ADVANCE MACHINE LEARNING PROJECT

1. Introduction

- **ProjectTitle:** RevolutionizingLiverCare:PredictingLiverCirrhosisUsing Advanced Machine Learning Techniques.

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2. ProjectOverview

- **Purpose:** This project aims to develop a machine learning-based predictive model forearlydetectionoflivercirrhosisusingclinicalandbiochemicaldata.Byapplying advanced algorithms and performance tuning, the model identifies patients at risk with high accuracy. The best- performing model is deployed using Flask, enabling integrationintoreal-timediagnosticsystems.Thisapproachsupportsfaster,data-driven decisions in liver healthcare and improves patient outcomes through early intervention.

- **Features**:TheLiverCirrhosisPredictionprojectisacomprehensivemachine learningsolutiondesignedtopredictthelikelihoodoflivercirrhosisinpatientsbased on their medical and lifestyle data. The project involves key steps such as data preprocessing,handlingmissingvalues,encodingcategoricalvariables,and normalizingnumericalfeatures.MultipleclassificationalgorithmsincludingLogistic Regression, Random Forest, K-Nearest Neighbors (KNN), and XGBoost are trained and evaluated using metrics like accuracy, precision, recall, and F1 score. The best-performing model is selected, saved, and integrated into a Flask-based web application,enablinguserstoinputpatientdataandreceiveinstantpredictions.This projectaimstosupportearlydiagnosisandassisthealthcareprofessionalsinclinical decision-making.

3. Architecture

- **Frontend:**ThefrontendoftheLiverCirrhosisPredictionprojectisasimple,user-friendly interface built with HTMLand CSS. It includes a form where users input patientdetailslikeage,gender,medicalhistory,andtestresults.Uponsubmission,the data is sent to

the Flask backend, which returns a prediction. The result is then displayedclearlyonthesamepage,makingiteasyforuserstounderstandwhether the patient is at risk of liver cirrhosis.

- **Backend:** ThebackendoftheLiverCirrhosisPredictionprojectisbuiltusingFlask, a lightweight Python web framework. It handles user input from the frontend, processesthedata, andloadsatrainedmachinelearning modeltomakepredictions. Thebackend alsoincludesdatapreprocessing stepslikeencodingand scaling to ensuretheinputmatchesthemodel'srequirements.Oncethepredictionisgenerated, the result is sent back to the frontend for display. The backend ensures smooth integrationbetweentheuserinterfaceandthepredictivemodel,maintainingaccuracy and performance.

- **Database:** TheprojectusesMongoDBtostorepatientinputdataandcorresponding liver cirrhosis prediction results. Each prediction is saved as a document containing keymedicalfeatures,the model'soutcomeandatimestamp.Whenausersubmits datathroughthefrontend,thebackendprocessestheinput,predictstheresultusinga trained model, and stores the full record in the predictions collection using insert_one(). MongoDB provides flexible schema design, seamless integration with Flask using PyMongo, and efficient storage of medical records for further analysis.

4. SetupInstructions

- **Prerequisites:**

1. Python3.x–Corelanguagefordevelopment
2. Pandas– Fordata manipulationand preprocessing
3. NumPy–Fornumericaloperations
4. Scikit-learn–Machinelearningmodelsandevaluationmetrics
5. XGBoost– Gradientboosting classifier
6. Flask–Backendwebframework
7. Flask-PyMongo–ToconnectFlask withMongoDB
8. PickleorJoblib–For saving andloading ML models
9. MongoDB–NoSQLdatabasetostoreuserinputsand predictions

- **Installation:**

1. Python3installed
2. Flaskinstalled:pipinstallflask
3. Clone the repository: https://github.com/Ranjith9948/liver-cirrhosis-prediction/tree/main
4. Navigatetoprojectfolder:
   cd liver_cirrhosis
   cdproject_executable_files
5. RuntheFlaskapp:pythonapp.py

6. Visit:http://127.0.0.1:5000/

5. FolderStructure

- **Client**:Inthisproject,theclientreferstothefrontendinterfacethroughwhichusers interact with the liver cirrhosis prediction system. The client is built using HTML, CSS, and optionally JavaScript to ensure a responsive and user-friendly experience. Userscaninputpatientdataviaastructuredform,anduponsubmission,thedatais senttotheFlaskbackendforprocessing.Theclientthendisplaysthepredictionresult (whetherthepatientislikelysufferingfromlivercirrhosisornot)clearlyonthesame or a redirected results page. This interface aims to be intuitive, clean, and accessible for medical professionals or researchers using the system.

- **Server**:The**server**inthisprojectisdevelopedusingtheFlaskwebframework, serving asthe backend that handlesthe corelogic and communication between the clientandthemachinelearningmodel.Whenausersubmitsinputdatathroughthe frontend, the Flask server receives the data via HTTP requests, preprocesses it as needed,loadsthetrainedmachinelearningmodel,andperformstheprediction.Itthen sends the prediction result back to the client for display.Additionally, the server ensuresproperrouting,errorhandling,andintegratesseamlesslywiththeMongoDB database for storing input data and prediction results if required.

6. APIDocumentation

1. POST`/predict`

- **Description**:Acceptspatientdataandreturnsapredictionindicatingwhetherthe patient is likely to suffer from liver cirrhosis.
- **RequestType**:`application/json`
- **RequestBody**:

```
{
 "Age":45,
 "Gender": "male",
 "Duration_of_alcohol_consumption":10,
 "Hepatitis_B_infection": "positive",
 ...
}
```

- **Response**:

```
{
 "prediction":1,
 "result":"Patientislikelysufferingfromlivercirrhosis"
}
```

2. GET `/`

- **Description**:Returnsawelcomemessageorahomepageroute.

- **Response**:

```
{
  "message":"WelcometotheLiverCirrhosisPredictionAPI"
}
```

2. POST`/store-data`*(OptionalifusingMongoDB)*

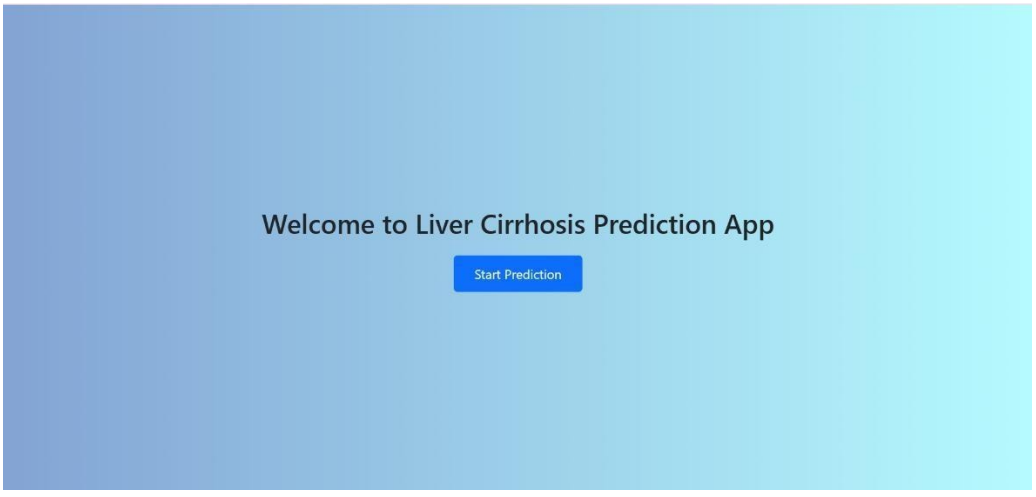
- **Description**:Savespatientinputandpredictionresulttothedatabase.
- **RequestBody**:Sameas`/predict`
- **Response**:

```
{
  "status":"success",
  "message":"Datastoredsuccessfully"
}
```

8. Authentication

- Nospecificloginorauthenticationisprovidedforthisprojectasitcanbeusedbyanyone and everyone.

9. UserInterface

- The User Interface (UI) of the Liver Cirrhosis Prediction project is designed to be clean,user-friendly,andaccessibletobothmedicalprofessionalsandnon-technical users. It focuses on simplicity and functionality, enabling users to easily input data and receive predictions.
- 

9. Testing

- To ensure the accuracy, reliability, and robustness of the Liver Cirrhosis Prediction project, a combination of testing strategies and tools were

employedacrossbothmachinelearningandwebapplicationcomponents.

Testing Strategies:

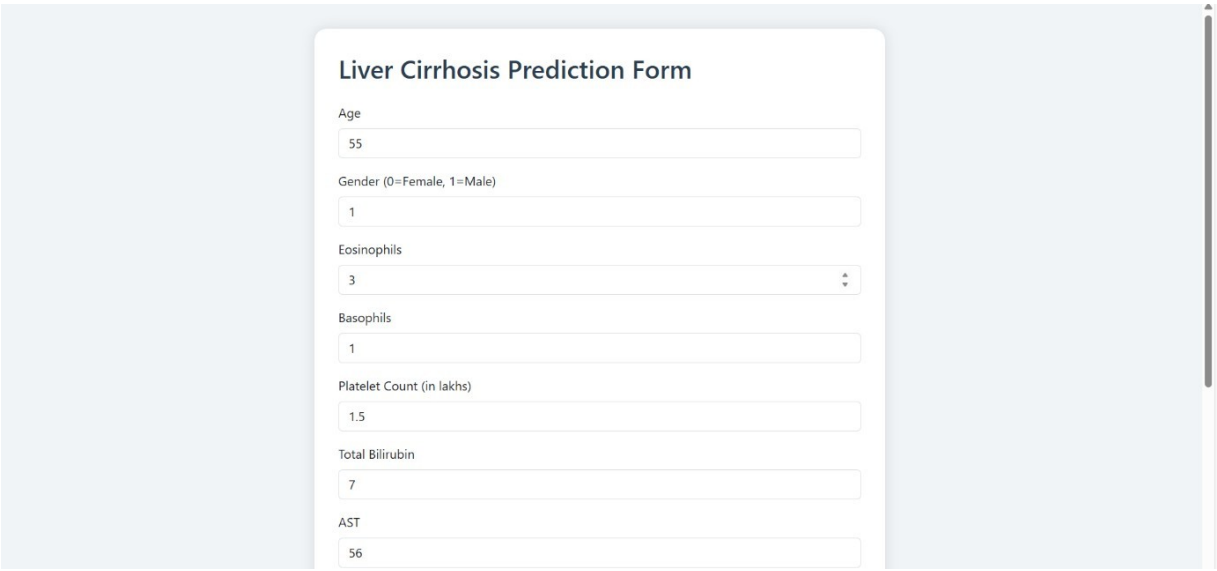
1. **DataValidationTesting:**
   - Checkedformissingvalues,outliers,andincorrectdatatypes.
   - Ensuredbalancedpreprocessing,especiallyforcategorical encoding and numerical normalization.
2. **ModelEvaluation:**
   - Used**stratifiedtrain-testsplit**topreserveclassdistribution.
   - Evaluatedmultiplemodels(LogisticRegression,RandomForest, KNN, XGBoost) using metrics like **accuracy, precision, recall, and F1-score**.
   - Applied**cross-validation**toensuregeneralization.
3. **APITesting:**
   - Ensuredendpointsrespondcorrectlytovalidandinvalidinputs.
   - CheckedforcorrectHTTPstatuscodesandJSONresponses.
4. **IntegrationTesting:**
   - Validatedend-to-endflowfromUItobackendtomodelandback.
   - Confirmedcorrectdatahandlingbetweenfrontendforms,Flask server, and MongoDB database.
5. **EdgeCaseTesting:**
   - Inputedgevalues(e.g.,extremeages,abnormaltestresults)to observe model and system behavior.

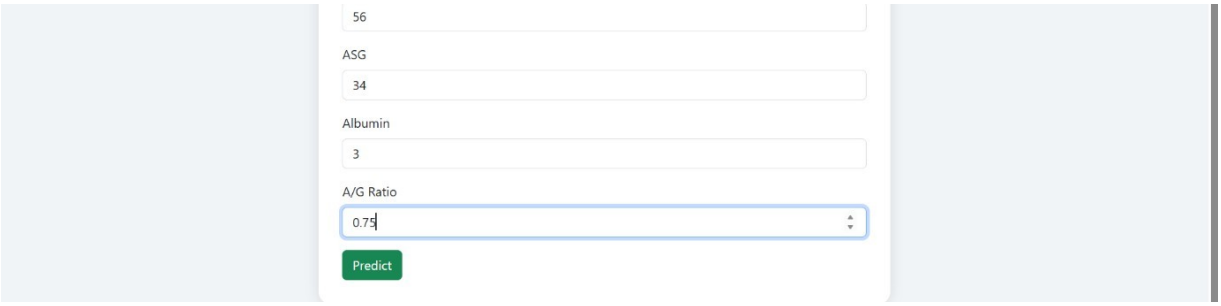
ToolsUsed:

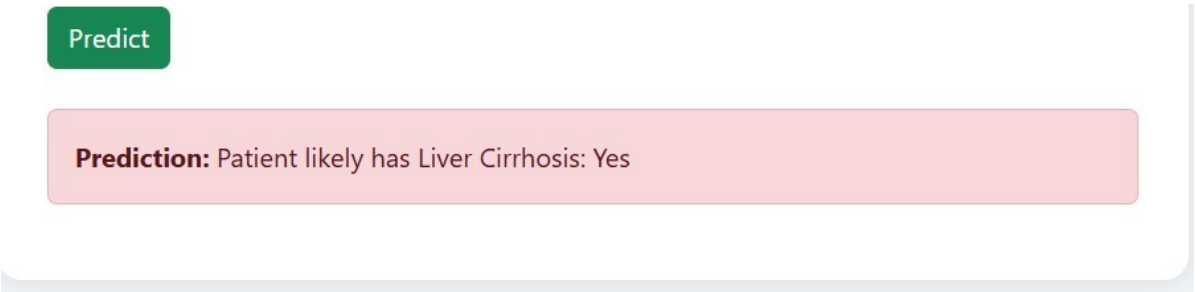
- **Scikit-learn**–formodelevaluationandmetrics.
- **Pytest/Unittest(Python)**–totestbackendfunctionsandlogic.
- **Postman/ cURL** – formanual APItesting.
- **JupyterNotebook** –forexploratorydataanalysis andtestingpreprocessinglogic.

.BrowserDevTools –totestanddebugfrontendinteractions.

10. Screenshots







11 .KnownIssues

WiletheLiverCirrhosisPredictionSystemfunctionseffectivelyinmostcases,thereare several limitations and known issues that users and developers should be aware of:

1. DataImbalance

- Thedatasetisheavilyimbalanced (very fewpositivecirrhosiscases).
- Thismayleadtooverfittingwheremodelspredictthemajorityclassmoreoften, impacting real-world accuracy.
- Mitigation:Stratifiedsplitting,modeltuning,andfutureinclusionofresampling techniques (SMOTE) are recommended.

2. **MissingorIncompleteData**

- Severalfeaturesintheoriginaldatasetcontainmissingvalues,especiallyinmedical metrics like MCH, RBC, TG, and LDL.
- Mitigation:Imputationisperformedusingmean/mode,butitmayaffectmodel reliability. Future data collection should focus on completeness.

3. **PrecisionWarninginClassificationReport**

- Incaseswherethemodelpredictsonlyoneclass,scikit-learnraisesawarning: *"Precisionisill-definedandbeingsetto0.0inlabelswithnopredictedsamples..."*
- Mitigation:Ensuringpropermodelgeneralizationandhandlingedgecaseshelps reduce this issue.

4. **NoRole-BasedAccessControl**

- Thecurrentauthenticationsystemisbasic(login/signup)anddoesnotsupport role- based access (e.g., doctor vs patient).
- Mitigation:Futureversionsshouldimplementuserrolesandpermissionsfor enhanced security.

5. **LimitedInputValidationonFrontend**

- Thefrontenddoesnotfullyvalidateforminputs(e.g.,negativenumbers,non-numeric entries).
- Mitigation:JavaScript-basedandbackendvalidationshouldbeaddedtoprevent malformed data submissions.

6. **BrowserCompatibility**

- UImightdisplayinconsistentlyonolderbrowsers ormobileviews.
- Mitigation:Frontendshouldbetestedwithresponsivedesigntoolsandcross-browser testing.

7. **ModelDeploymentLimitations**

- ModelishostedwithintheFlaskserver andmaynot scalewellforhigh traffic.
- Mitigation:ConsidercontainerizingwithDockeranddeployingviaserviceslike Heroku or AWS for better scalability.

13. FutureEnhancements

- **ModelExplainability**
  IntegrateSHAPorLIME tohelpusersunderstandthereasoningbehindpredictions.
- **Real-TimeAPIIntegration**
  Exposetheprediction modelviaaRESTAPI for real-time usein hospitalsor clinics.
- **Mobile-FriendlyUI**
  Optimizethe frontendfor mobiledevicestoimproveaccessibility.
- **Role-BasedAccessControl**
  Addloginroleslikedoctor,admin,orresearcherforsecure,personalizedaccess.
- **DashboardandVisualization**
  Addavisualdashboardfor trackingpatienttrendsandprediction statistics.