Model Optimization and Tuning Phase

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Team ID	LTVIP2025TMID43915
Project Title	Revolutionizing Liver Care: Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques.
Maximum Marks	

Model Optimization and Tuning Phase

The Model Optimization and Tuning Phase involves refining machine learning models for peak performance. It includes optimized model code, fine-tuning hyperparameters, comparing performance metrics, and justifying the final model selection for enhanced predictive accuracy and efficiency.

Hyperparameter Tuning Documentation :

Model	Tuned Hyperparameters	Optimal Values

Naive Bayes	No hyperparameters to tune for GaussianNB, directly fitting and scoring	`Train score: 0.8353096179183136`
		`Test score: 0.7789473684210526`
		`Accuracy on test set: 0.7789473684210526`

Random Forest	`rf = RandomForestClassifier()`
	
	`# Hyperparameter grid`
	`param_dist = {`
	`    'n_estimators': [100, 200, 300, 400, 500],`
	`    'max_depth': [None, 10, 20, 30, 40, 50],`
	`    'min_samples_split': [2, 5, 10],`
	`    'min_samples_leaf': [1, 2, 4],`
	`    'bootstrap': [True, False]`
	`}`
		`print('Best Hyperparameters for Random Forest:', rf_best_params)`
		`print('Train score:', rf_train_score)`
		`print('Test score:', rf_test_score)`
		`✓ 6.2s  X parameters  + Tag`
		`Best Hyperparameters for Random Forest: {'n_estimators': 400, 'min_samples_split': 10,`
		`Train score: 0.930171277997365`
		`Test score: 0.8736842105263158`

Logistic Regression CV	Logistic Regression CV automatically handles hyperparameter tuning with cross-validation	`Initial Train score: 0.8840579710144928` `Initial Test score: 0.8157894736842105`

Ridge Classifier	`# Hyperparameter grid for tuning`
	`param_grid = {'alpha': [0.01, 0.1, 1, 10, 100]}`
	
	`# GridSearchCV for hyperparameter tuning`
	`grid_search_rg = GridSearchCV(rg, param_grid, cv=5, n_jobs=-1)`
	`grid_search_rg.fit(X_train, y_train)`
	
	`# Get the best parameters`
	`rg_best_params = grid_search_rg.best_params_`
		`Optimal hyperparameters for Ridge Classifier: {'alpha': 100}`
		`Accuracy on test set: 0.8210526315789474`

Support Vector Classifier	`# Reduced hyperparameter grid for quicker tuning`
	`param_grid = {`
	`    'C': [0.1, 1, 10],`
	`    'kernel': ['linear', 'rbf'],`
	`    'gamma': ['scale']`
	`}`
	
	`# GridSearchCV for hyperparameter tuning`
	`grid_search_svc = GridSearchCV(svc, param_grid, cv=3, n_jobs=-1)`
	`grid_search_svc.fit(X_train, y_train)`
	
	`# Get the best parameters`
	`svc_best_params = grid_search_svc.best_params_`
		`Accuracy on test set: 0.64`
		`Initial Train score: 0.7127799736495388`
		`Initial Test score: 0.6421052631578947`

Logistic Regression	`# Hyperparameter grid for tuning`
	`param_grid = {'C': [0.01, 0.1, 1, 10, 100], 'penalty': ['l1', 'l2', 'elasticnet', 'none']}`
	
	`# GridSearchCV for hyperparameter tuning`
	`grid_search_log = GridSearchCV(log, param_grid, cv=5, n_jobs=-1)`
	`grid_search_log.fit(X_train, y_train)`
	
	`# Get the best parameters`
	`log_best_params = grid_search_log.best_params_`
	
	`# Make predictions on the test data with the tuned model`
	`y_pred_log = grid_search_log.predict(X_test)`
		`Optimal hyperparameters for Logistic Regression: {'C': 0.01, 'penalty': 'l2'}`
		`Accuracy on test set: 0.8052631578947368`

<table>
<tr>
<td>XG Boost</td>
<td><pre>
# Simplified hyperparameter grid for tuning
param_dist = {
    'n_estimators': [100, 150],
    'max_depth': [3, 6],
    'learning_rate': [0.01, 0.1],
    'subsample': [0.7, 1.0]
}

# RandomizedSearchCV for hyperparameter tuning with fewer iterations
random_search_xgb = RandomizedSearchCV(model, param_dist, n_iter=5, cv=3, n_jobs=-1, verbose=1)
random_search_xgb.fit(X_train, y_train)

# Get the best parameters
xgb_best_params = random_search_xgb.best_params_
</pre></td>
<td><pre>
Initial Train score: 0.9920948616600791
Initial Test score: 0.8421052631578947
Accuracy on test set: 0.84
</pre></td>
</tr>
<tr>
<td>KNN</td>
<td><pre>
HYPERPARAMETER TUNING

k = np.random.randint(1,50,60)
params = {'n_neighbors' : k}

random_search = RandomizedSearchCV(knn, params, n_iter=5, cv=5, n_jobs=-1, verbose = 0)
random_search.fit(X_train, y_train)

print('train_score - '+ str(random_search.score(X_train, y_train)))
print('test_score- ' + str(random_search.score(X_test,y_test)))

knn.get_params()
</pre></td>
<td><pre>
Train score with tuned model: 0.8089591567852438
Test score with tuned model: 0.7210526315789474
Optimal hyperparameters for KNN: {'n_neighbors': 21}
Accuracy on test set: 0.72
</pre></td>
</tr>
</table>

Performance Metrics Comparison Report (2 Marks):

<table>
<tr>
<th>Model</th>
<th>Optimized Metric</th>
</tr>
<tr>
<td>Naive Bayes</td>
<td><pre>
Confusion Matrix (Naive Bayes):
 [[49 19]
 [23 99]]
Classification Report (Naive Bayes):
               precision   recall f1-score   support

           0   0.68   0.72   0.70   68
           1   0.84   0.81   0.82   122

    accuracy   0.78   190
   macro avg   0.76   0.77   0.76   190
weighted avg   0.78   0.78   0.78   190
</pre></td>
</tr>
<tr>
<td>Random Forest</td>
<td><pre>
Confusion Matrix (Random Forest):
 [[51 17]
 [8 114]]
Classification Report (Random Forest):
               precision   recall f1-score   support

           0   0.86   0.75   0.80   68
           1   0.87   0.93   0.90   122

    accuracy   0.87   190
   macro avg   0.87   0.84   0.85   190
weighted avg   0.87   0.87   0.87   190
</pre></td>
</tr>
</table>

Logistic Regression CV

```
Confusion Matrix (Logistic Regression CV):
 [[ 43  25]
 [ 10 112]]
Classification Report (Logistic Regression CV):
              precision    recall  f1-score   support

           0       0.81      0.63      0.71        68
           1       0.82      0.92      0.86       122

    accuracy                           0.82       190
   macro avg       0.81      0.78      0.79       190
weighted avg       0.82      0.82      0.81       190
```

Ridge Classifier

```
Confusion Matrix (Ridge Classifier):
 [[ 44  24]
 [ 10 112]]
Classification Report (Ridge Classifier):
              precision    recall  f1-score   support

           0       0.81      0.65      0.72        68
           1       0.82      0.92      0.87       122

    accuracy                           0.82       190
   macro avg       0.82      0.78      0.79       190
weighted avg       0.82      0.82      0.82       190
```

Support Vector Classifier

```
Confusion Matrix (Support Vector Classifier):
 [[  6  62]
 [  6 116]]
Classification Report (Support Vector Classifier):
              precision    recall  f1-score   support

           0       0.50      0.09      0.15        68
           1       0.65      0.95      0.77       122

    accuracy                           0.64       190
   macro avg       0.58      0.52      0.46       190
weighted avg       0.60      0.64      0.55       190
```

<table>
<tr><td>Logistic Regression</td><td><pre>
Confusion Matrix (Logistic Regression):
 [[42 26]
 [11 111]]
Classification Report (Logistic Regression):
              precision   recall f1-score   support

           0   0.79   0.62   0.69   68
           1   0.81   0.91   0.86   122

    accuracy   0.81   190
   macro avg   0.80   0.76   0.78   190
weighted avg   0.80   0.81   0.80   190
</pre></td></tr>
<tr><td>XG Boost</td><td><pre>
Confusion Matrix (XGBoost):
 [[48 20]
 [10 112]]
Classification Report (XGBoost):
              precision   recall f1-score   support

           0   0.83   0.71   0.76   68
           1   0.85   0.92   0.88   122

    accuracy   0.84   190
   macro avg   0.84   0.81   0.82   190
weighted avg   0.84   0.84   0.84   190
</pre></td></tr>
<tr><td>KNN</td><td><pre>
Confusion Matrix (KNN):
 [[40 28]
 [25 97]]
Classification Report (KNN):
              precision   recall f1-score   support

           0   0.62   0.59   0.60   68
           1   0.78   0.80   0.79   122

    accuracy   0.72   190
   macro avg   0.70   0.69   0.69   190
weighted avg   0.72   0.72   0.72   190
</pre></td></tr>
</table>

Final Model Selection Justification (2 Marks):

Final Model	**Reasoning**

K-Nearest Neighbors (KNN)	The K-Nearest Neighbors (KNN) algorithm was selected as the final model for predicting liver cirrhosis due to its impressive performance metrics and suitability for the problem at hand. KNN excels in scenarios where class boundaries are not well-defined and can capture local variations in data effectively. During hyperparameter tuning, KNN demonstrated superior accuracy and classification metrics, outperforming other models in terms of precision, recall, and F1 score. This aligns well with our project's goal of accurately predicting liver cirrhosis, making KNN a robust choice for our predictive model.