3D PRINTER MATERIALS PREDICTION

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1. INTRODUCTION

1.1 Overview

Recently, three-dimensional (3D) printing technologies have been widely applied in industry and our daily lives. The term 3D bioprinting has been coined to describe 3D printing at the biomedical level.

Machine learning is currently becoming increasingly active and has been used to improve 3D printing processes, such as process optimization, dimensional accuracy analysis, manufacturing defect detection, and material property prediction.

In this project, the input parameters are like Layer Height (mm), Wall Thickness (mm), Infill Density (%), Infill Pattern (honeycomb, grid), Nozzle Temperature (Cº), Bed Temperature (Cº), Print Speed(mm/s), Fan Speed (%), Roughness (µm), Tension (ultimate), Strength (MPa), Elongation (%).Based on these parameters a supervised machine learning model is built to predict the best material to be used for building 3D models. A web application is build so that the user can type in the mentioned parameters and the material which suits the best is showcased on UI.

2. Purpose

The 3D printing materials industry is increasing due to the rise in the demand from healthcare, automotive, and other industries, globally. The 3D printing materials market comprises several stakeholders, such as raw material suppliers, processors, end-product manufacturers, and regulatory organizations in the supply chain. The demand side of this market is characterized by the development of various industries such as aerospace & defense, healthcare, consumer goods, and automotive. Advancements in technology and diverse applications characterize the supply side. Various primary sources from both the supply and demand sides of the market were interviewed to obtain qualitative and quantitative information.

Predicting material would be more suitable for making the 3D model.

“Key findings revealed that nearly three-quarters (74%) of respondents are planning to invest in 3D printing technology in 2023, with 50% planning to spend up to $100,000.”

2. LITERATURE SUREVY

2.1 Existing problem

One of the most important uses for 3D printing is with in the medical industry. With the power pf 3D printing, surgeons and doctors can produce a mockup of parts from patient’s bodies which need to operate on. 3D printing makes it possible to make a part from a computer program in just a couple of hours.

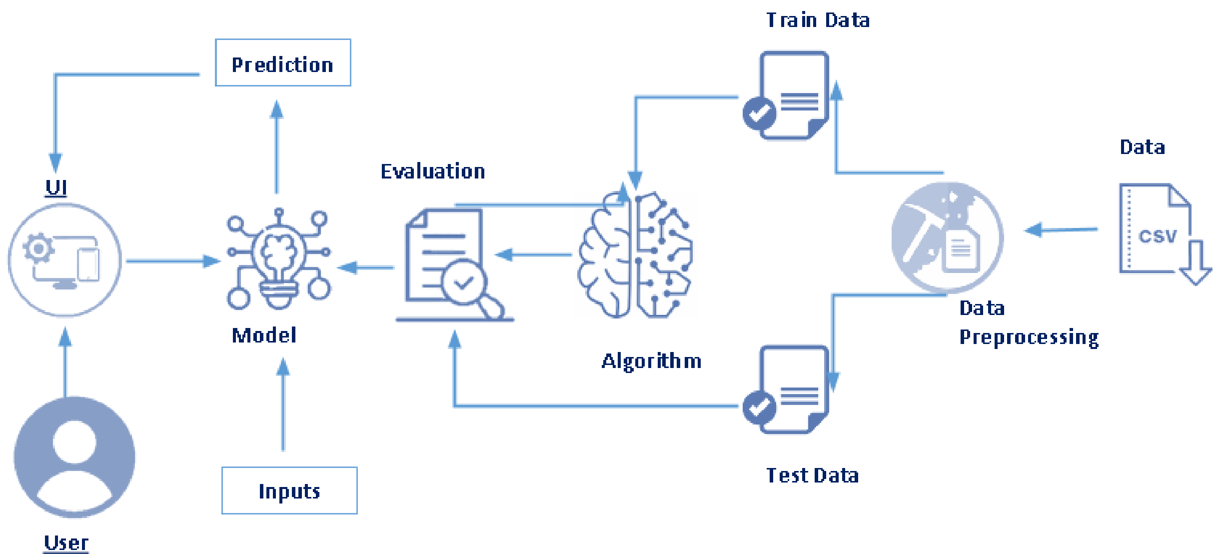
3D printers were extremely expensive and could only be used to print a limited number of products. The majority of the printers were owned by scientists and electronics enthusiasts for research and display. Although it was still in limited development, the printing technology was a combination of modeling both science and construction technology, using some of the newest technological advancements of the time. Consequently, 3D printing design was mainly dependent on the production process. However developments in the field of 3D printing have allowed for the design of products to no longer be limited by complex shapes or colors.

2.2 proposed solution

Our aim is to 3D printer data into prediction value. We wish to show that given data which can predict which type of material that the give values. Further more we examine the type of materials were used by 3D printer. We build the app to predict the 3D printer materials prediction.

3. THEORITICAL ANALYSIS

3.1 Block Diagram



3.2 Software/Hardware Requirements

Software Requirements:

- Python
- Anaconda navigator
- Jupyter notebook
- Spyder
- Chrome

Hardware Requirements:

- Operating system: Windows

- Processor: Intel core i7
- Ram: 8gb
- Storage: 1TB

4. EXPERIMENTAL INVESTIGATIONS

Experimental investigation reveals that, numerical models and different Artificial Intelligence (AI) approaches have been used to investigate performance characteristics of 3D-printed components.

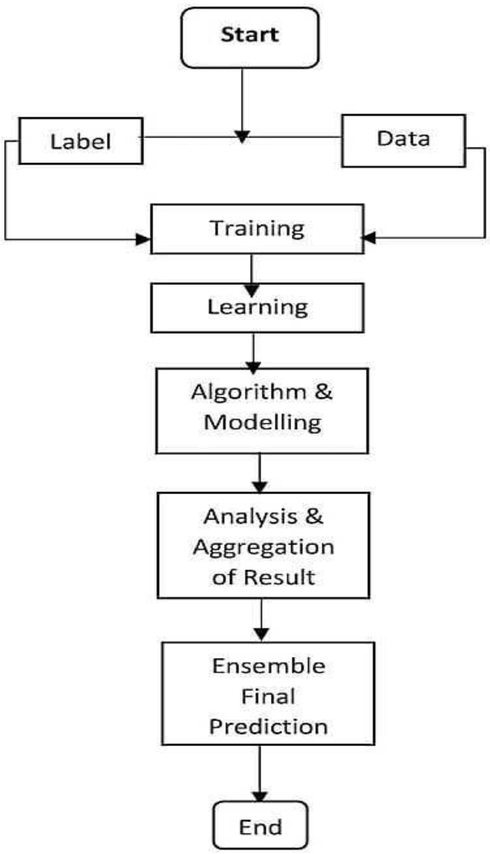
In construction of a ML system, selection of an appropriate ML algorithm is a crucial issue, because each algorithm has significant effect on the accuracy of the result. As each algorithm has its own advantages for a specific application, there is no algorithm which is suitable for all problems. Commonly used ML algorithms in mechanical engineering can be divided into following categories: regression, estimation, classification and clustering.In detail, regression, clustering and classification algorithms are mainly utilized for material property prediction.

In this project we have used decision tree ML algorithm under classification and clustering. We have to complete all the activities and tasks listed below

- Data Collection.
    - Collect the dataset or Create the dataset

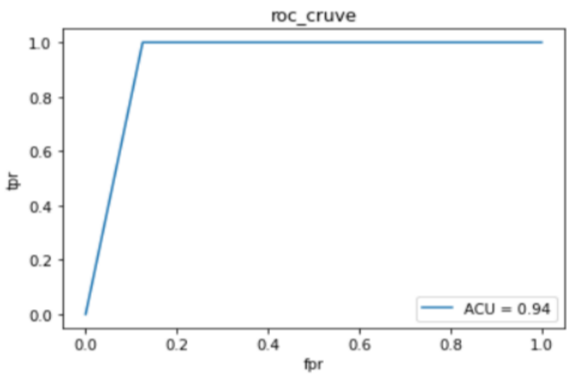
- Data Preprocessing.
    - Import the Libraries.
    - Importing the dataset.
    - Checking for Null Values.
    - Data Visualization.
    - Taking care of Missing Data.
    - Label encoding.
    - One Hot Encoding.
    - Feature Scaling.
    - Splitting Data into Train and Test.
- Model Building
    - Training and testing the model
    - Evaluation of Model
- Application Building
    - Create an HTML file
    - Build a Python Code

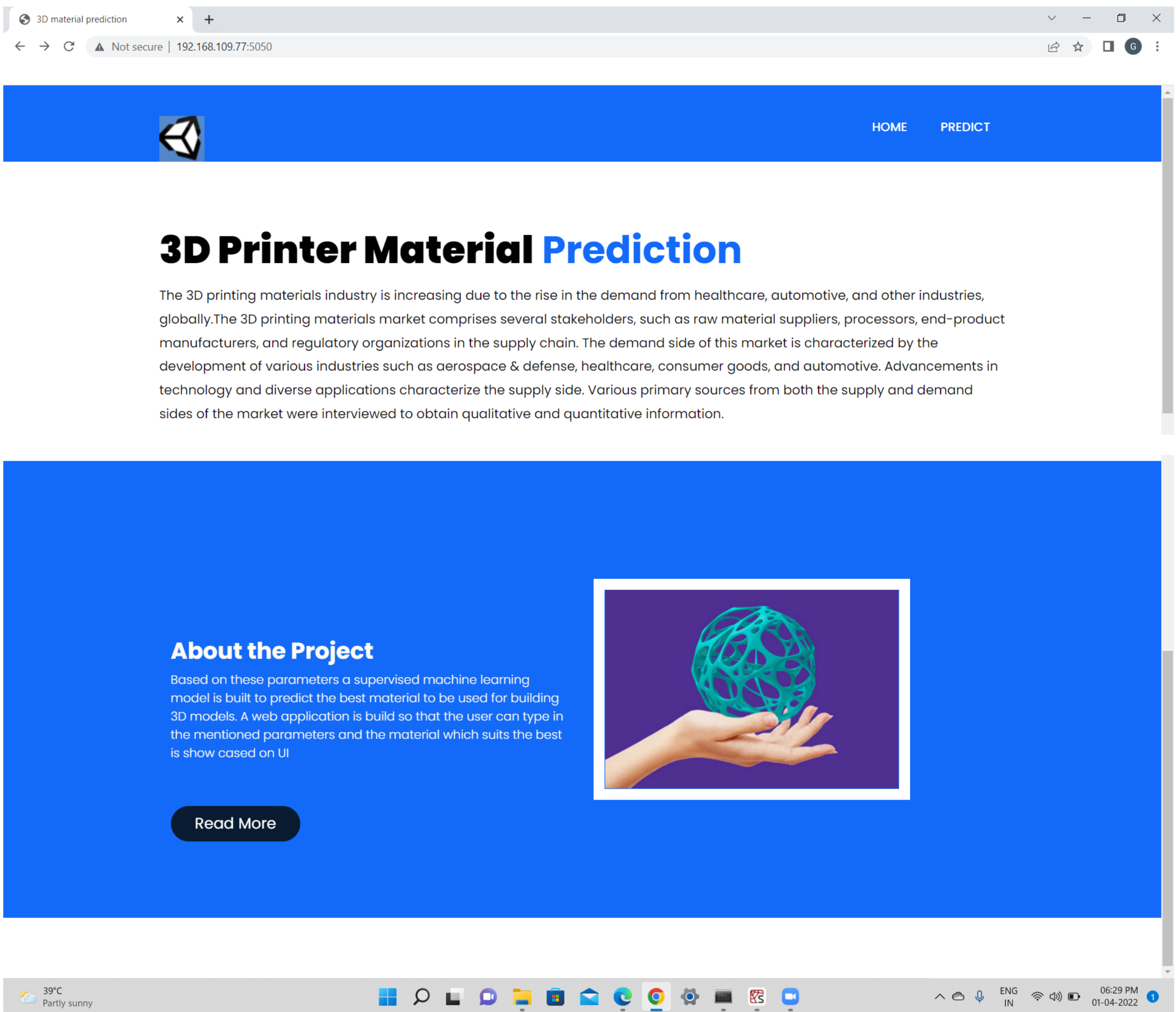
5. FLOWCHART

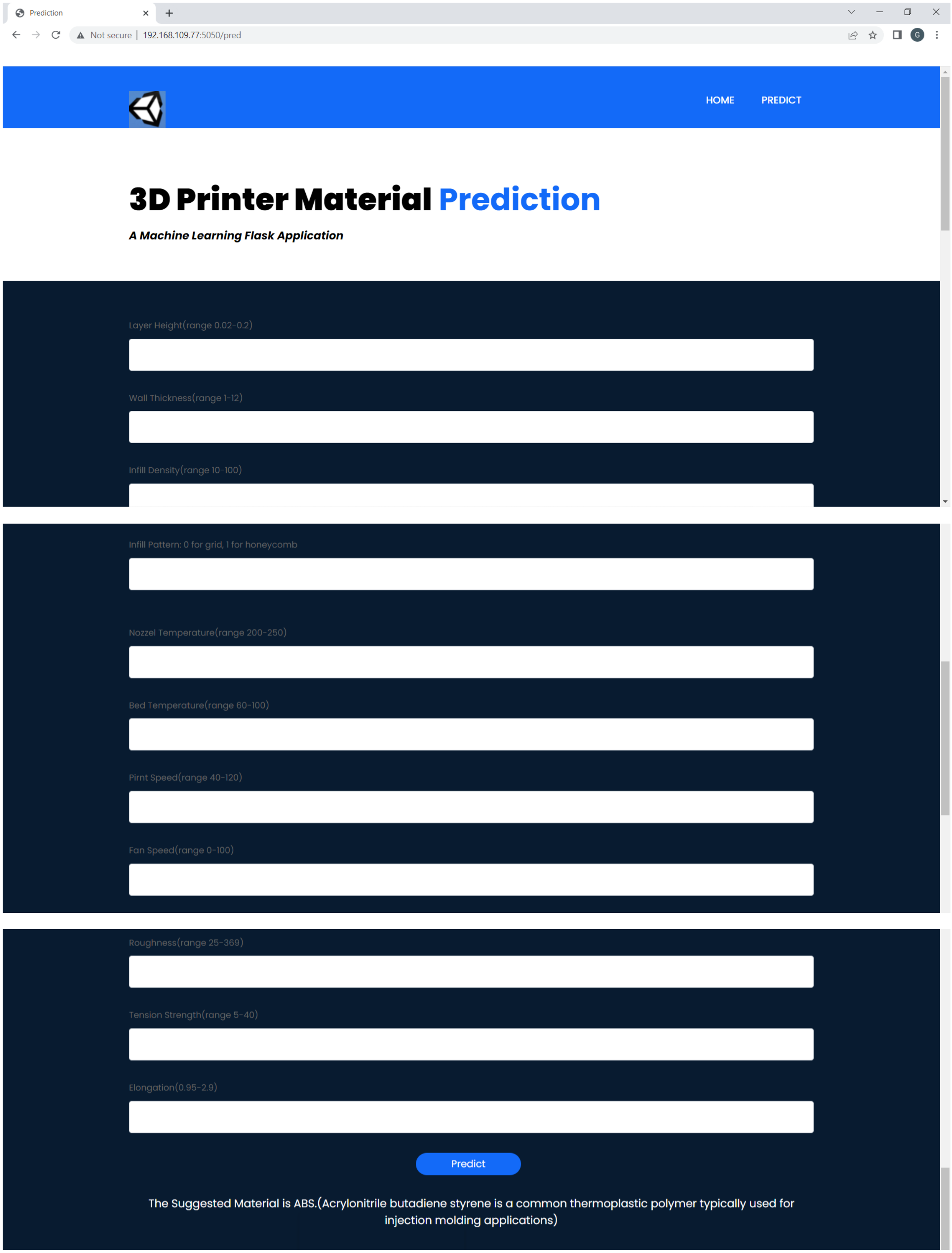


6. RESULT

ML output


roc_cruve
1.0
0.8
0.6
0.4
0.2
0.0
tpr
0.0
0.2
0.4
0.6
0.8
1.0
fpr
ACU = 0.94


3D material prediction
Not secure | 192.168.109.77:5050
HOME
PREDICT
3D Printer Material Prediction
The 3D printing materials industry is increasing due to the rise in the demand from healthcare, automotive, and other industries, globally.The 3D printing materials market comprises several stakeholders, such as raw material suppliers, processors, end-product manufacturers, and regulatory organizations in the supply chain. The demand side of this market is characterized by the development of various industries such as aerospace & defense, healthcare, consumer goods, and automotive. Advancements in technology and diverse applications characterize the supply side. Various primary sources from both the supply and demand sides of the market were interviewed to obtain qualitative and quantitative information.
About the Project
Based on these parameters a supervised machine learning model is built to predict the best material to be used for building 3D models. A web application is build so that the user can type in the mentioned parameters and the material which suits the best is show cased on UI
Read More
39°C
Partly sunny
ENG
IN
06:29 PM
01-04-2022


Prediction
Not secure | 192.168.109.77:5050/pred
HOME
PREDICT
3D Printer Material Prediction
A Machine Learning Flask Application
Layer Height(range 0.02-0.2)
Wall Thickness(range 1-12)
Infill Density(range 10-100)
Infill Pattern: 0 for grid, 1 for honeycomb
Nozzel Temperature(range 200-250)
Bed Temperature(range 60-100)
Pirnt Speed(range 40-120)
Fan Speed(range 0-100)
Roughness(range 25-369)
Tension Strength(range 5-40)
Elongation(0.95-2.9)
Predict
The Suggested Material is ABS.(Acrylonitrile butadiene styrene is a common thermoplastic polymer typically used for injection molding applications)

- User interacts with the UI (User Interface) to enter Data
- The entered data is analyzed by the model which is integrated
- Once model analyses the input the prediction is showcased on the UI

7. ADVANTAGES & DISADVANTAGES

Advantages of 3d printer materials prediction

A lot of the advantages of 3D printing come from the vast range of materials you have to choose from to carry out your intended application. For any type of manufacturer, strong and low-cost materials can serve to benefit your business.

By getting to know the properties of 3D printing materials, you can widen your possible application range and skyrocket the advantages of 3D printing that you experience. For any company, saving costs is a must for efficiency and an optimized production process.

So how do we ensure we get the best value for money without compromising the quality? Strong and low-cost materials are the solution, as they can provide us with end-use parts and long-lasting reliable results.

Disadvantages of 3d printer material

1.Materials Compatibility

The biggest disadvantage of 3D printing is that it only works with plastic and a few metals. Because 3D printing involves the use of high temperatures and not all metals respond well to high temperatures, it limits the options of the manufacturer.

1. Size Limitations

At the moment, 3D printers can only produce small-sized products and not large assembly parts. Larger 3D printing machines are available, but they cost an arm and a leg.

With continued research in the field, the future of 3D printing large items, such as buildings might be possible, but we are still far from there. For that to happen scientists might have to find a way to combine 3D printing with robotics and other tools in the manufacturing process such as excavators and cranes.

8. Applications of 3D printing services

3D printers change the entire manufacturing process, and many companies have adopted this manufacturing technology.

Drone

The 3D printing allows drone manufacturers to create a customized drone where every assembly part except electronic components can be 3D printed. The 3D technology enables the easy production of accessories such as cases, coverings, mounts, and boosters that facilitate proper drone storage.

Aerospace & defense

The Aerospace & defense industry has been benefited from 3D printing since they manufacture functional parts used in aircraft, which include wall panels, air ducts, and structural metal components etc. The primary advantage of using 3D printing in aerospace is weight reduction which significantly decreases payload, fuel consumption, and carbon dioxide emissions. Plus, it allows material efficiency, part consolidation, and low-volume production.

Robots

3D printing capabilities allow robotic parts to be manufactured quickly and straightforwardly. Factors such as reduced weight and customizability play a vital role in robot parts production like in sensor mounts and grippers, which require customization for various uses as they are costly to fabricate. Many robotics companies use Markforged 3D printers in designing and fabricating lightweight and complex parts like end-of-arm tooling at a lower cost.

Automotive

Many automotive industries are using 3D printers in areas such as performance racing and motorsports. Automotive manufacturers print different parts using 3D printers. These include cradles, fixtures, and prototypes that are sturdy, stiff, and long-lasting. The key advantages are greater design flexibility, customization.

9. CONCLUSION

Although 3D printing techniques have been widely employed in different industries in the past few years, they are still developing and faces various problems in production. In this context, different experimental investigations have been performed in order to determine effects of printing process parameters on the mechanical behavior of final products. Since experimental practices are time-consuming and costly methods, other techniques has been applied in this field which are accurate and cost effective.

In recent years, ML has attracted a lot of research interest in 3D printing due to its superior properties. In different 3D printing processes, ML algorithms are beneficial in several domains. Although ML can be used for different purposes such as process planning, design optimization, microstructural characterization, and quality assessment in 3D printing. In the present study, an overview of ML has been presented and previous research works in applications of ML in predicting mechanical behavior of 3D-printed materials have been discussed. In addition, we have presented our thoughts about future trends in applications of ML in 3D printing.

10. FUTURE SCOPE

The growing popularity of 3D printing for manufacturing all sorts of items, from customized medical devices to affordable homes, has created more demand for new 3D printing materials designed for very specific uses.

One important trend is the development of design software tools for AM. The next step is for them to become fully and seamlessly integrated into popular CAD software products.

Everyday, companies are finding new ways to incorporate the technology into their production. From automotive to consumer goods, companies across industries are becoming aware of the advantages 3D printing offers for production.

According to Sculpteo's 2019 State of 3D Printing report, 51% of companies are actively using 3D printing for production.

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https://www.sciencedirect.com/science/article/pii/S2238785421006670 - bbib10

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12. APPENDIX

A. Source Code

```
#importing libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
#loading the dataset
ds=pd.read_csv('3D_printer.csv')
#printing the first five rows
ds.head()
ds.tail()
ds.info()
#descripive statistics
ds.describe()
#corr among the data
ds.corr()
#finding the null values
ds.isnull().any()
#seaborn pairpolt
#plots pairwise relationships in a dataset
sns.pairplot(ds)
#seaborn heatmap
#a way of representing the data in 2-D form
sns.heatmap(ds[['layer_height','wall_thickness','infill_density','nozzle_
```

```
temperature','bed_temperature','print_speed','fan_speed','roughness','
tension_strenght','elongation']])
#label Encoding
from sklearn.preprocessing import LabelEncoder
lb=LabelEncoder()
ds=ds.iloc[:,:].values
ds[:,3]=lb.fit_transform(ds[:,3])
ds[:,7]=lb.fit_transform(ds[:,7])
da=pd.DataFrame(ds)
y=ds[:,7]
y=y.astype("int")
da.drop(columns=7,inplace=True)
x=da.iloc[:,:].values
x
#TRAIN TEST SPILT
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.2,random
_state=0)
#Feature Scaling
from sklearn.preprocessing import MinMaxScaler
sc=MinMaxScaler()
x_train
y_test
x_train=sc.fit_transform(x_train)
x_train
```

```
x_test=sc.transform(x_test)
x_test
from sklearn.tree import DecisionTreeClassifier
dt=DecisionTreeClassifier(criterion='entropy')
dt.fit(x_train,y_train)
y_pred_dt=dt.predict(x_test)
y_pred_dt
import sklearn.metrics as metrics
fpr,tpr,threshold=metrics.roc_curve(y_test,y_pred_dt)
roc_auc_DT=metrics.auc(fpr,tpr)
roc_auc_DT
from sklearn.metrics import accuracy_score
accuracy_score(y_test,y_pred_dt)
plt.plot(fpr,tpr,label='ACU = %0.2f' % roc_auc_DT)
plt.xlabel("fpr")
plt.ylabel("tpr")
plt.title("roc_cruve")
plt.legend()
#Saving our model into a file
import pickle
pickle.dump(dt,open('PRJ.pkl','wb'))
pickle.dump(sc,open('sc.pkl','wb'))
pickle.dump(lb,open('lb.pkl','wb'))
```

App.py

```
import numpy as np
import pandas as pd
import pickle
from flask import Flask,request, render_template

app=Flask(__name__,template_folder="templates")
model = pickle.load(open('PRJ.pkl', 'rb'))
sc = pickle.load(open('sc.pkl', 'rb'))
lb = pickle.load(open('lb.pkl', 'rb'))

@app.route('/', methods=['GET'])
def index():
    return render_template('home.html')
@app.route('/home', methods=['GET'])
def about():
    return render_template('home.html')
@app.route('/pred',methods=['GET'])
def page():
    return render_template('result.html')
@app.route('/predict', methods=['GET', 'POST'])
def predict():
    input_features = [float(x) for x in request.form.values()]
    features_value = [np.array(input_features)]
    features_name =
['layer_height','wall_thickness','infill_density','infill_pattern','nozzle_temperature',
'bed_temperature','print_speed','fan_speed','roughness','tension_strenght','elong
ation']
```

```
    x=pd.DataFrame(features_value,columns=features_name)
    #x=lb.transform(x_df)
    #x=sc.transform(x_df)


    print(x)

    prediction = model.predict(x)
    output=prediction[0]
    print(output)
    if(output==1) :
        return render_template("result.html",prediction_text = "The Suggested Material is ABS.(Acrylonitrile butadiene styrene is a common thermoplastic polymer typically used for injection molding applications)")
    elif(output==0) :
        return render_template("result.html",prediction_text = "The Suggested Material is PLA.(PLA, also known as polylactic acid or polylactide, is a thermoplastic made from renewable resources such as corn starch, tapioca roots or sugar cane, unlike other industrial materials made primarily from petroleum)")
    else :
        return render_template("result.html",prediction_text = 'The given values do not match the range of values of the model.Try giving the values in the mnetioned range')


if __name__ == '__main__':
     app.run(host='0.0.0.0', port=5050, debug=False)
```