for n_neighbors
accuracy_scores = []

for n_neighbors in n_neighbors_list:
    knn_classifier = KNNClassifier(n_neighbors=n_neighbors, p=1)
    knn_classifier.fit(x_train, y_train)
    accuracy = knn_classifier.score(x_test,y_test)
    accuracy_scores.append(accuracy)

# Find the highest accuracy and its corresponding n_neighbors value
max_accuracy = max(accuracy_scores)
best_n_neighbors = n_neighbors_list[accuracy_scores.index(max_accuracy)]

print("Highest Accuracy:", max_accuracy)
print("Corresponding k value (n_neighbors):", best_n_neighbors)
```

```
Highest Accuracy: 0.8761726078799249
Corresponding k value (n_neighbors): 13
```

```
model_manhattan = KNNClassifier(n_neighbors=13, p=1)
scores = k_fold_cross_validation(x, y, model_manhattan, k=5)
print("Cross-validation scores:", scores)
print("Average score:", np.mean(scores))
```

```
Cross-validation scores: [0.5766103814884302, 0.8248905565978737, 0.9449656035021888, 0.9687304565353346, 0.991869918699187]
Average score: 0.8614133833646029
```

THANK YOU