EMPATHY ASSESSMENT FROM EYE FIXATIONS

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1. Introduction

In recent days, some machine learning algorithms are used to examine eye movements during social interactions and predict a person's level of empathy. This technique is known as empathy evaluation from eye fixations. The eye tracking technology is used to watch where individuals look and machine learning algorithms are then used to find patterns that can be used to estimate a person's level of empathy. The main goal of measuring empathy is to provide more accurate and trustworthy empathy measurements by using eye fixations. It may be used to enhance social interactions, identify and cure social deficiencies, and research the neurological underpinnings of empathy. Several disciplines, including psychology, psychiatry, neurology, and human-computer interaction, could benefit from the use of this strategy.

2. Tasks

2.1 Assignment 1

1. Data Collection

Participant	Gender	Age	Class	CARS Score	Tracking Rati...	Color
18	M	11.7	ASD	34.5	18.7598	Khaki
18	M	11.7	ASD	34.5	18.7598	Khaki
18	M	11.7	ASD	34.5	18.7598	Khaki
18	M	11.7	ASD	34.5	18.7598	Khaki
18	M	11.7	ASD	34.5	18.7598	Khaki
18	M	11.7	ASD	34.5	18.7598	Khaki
18	M	11.7	ASD	34.5	18.7598	Khaki
18	M	11.7	ASD	34.5	18.7598	Khaki
18	M	11.7	ASD	34.5	18.7598	Khaki

Figure: Merged Dataset

(Source: Lencastre *et al.* 2022)

This figure displays the merged dataset. It is created after merging eye tracking dataset and metadata participant datasets.

2. Data Preprocessing and cleaning

	3
Par…	0
Gen…	0
Age	0
Cla…	0
CAR…	0
Tra…	0
Col…	0
Cat…	0
Cat…	0
Cat…	0

Figure: Checking null values

(Source: Generated by the learner)

Here, the null values are checked and there are no null values in this merged dataset.

Figure: Shape of dataset

(Source: Created by the learner)

The dataset contains 10 columns and 1862 rows.

	Age	CARS Score	Tracking Rati...
cou…	1862.0	1862.0	1862.0
mean	11.71439312567132	34.787862513426425	19.38474951664876
std	0.035111431060051…	0.7022286212010108	1.5245383366273952
min	11.7	34.5	18.7598
25%	11.7	34.5	18.7598
50%	11.7	34.5	18.7598
75%	11.7	34.5	18.7598
max	11.8	36.5	23.1018

Figure: Description of dataset

(Source: Generated by the learner)

The mean value of age is 11.7 and CARS score is 34.5.

Age	CARS Score	Tracking Rati...	Color	Category Gr...	Category Rig...	Category Left
11.7	34.5	18.7598	1	1	4	4
11.7	34.5	18.7598	1	0	1	1
11.7	34.5	18.7598	1	0	1	1
11.7	34.5	18.7598	1	0	1	1
11.7	34.5	18.7598	1	0	1	1
11.7	34.5	18.7598	1	0	1	1
11.7	34.5	18.7598	1	0	1	1
11.7	34.5	18.7598	1	0	1	1
11.7	34.5	18.7598	1	0	1	1

Figure: Converting into numerical variables

(Source: Created by the learner)

Here, some string type variables are converted into numerical variables.

3. Data Analysis

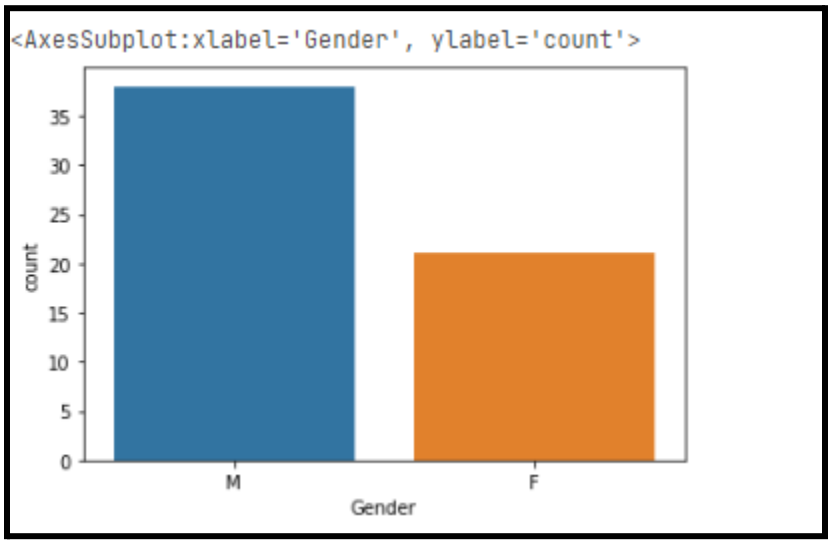


Figure: Counting males and females

(Source: Created by the learner)

The percentage of male participants are higher compared to females.

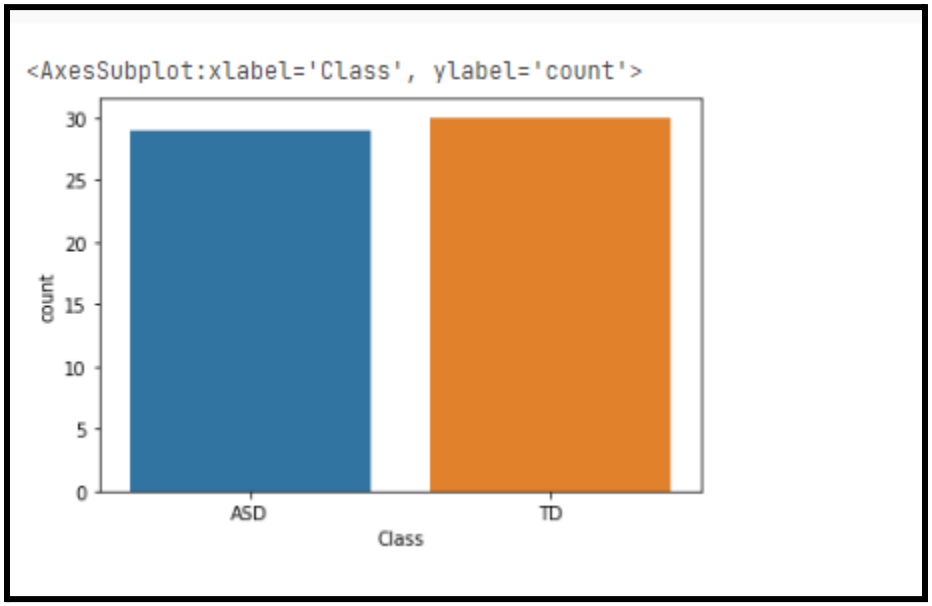


Figure: Class of eye gaze

(Source: Generated by the researcher)

The class TD ("Typical development") is higher than ASD in terms of eye gaze.

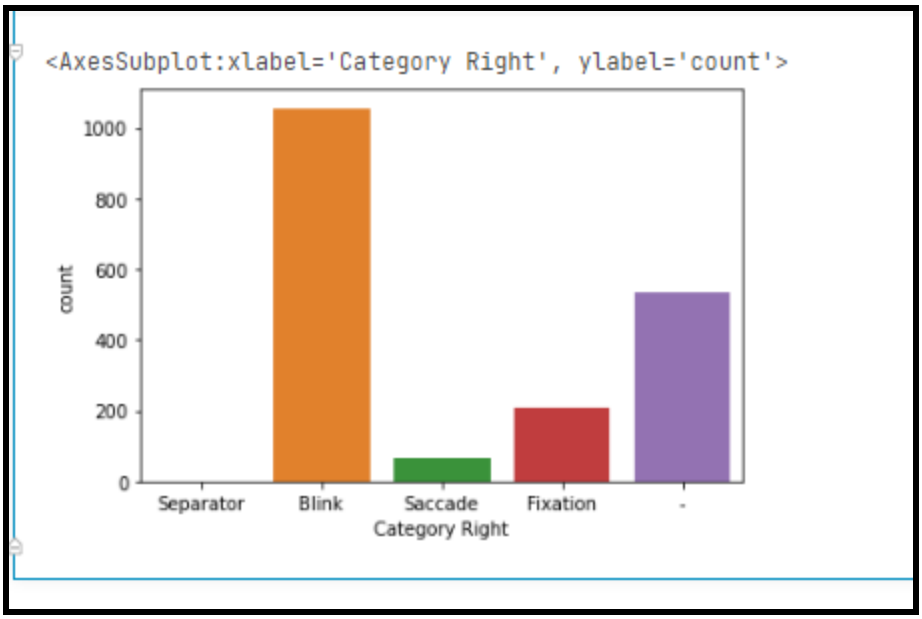
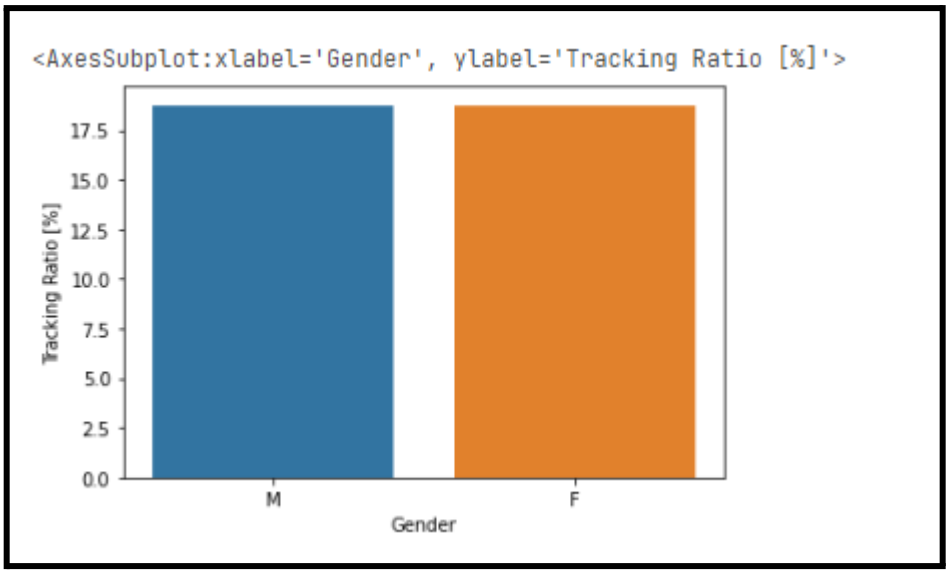


Figure: Counting category of eye

(Source: Created by the researcher)

The “blink” type category is the highest and “saccade” category is the lowest compared to other categories.



,

Figure: Tracking ratio in terms of gender

(Source: Created by the researcher)

The tracking ratio is almost equal in the case of male and females.

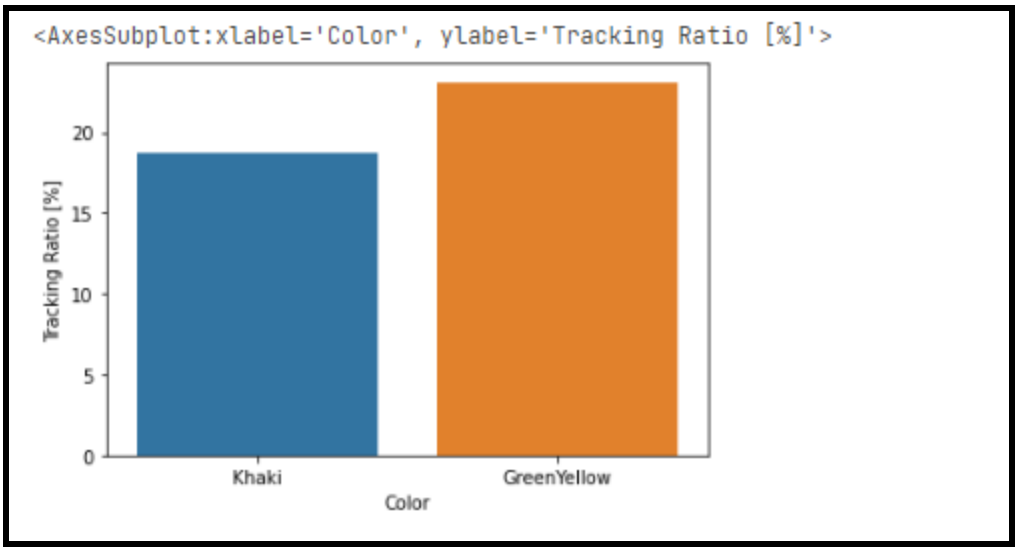


Figure: Measuring tracking ratio in terms of eye color

(Source: Created by the learner)

Here, the tracking ratio is measured in terms of eye color. The tracking ratio percentage is higher in the case of green-yellow color of eye compared to khaki.

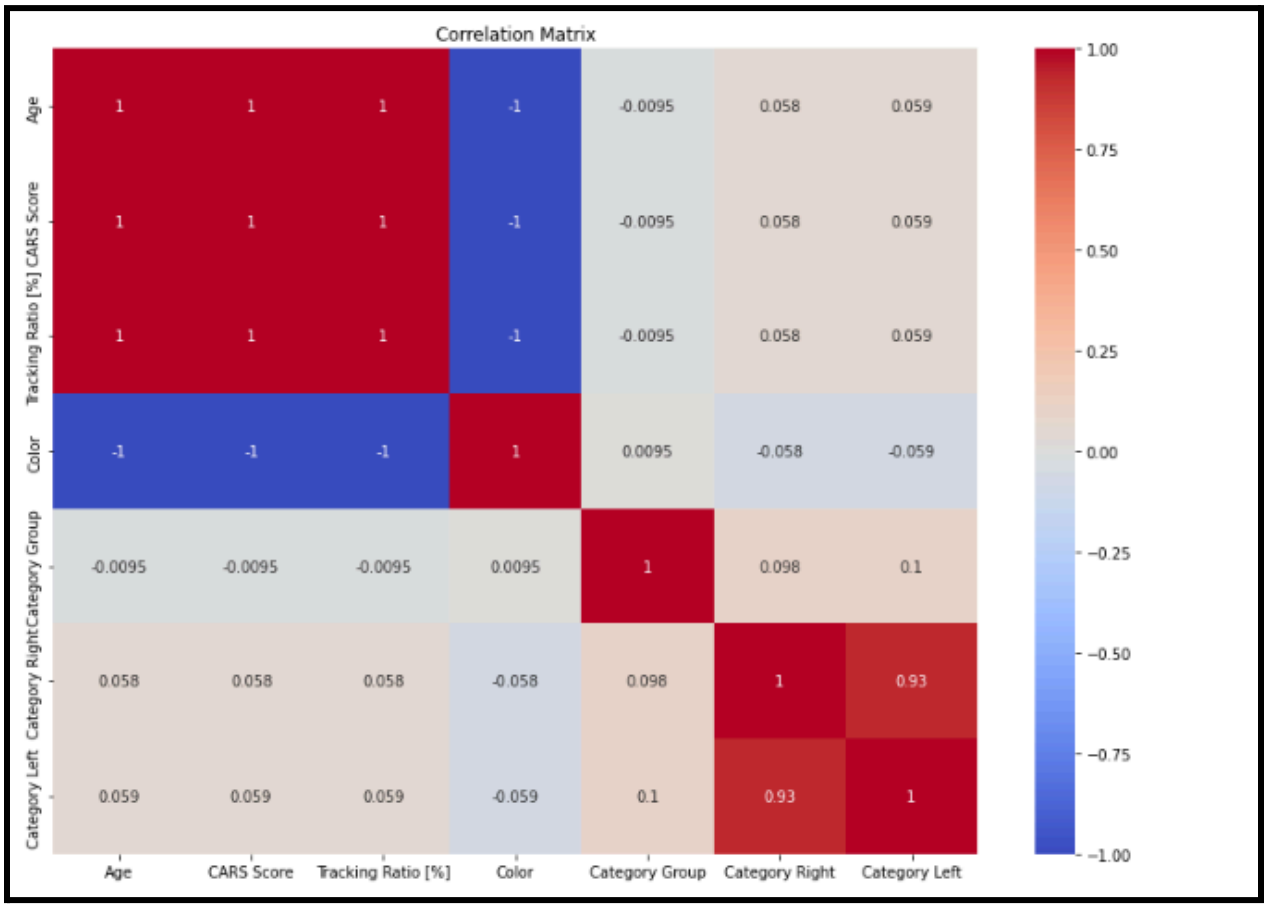


Figure: Heat map

(Source: Created by the learner)

The (+) correlation value means the variables are positively correlated and vice versa. Here, The correlation value between age and category group is -0.095 means both the variables are negatively correlated.

2.2 Assignment 2

1. ML modeling

X

Table Raw Visualize Statistics

	Age	CARS Score	Tracking Rati...	Color	Category Gr...	Category Left
33	11.7	34.5	18.7598	1	0	2
34	11.7	34.5	18.7598	1	0	2
35	11.7	34.5	18.7598	1	0	1
36	11.7	34.5	18.7598	1	0	1
37	11.7	34.5	18.7598	1	0	1
38	11.7	34.5	18.7598	1	0	1
39	11.7	34.5	18.7598	1	0	1
40	11.7	34.5	18.7598	1	0	1
41	11.7	34.5	18.7598	1	0	1

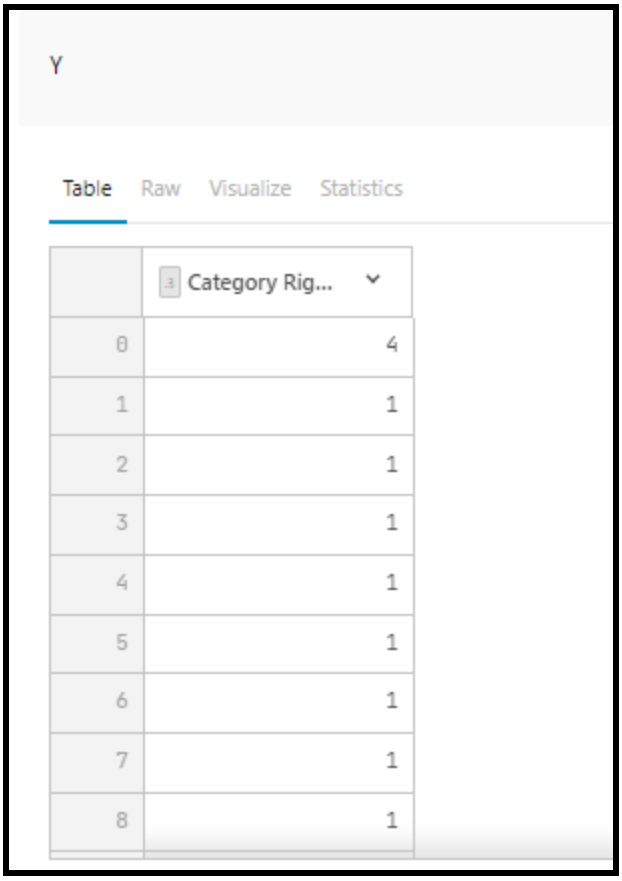


Figure: Separating dependent and independent variables

(Source: Created by the learner)

Here, the independent variables are kept in the X-axis and the dependent variable is separated into the Y-axis.

```
X_train, X_test, Y_train, Y_test=train_test_split(X,Y,test_size=0.3, random_state=0) ## train test splitting
```

Figure: Train test splitting

(Source: Created by the learner)

After separating independent and dependent variables, the dataset is 70% trained and 30% tested.

```
# Set up k-fold cross-validation with 5 folds
kfold = KFold(n_splits=5, shuffle=True, random_state=42)

# Perform cross-validation on the model using the k-fold generator
scores = cross_val_score(model, X, Y, cv=kfold)
```

Figure: Cross validation method

(Source: Generated by the learner)

Here, the cross validation method is applied. Here, a k-fold cross-validation procedure is set up and cross-validation is performed on a model using the k-fold generator. The dataset is divided into 5 subsets and there are 42 random state generators.

2. Results and findings

Decision Tree Classifier

```
Accuracy of decision tree classifier: 0.9785330948121646
```

Figure: Accuracy of decision tree

(Source: Generated by the learner)

The accuracy of the decision tree classifier is 97.8%.

```
Precision Score :  0.9599449259660527
Recall Score :  0.9785330948121646
f1 Score :  0.9785148132940138
```

Figure: Performance metrics of decision tree

(Source: Generated by the learner)

The precision score is 95.99%, recall score is 97.8%, and f1 score is 97.8%.

	0	1	2	3
0	154	5	0	0
1	1	306	2	2
2	0	0	69	0
3	1	1	0	18

Figure: Confusion matrix of decision tree

(Source: Created by the learner)

The false negative and false positive values are close to 0 where the true (-) value is 306 and the true (+) value is 154. The model correctly predicts the empathy score of the person.

```
Cross-validation scores: [0.97855228 0.97319035 0.96774194 0.9811828  0.96505376]
Mean cross-validation score: 0.9731442243939
```

Figure: Cross validation score of decision tree

(Source: Generated by the learner)

The mean cross validation score is 0.973.

Neural Network

```
Accuracy of Neural network: 0.9463327370304114
```

Figure: Accuracy of Neural network

(Source: Created by the learner)

The accuracy of the neural network is 94%.

```
array([[154,   5,   0,   0],
       [  1, 306,   2,   2],
       [  0,   0,  69,   0],
       [  1,   1,   0,  18]])
```

Figure: Confusion matrix of neural network

(Source: Generated by the learner)

Here, the true positive value is 154 and the true negative value is 306. The model correctly predicted the empathy score of the person.

```
Precision Score :  0.9599449259660527
Recall Score :  0.9785330948121646
f1 Score :  0.9785148132940138
```

Figure: Calculating performance metrics of Neural network

(Source: Generated by the learner)

Precision score is 0.959, f1 score is 0.978, and recall score is 0.978.

```
Cross-validation scores: [0.94369973 0.97319035 0.94892473 0.9811828  0.96505376]
Mean cross-validation score: 0.9624102741503069
```

Figure: Displaying cross-validation score

(Source: Created by the learner)

The mean cross-validation score of the Neural network is 0.962.

	Model	Accuracy
0	Decision Tree Cla…	97.85330948121646
1	Neural Network	94.63327370304114

Figure: Comparing accuracy

(Source: Created by the learner)

Here, the accuracy between two ML models is compared and the accuracy of the decision tree classifier is higher compared to the Neural network.

3. Discussion

1) The accuracy of the systems based on several factors like the overall quality of eye tracking data, the diversity and size of the training dataset, and also the ML algorithms used. These two ML algorithms can deliver some valuable insights into empathic procedures. The accuracy of two algorithms is above 90% and it correctly predicts the empathy of a person. It needs to be further compared and validated with other established measures (Gillespie *et al.* 2021).
2) There are some factors that should be considered by the HR department:
    - The startup can deliver evidence of the reliability and validity of the assessment tool. This can demonstrate the accuracy of the model and validates against established empathy measures.
    - The startup can have robust data security and privacy policies to prevent personal information (Sayar, 2022).

- The startup can adhere to some guidelines and ethical principles for conducting research including human participants.
- The startup can offer an eco-friendly and cost-effective solution that meets the requirements of the HR department and always delivers value for money (Zhang *et al.* 2022).

3) Some insights are there that can help the startup in the future:
    - It is mandatory to use multiple empathy measures including behavioral and self-report measures to determine a comprehensive recognition of an individual.
    - The startup can consider expanding the diversity and size of the dataset in order to enhance the accuracy of the model. This can be used to train the ML algorithms (Berkovsky *et al.* 2019).
    - It is significant to ensure that the overall dataset is free from bias. The startup should consider using several techniques like data augmentation to enhance the diversity and decrease some possible sources of bias.

3.Conclusion

This report concludes that empathy assessment has the potential to deliver a more impartial and trustworthy indicator of empathy during social interactions by using eye fixations. In this method, eye tracking technology is used to track eye movements during conversations, and machine learning algorithms are then used to analyze the data and find patterns related to various levels of empathy. The resulting hypotheses may help to enhance social interactions, identify and treat social deficiencies, and investigate the neurological underpinnings of empathy. This technique has the potential to deepen our comprehension of empathy and enhance social outcomes in disciplines like psychology, psychiatry, neuroscience, and human-computer interaction. In addition, several ML algorithms have been applied and the accuracy of the Decision tree is the highest and all the predictions are correct because the confusion matrix contains a lot of true (+) and true (-) values.

References

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