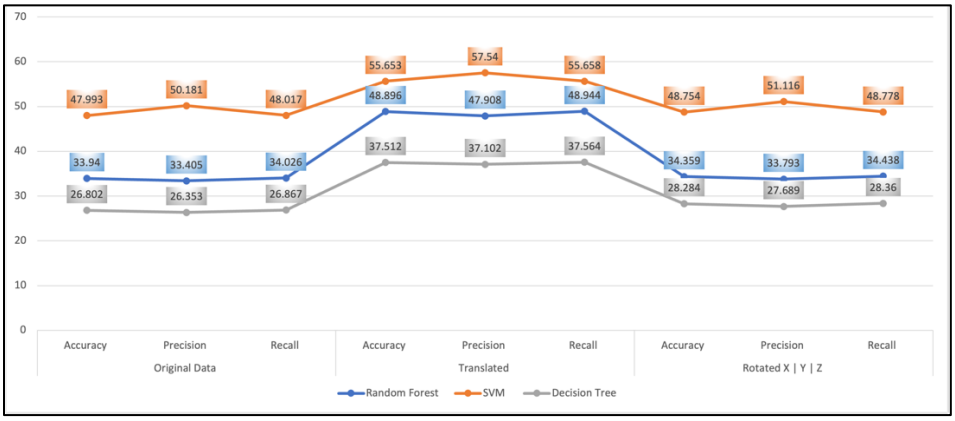
3D Expression Recognition

Name: Leela Sumanth Manduva

1. Classification results for each experiment:

Classifier/ Data Type	Original Data			Translated			Rotated X | Y | Z		
Metric	**Accuracy**	**Precision**	**Recall**	**Accuracy**	**Precision**	**Recall**	**Accuracy**	**Precision**	**Recall**
Random Forest	0.33942	0.33405	0.34026	0.48896	0.47908	0.48944	0.34359	0.33793	0.34438
SVM	0.47993	0.50181	0.48017	0.55653	0.57540	0.55658	0.48754	0.51116	0.48778
Decision Tree	0.26802	0.26353	0.26867	0.37512	0.37102	0.37564	0.28284	0.27689	0.28360

2. Comparing Classifier Performance on Various Data Types:



- In my case, SVM worked best for the given dataset. It has more accuracy, precision, and recall than the other two classifiers.
- High-dimensional datasets like this one are a good fit for SVMs. It has a lot of features to take into account with 83 landmarks per face and each landmark with x, y, and z-axis.
- Decision trees and Random Forests are both prone to overfitting the data. Decision trees and Random Forests can readily overfit the training data when there are lots of features (such as landmarks) in the data.
- SVMs, a kind of binary classification technique, perform well in feature spaces with several dimensions. Because support vectors, which only require a portion of the data to generate the decision boundary, can handle big datasets.

3. Analyzing Misclassifications of Top Classifier (SVM) on Different Data Types :

- The top classifier for me is SVM. It has high accuracy precision and recall compared to the other two.
- In my analysis, for all the data types the misclassifications were the same. They are:
    1. **Original: Angry – Predicted(Highest): Sad:** For me this misclassification makes sense. Because it is reasonable for some people to confuse the expression of anger with sadness, as both emotions can involve a downturned mouth, closing eyelids, and furrowed eyebrows.

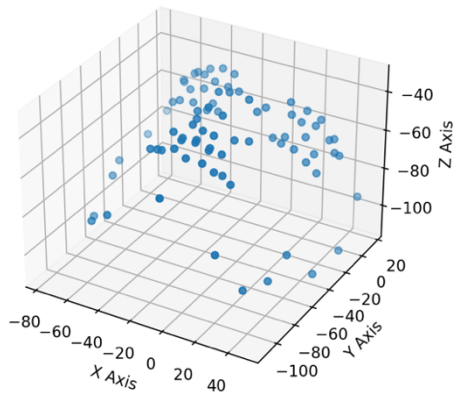
2. **Original: Disgust – Predicted(Highest): Fear:** Disgust and fear can share some similarities in terms of facial expressions such as wrinkling the nose or widening the eyes, so it's possible that they could be misclassified. This makes sense to me.
3. **Original: Fear – Predicted(Highest): Happy:** Misclassifying fear as happy and happy as fear makes less sense for me based on facial expressions alone. Fear typically involves a tense or contracted facial expression, with raised eyebrows and a furrowed brow, whereas happiness involves a relaxed expression with a smile and raised cheeks.
4. **Original: Happy – Predicted(Highest): Fear:** Misclassifying fear as happy and happy as fear makes less sense for me based on facial expressions alone. Fear typically involves a tense or contracted facial expression, with raised eyebrows and a furrowed brow, whereas happiness involves a relaxed expression with a smile and raised cheeks.
5. **Original: Sad – Predicted(Highest): Angry:** Misclassifying anger as sadness and sadness as anger makes sense as both emotions can involve facial features such as a furrowed brow or downturned mouth, which could be ambiguous.
6. **Original: Surprise – Predicted(Highest): Fear:** Misclassifying surprise as fear also makes sense as both emotions involve widened eyes, widening mouth, and raised eyebrows, which could be difficult to distinguish.

4. Understanding Differences in Classifier Performance Across Data Types:

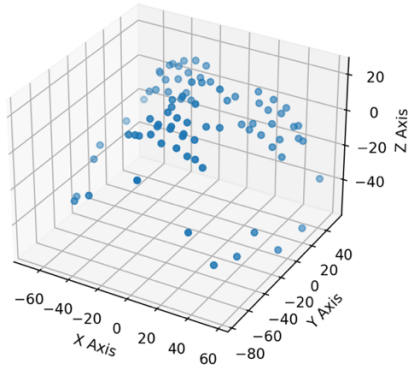
- I got different results for each of the classifiers and SVM performed the best.
- This is because SVM is particularly effective for datasets with a large number of features. In this case, each face has 83 landmarks in 3 dimensions, resulting in a high-dimensional dataset. SVM is known to perform well on such datasets as it can effectively separate the data points in high-dimensional space.
- Random Forest and Decision Tree classifiers are prone to overfitting when the number of features is high. They tend to create complex decision boundaries that can lead to overfitting, especially when the number of trees in the forest is high.
- In terms of data types, I got almost the same results for Original and Rotated data because, In facial recognition, the relative position and orientation of facial landmarks are important features used by the classifiers to distinguish between different facial expressions. Therefore, rotating the landmarks by 180 degrees still preserves the relative relationships between the landmarks, and thus the classifier can still identify the facial expression with almost the same accuracy as the original data.
- Translated data resulted in the best results compared to the other two this is maybe because translation involves shifting the landmarks of each face to the origin, resulting in a change in the spatial relationships between the landmarks. This can make it easier for the classifiers to distinguish between different facial expressions, as the differences in spatial relationships between the landmarks can be more pronounced.

5. **3D Scatter Plots for Each Data Type (Original, Translated, Rotate**

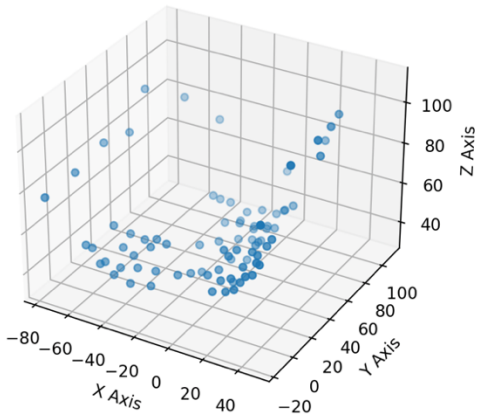
Original:



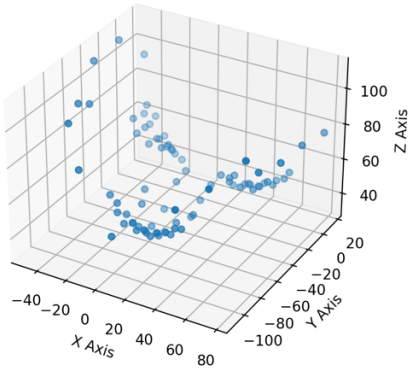
Translated:



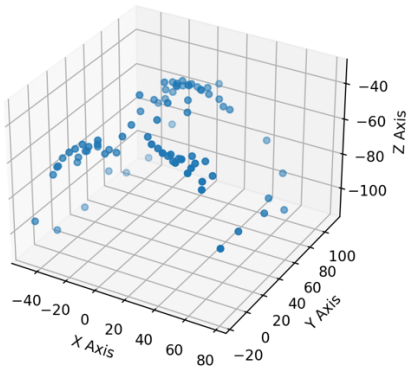
RotatedX:



RotatedY:



RotatedZ:



6. Classifier Explanation:

Random Forest Classifier:

- Random Forest Classifier is an ensemble learning technique that builds numerous decision trees as it is being trained and then combines them to get a final result.
- Random Forest creates a decision tree for each collection of characteristics it chooses at random from the dataset. The average of each tree's forecasts is then used to determine the final prediction.
- The primary benefit of Random Forest is that it lowers the danger of overfitting, which is a problem with decision trees.
- This is due to the fact that it creates a more reliable and accurate model by averaging the predictions given by many decision trees.
- Machine learning problems including classification, regression, and feature selection all employ the Random Forest method.

Support Vector Machine Classifier:

- Finding a hyperplane in an N-dimensional space (N is the number of features) that categorizes the data points clearly is the goal of the support vector machine method.
- There are a variety of different hyperplanes that might be used to split the two classes of data points.
- Finding a plane with the greatest margin—that is, the greatest separation between data points from both classes—is the goal of SVM.
- Increasing the margin distance adds some reinforcement, increasing the confidence with which future data points may be categorized.
- In machine learning, the Support Vector Machine (SVM) classifier is frequently used for classification tasks, particularly when working with high-dimensional and complicated datasets. It can be implemented in a variety of industries, including bioinformatics, natural language processing, and image identification.

Decision Tree Classifier:

- The classifier chooses the feature that best separates the data at each split after recursively dividing the data into smaller subsets depending on the input characteristics.
- Until a stopping requirement is satisfied, such as reaching a maximum depth or a minimum amount of samples in a leaf node, this process continues.
- A new data point is classified by moving it through the decision tree along the decision-making path determined by its input attributes until it reaches a leaf node, which delivers the classification output.
- It is useful for categorization tasks like estimating the probability of an event happening. It can also be applied to feature selection, which finds the crucial elements that influence the classification result.

Confusion Matrix:

- The best classifier among the three is SVM.
- **Original:**

Emotions	Angry	Disgust	Fear	Happy	Sad	Surprise
Angry	5755	2371	1337	1022	3662	1217
Disgust	642	4047	1282	797	183	841
Fear	737	1480	3429	1788	1087	1631
Happy	209	553	1402	5484	79	113
Sad	2250	806	1236	529	4879	751
Surprise	531	914	1358	353	252	5395

- **Translated:**

Emotions	Angry	Disgust	Fear	Happy	Sad	Surprise
Angry	6485	2097	1159	1219	2859	999
Disgust	584	4981	1673	718	163	628
Fear	683	1361	3820	1419	686	1281
Happy	100	703	1507	6044	47	261
Sad	2052	576	989	385	6341	834
Surprise	220	453	896	188	46	5945

- **RotatedX:**

Emotions	Angry	Disgust	Fear	Happy	Sad	Surprise
Angry	5951	2324	1338	1007	3611	1214
Disgust	653	3956	1195	780	88	802
Fear	774	1524	3476	1778	1097	1699
Happy	118	617	1439	5520	57	89
Sad	2176	821	1277	542	5041	758
Surprise	452	929	1319	346	248	5386

- **RotatedY:**

Emotions	Angry	Disgust	Fear	Happy	Sad	Surprise
Angry	5980	2359	1348	1004	3615	1221
Disgust	662	3912	1162	734	92	791
Fear	789	1566	358	1751	1088	1714
Happy	91	612	1436	5600	45	86
Sad	2170	843	1252	544	5059	759
Surprise	432	879	1298	340	243	5377

- **RotatedZ:**

Emotions	Angry	Disgust	Fear	Happy	Sad	Surprise
Angry	5987	2346	1356	1008	3620	1220
Disgust	664	3913	1131	730	100	784
Fear	782	1588	3572	1739	1082	1715
Happy	83	624	1467	5625	41	89
Sad	2186	852	1237	541	5065	761
Surprise	422	848	1281	330	234	5379

SVM:

Classifier/ Data Type	Original Data			Translated			Rotated X | Y | Z		
Metric	**Accuracy**	**Precision**	**Recall**	**Accuracy**	**Precision**	**Recall**	**Accuracy**	**Precision**	**Recall**
SVM	0.47993	0.50181	0.48017	0.55653	0.57540	0.55658	0.48754	0.51116	0.48778

- The SVM classifier performed better than the Random Forest and Decision Tree classifier on the original data, with an accuracy of 47.993%, a precision of 50.181%, and a recall of 48.017%.
- After applying translation and rotation to the data, the performance of the model improved further, with an accuracy of 55.653%, precision of 57.540%, and recall of 55.658%.
- SVM has given the best results among the three classifiers.
- It has high Accuracy, Precision, and Recall values at around an average of 50.
- It has correctly classified happy and angry faces data more precisely compared to other emotions.

Random Forest:

Classifier/ Data Type	Original Data			Translated			Rotated X | Y | Z		
Metric	**Accuracy**	**Precision**	**Recall**	**Accuracy**	**Precision**	**Recall**	**Accuracy**	**Precision**	**Recall**
Random Forest	0.33942	0.33405	0.34026	0.48896	0.47908	0.48944	0.34359	0.33793	0.34438

- Based on the results, the random forest classifier achieved an overall accuracy of 33.942% on the original data, which increased to 48.896% on the translated data but dropped to 34.359% on the rotated data.
- Similarly, the precision and recall scores also followed similar trends across the three datasets, with the highest scores obtained on the translated data and the lowest scores on the rotated data.
- The results suggest that the random forest classifier may be sensitive to certain types of data transformations and may perform better on datasets that are similar to the translated version of the data.

Decision Tree:

Classifier/ Data Type	Original Data			Translated			Rotated X | Y | Z		
Metric	**Accuracy**	**Precision**	**Recall**	**Accuracy**	**Precision**	**Recall**	**Accuracy**	**Precision**	**Recall**
Decision Tree	0.26802	0.26353	0.26867	0.37512	0.37102	0.37564	0.28284	0.27689	0.28360

- In terms of accuracy, the classifier performed the best on the translated data with an accuracy of 37.512%. This is a slight improvement over the original data accuracy of 26.802%.
- However, the precision and recall scores on the translated data were only slightly better than the original data.
- The classifier performed the worst on the rotated data with an accuracy of 28.284%. Overall, the decision tree classifier did not perform very well on any of the data types.