SEMESTER-7 BE MAJOR PROJECT ORAL EXAM

WASTE MANAGEMENT WEBSITE WITH MACHINE LEARNING FEATURES

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INTRODUCTION

- Waste Management is a fundamental issue in all parts of the world. As the population is on the rise, waste and in turn pollution rises in both urban and rural settings. Most of the waste collected is dumped into landfills, which is rising, and is predicted to increase by 70 percent by 2025. With the emerging urban areas, there has been a steady increase in waste that is being dumped.
- Improper disposal of waste harms the environment around us, leading to pollution, and many more hazards to air, water, soil and diseases. There has been a push for digitization of this, as technology is rapidly growing. To tackle this, we have proposed a system which will automate the work of distinguishing between different types of wastes, such as metals, plastics, paper and many more. Using Deep Learning, we plan on training a data set, which can then be used to identify the waste. This will be helpful is recycling of waste, as well as proper disposal of waste which is biodegradable, and thus help the environment, while being efficient.

ANALYSIS

- Waste is classified waste into six categories such as metal, paper, glass, trash, plastic, cardboard.
- The data-set contains images of solid waste objects across 6 classes with about 100–500 images in each type of waste, totaling about around 2497 images.
- Whatever the image is collected is re-sized or transform to suitable type which the algorithm can use for proper training.
- For the pre-processing stage, data augmentation method was performed on the images, because of the small data size.
- A convolution neural network (ConvNet or CNN) is one of the most popular algorithms for deep learning, a type of machine learning where a model learns to perform the task of classification directly from text, images, videos or sound.
- Due to the fact that the trash image dataset is small, pre-trained ResNet-50 model is used which is a type of Convolutional Neural Network architecture

LITERATURE REVIEW

- The accumulation of solid waste in the urban area is becoming a great concern, and it would result in environmental pollution and may be hazardous to human health if it is not properly managed.
- An advanced classification system is developed using Convolutional Neural Network (CNN) model that is using deep learning which is used to classify variety of waste materials into different groups/types such as glass, metal, paper, and plastic, etc.
- The idea behind all the projects was to classify all the waste material into different categories and minimize the human effort and develop an automated system which will classify waste accurately and efficiency.
- Many different algorithms have been developed for the classification of images, such has RNNs, SVMs, ANN etc, but Convolutional Neural Network which is a Machine Learning algorithm has really performed better than them all.
- CNNs hit the spot when the algorithm was used to win the 2012 image-Net large-scale visual recognition challenge (ILSVRC) which was proposed earlier. Since 2012 many different CNN architectures have been developed which has solved many image classification problems.

No.	TITLE	YEAR	AUTHOR	METHODOLOGY	FINDINGS	LIMITATIONS
1)	Automatic classification of solid waste using deep learning	Springer, 2020	V. P. Brintha, R. Rekha, J. Nandhini, N. Sreekaarthick, B. Ishwaryaa, et al.	The proposed idea mainly concentrates on the classification and identification of the waste that is being dumped into the garbage.	The developed system could identify different types of wastes when shown individually with different accuracies.	The system is not able to classify waste accurately when the image contain more than one waste category.
2)	An automatic classification method for environment	IEEE,2016	S.Sudha M.Vidhyalakshmi K.Pavithra K.Sangeetha	The implementation part is done using Caffe which is a deep learning framework as software. Deep learning and deep features have only recently achieved strong results in many tasks.	The developed system would pioneer the work for solid waste management process in the field of Artificial Intelligence. When properly trained, the system is highly efficient	It has very less accurate due to use of caffe.
3)	Intelligent waste classification system using deep learning CNN	SMPM,2019	Olugboja Adedeji, Zenghui Wang	The proposed method is developed based on the ResNet-50 pre-trained model, SVM.	The proposed system is able to classify waste with 87%accuracy.	The model is trained using small dataset and thus accuracy was not optimal.
4)	Automation of Waste Sorting with Deep Learning	IEEE WVC,2019	Joao Sousa , Ana Rebelo, Jaime S. Cardoso	Basic R-CNN, Hierarchical Approachs used using multi-labeled datasets and traininf for shape and materials	The direct R-CNN used gave a mAP of 74.1%, using a hierarchical approach gave a mAP of 80.9% for materials, and 86% for shapes showing improvement on R-CNN methods	It uses a non controlled data set which makes training difficult and the model is specifically trained for food trays.

LITERATURE SURVEY

Paper name	Problem solved	Demerits
An automatic classification method for environment: Friendly waste segregation using deep learning	A proposition for a system that automatically classifies waste using deep learning	Cannot classify medical waste and e-waste due to government restrictions
Comparing deep learning and support vector machines for autonomous waste sorting	To use SVM model to classify waste into plastic, paper and metal	Small amount of images is used in the training set
Automatic waste classification using computer vision as an application in Colombian high schools	Integrating computer vision into developing an application to classify waste automatically into the IEAB	The wrong classifications, the reduced waste and the images in the database indicate that this technique is not enough to carry out the classification in a system of the real scale
Municipal solid waste classification using microwave non-destructive testing technique	This paper presents basic researches of the variation of microwave signal propagation characterization to verify microwave is suitable for MSW classification	Resolution of microwave non-destructive detection of MSW is not always high enough and can be improved only by using stronger microwaves
Smart recycle bin: A conceptual approach of smart waste management with integrated web- based system	A smart recycle bin that caters for recycling glass, paper, aluminium cans and plastic products that automatically evaluate the value of the wastes thrown and accordingly provide 3R card	It is not a very energy-efficient process when the scale of the project is increased

PROBLEM STATEMENT

- The increasing population poses serious threats like limitation of living space, education and employment. But a major serious problem is the enormous amount of waste generation each minute. Waste management is a big challenge in urban areas for most of the countries throughout the world. An astounding ton of waste is generated on a daily basis, but only 5% of this large amount of waste is recycled.
- A possible solution for this could be segregating the waste at the starting stage itself. The identification of the waste is to be properly managed so as to minimize the risks to the health and safety of patients, the public, and the environment. Currently there is no effective system for identification of various types of wastes at a household level. The purpose of our project is to make a simple, low cost and user-friendly waste management system for urban households to waste management process more effective in India.

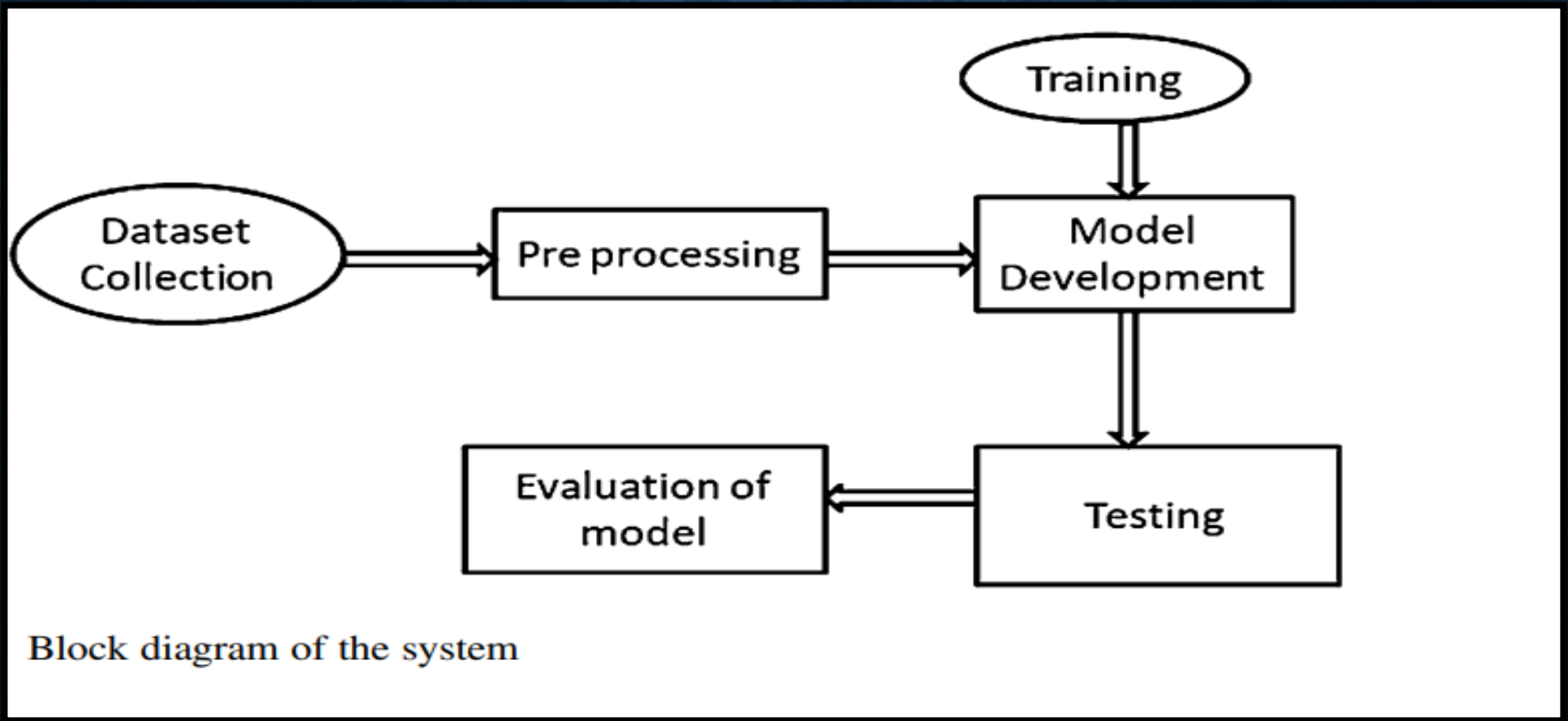
EXISTING SYSTEM

- The existing systems of waste classification range is primitive and not user friendly.
- With the introduction of Machine Learning Algorithms, it has become easier for training models to detect and classify waste, and is being implemented slowly at industrial levels for sorting of waste at waste management plants, etc.
- This is done by using Deep Learning algorithms such as Convolution Neural Networks and Recurrent Neural Networks. IoT operations such as high-speed cameras and robotic arms have also been used in industrial application of Waste Management.
- The hardware components along with older and smaller datasets makes the process of Classification complex at a large scale.

PROPOSED SYSTEM

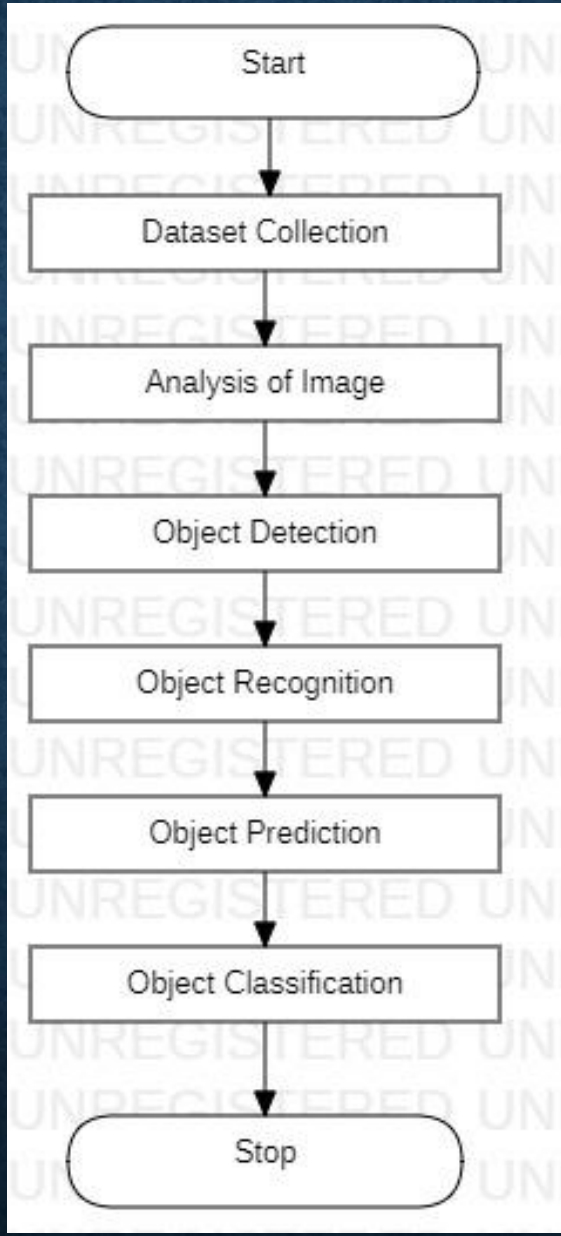
- The proposed methodology mainly focuses on the identification and classification of the waste that is being dumped. Commonly, waste is unsegregated when dumped into landfills, which can cause nonbiodegradable waste thousands of years to decompose.
- The proposed idea of the project is to provide with an efficient and digital solution to this, where a computer system is able to detect and classify the waste item irrespective of shape, size and other factors.
- The project will also be able to learn by itself and hence be constantly updating itself, all while being user friendly for the basic users of the system, allowing them to classify and better dispose of the waste.

SYSTEM ARCHITECTURE



Block diagram of the system

BASIC FLOW OF IMAGE CLASSIFIER

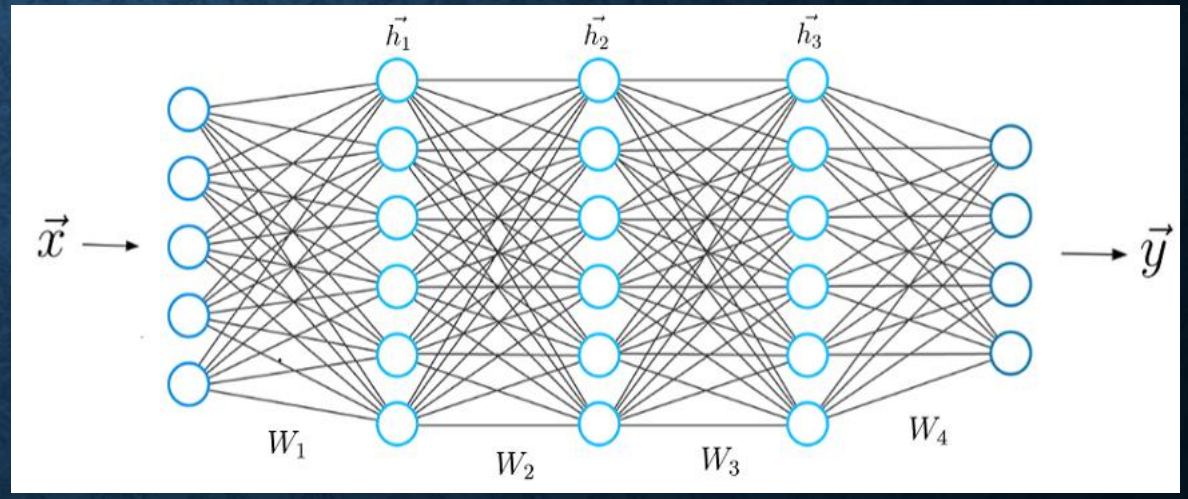


REQUIRED ALGORITHMS

DEEP LEARNING ALGORITHMS:

CONVOLUTIONAL NEURAL NETWORK (CNN):

A convolution neural network (ConvNet or CNN) is one of the most popular algorithms for deep learning, a type of machine learning where a model learns to perform the task of classification directly from text, images, videos or sound. CNNs are specifically useful for finding the patterns in images to detect and recognize objects, faces and poses



- **ResNet-50**: -

- Due to the fact that the trash image dataset is small, we used a pre-trained ResNet-50 model which is a type of Convolutional Neural Network architecture. When the depth is increased, the recognition accuracy of the convolutional neural network can be increased, but due to the increase in depth, the signal that is supposed to modify the weight is reduced at the earlier layer of the CNN.
- This will make learning at the earlier layers inconsequentially and this is called vanishing gradient. Adding more and more layers to the network always leads to training error.
- Residual Network (ResNet-50) is different from the normal convolutional Neural network in that, it is able to go around this problem of vanishing gradient by designing the Convolutional neural network using modules which are called residual models, the ResNet model.

PROJECT DEVELOPMENT

Hardware Requirements

- Deep learning is a very CPU intensive thing to be running. Here are some system requirements to adhere to:

- Quad core Intel Core i5 8th Generation or higher (Dual core is not the best for this kind of work, but manageable)
- 8GB of RAM or higher.
- Minimum of 50GB of storage free
- Premium graphics cards, with Nvidia GTX 980 or higher

Software Requirements

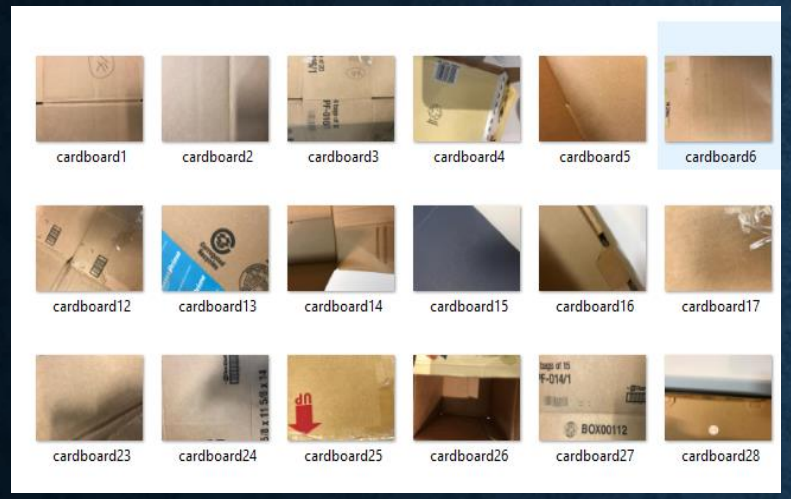
- ✓ Python 3.7 or higher versions
- ✓ Jupyter Notebook/Google-Colab
- ✓ TensorFlow
- ✓ PyTorch
- ✓ OpenCV
- ✓ IDE/Text-Editors
- ✓ Other Python Libraries
- ✓ Frameworks like FLASK, etc

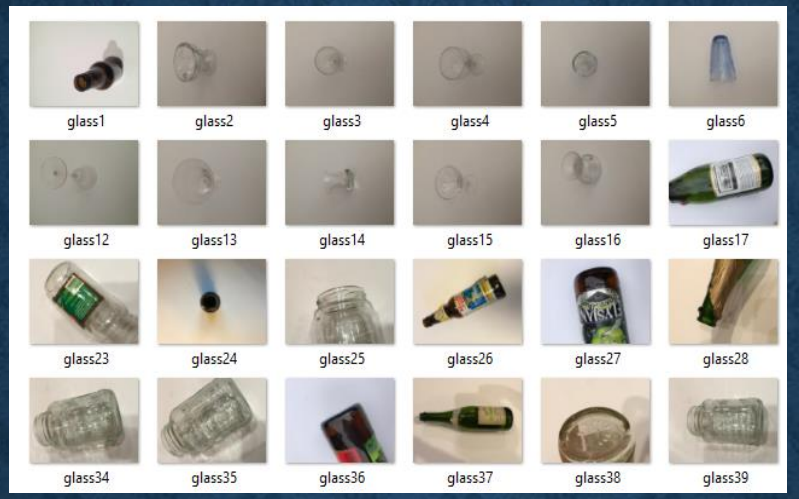
Platform	Hardware	Operating System	Supported Versions
Windows/Linux	Intel/AMD 64-bit	Windows	10/Ubuntu -18.04

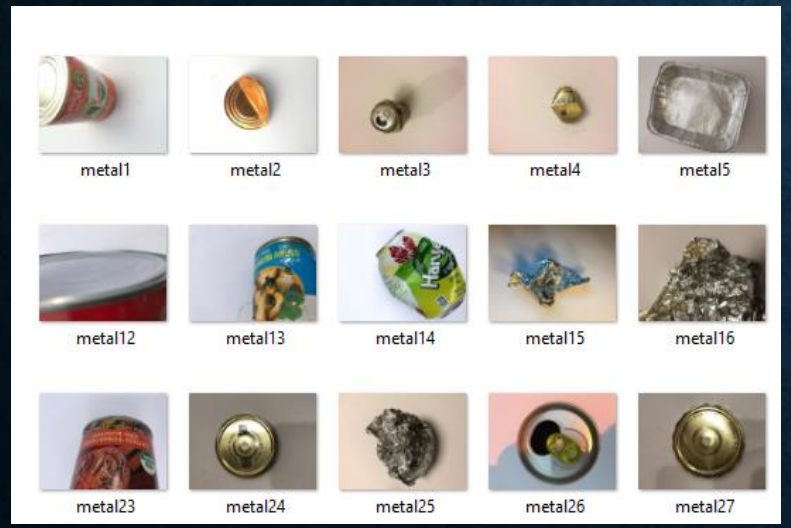
DATASET FOR TRAINING

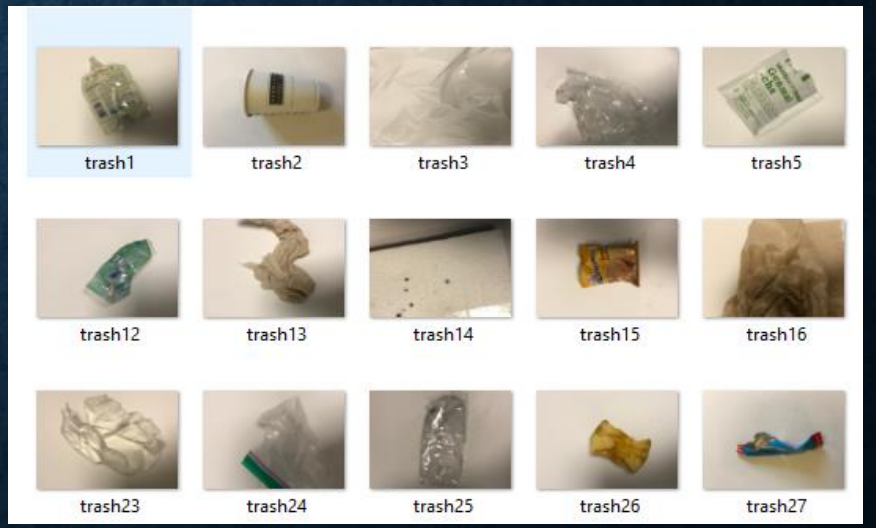
- Our dataset includes images of different categories of waste such as cardboard images, paper, plastic, metal, glass, other trash images,etc
- This includes:
- Cardboard:- 403 images
- Glass :- 501 images
- Metal:- 410 images
- Paper:- 594 images
- Plastic :- 492 images
- Other Trash:- 137 images
- Total around:- approximately 2500 images

IMAGES FROM DATASET FOR CLASSSIFICATION









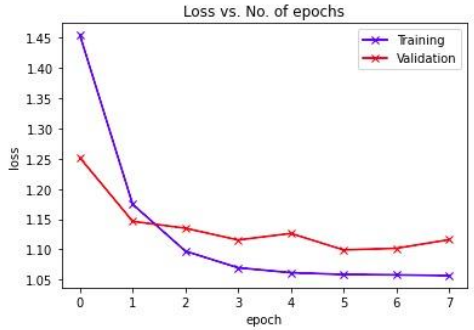
IMPLEMENTATION OF CLASSIFICATION MODEL

Let's start training the model:

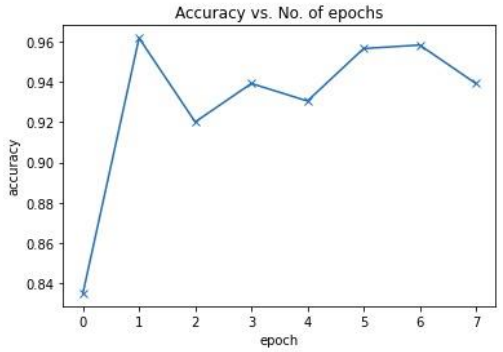
```
[ ] num_epochs = 8
    opt_func = torch.optim.Adam
    lr = 5.5e-5

    history = fit(num_epochs, lr, model, train_dl, val_dl, opt_func)
```

```
Epoch 1: train_loss: 1.4542, val_loss: 1.2516, val_acc: 0.8351
Epoch 2: train_loss: 1.1746, val_loss: 1.1465, val_acc: 0.9618
Epoch 3: train_loss: 1.0972, val_loss: 1.1351, val_acc: 0.9201
Epoch 4: train_loss: 1.0697, val_loss: 1.1157, val_acc: 0.9392
Epoch 5: train_loss: 1.0616, val_loss: 1.1265, val_acc: 0.9306
Epoch 6: train_loss: 1.0586, val_loss: 1.0992, val_acc: 0.9566
Epoch 7: train_loss: 1.0579, val_loss: 1.1019, val_acc: 0.9583
Epoch 8: train_loss: 1.0569, val_loss: 1.1161, val_acc: 0.9392
```

```
[ ] def plot_losses(history):
        train_losses = [x.get('train_loss') for x in history]
        val_losses = [x['val_loss'] for x in history]
        plt.plot(train_losses, '-bx')
        plt.plot(val_losses, '-rx')
        plt.xlabel('epoch')
        plt.ylabel('loss')
        plt.legend(['Training', 'Validation'])
        plt.title('Loss vs. No. of epochs');

    plot_losses(history)
```



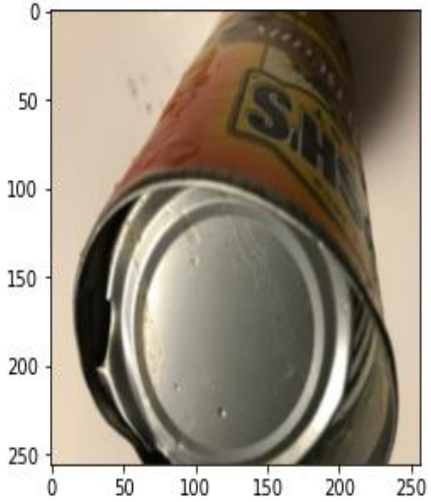

```
[ ] def plot_accuracies(history):
        accuracies = [x['val_acc'] for x in history]
        plt.plot(accuracies, '-x')
        plt.xlabel('epoch')
        plt.ylabel('accuracy')
        plt.title('Accuracy vs. No. of epochs');

    plot_accuracies(history)
```



PREDICTION OUTPUT OF MODEL IN COLAB

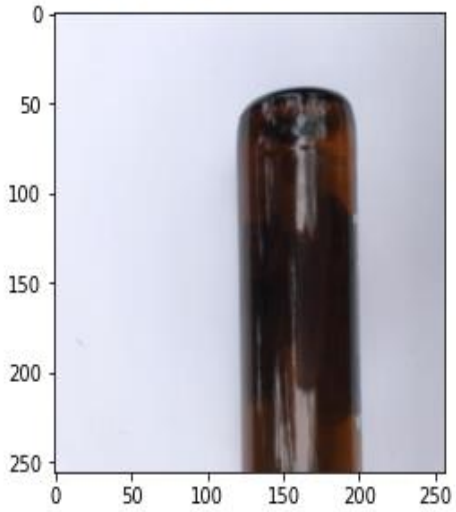
```
[ ] img, label = test_ds[17]
    plt.imshow(img.permute(1, 2, 0))
    print('Label:', dataset.classes[label], ', Predicted:', predict_image(img, model))
```

```
Label: metal , Predicted: metal
```




```
img, label = test_ds[23]
plt.imshow(img.permute(1, 2, 0))
print('Label:', dataset.classes[label], ', Predicted:', predict_image(img, model))
```

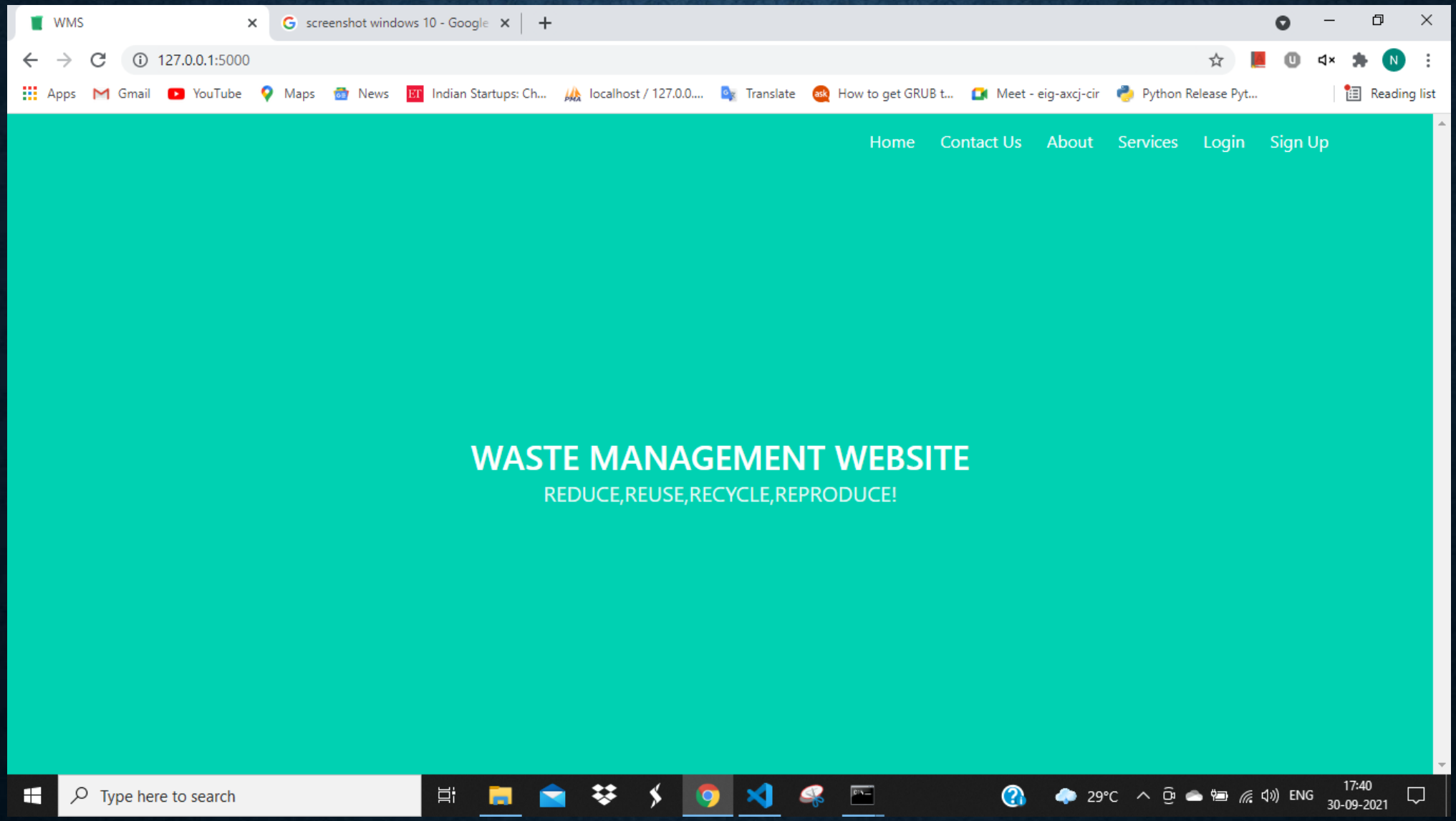
```
Label: glass , Predicted: glass
```



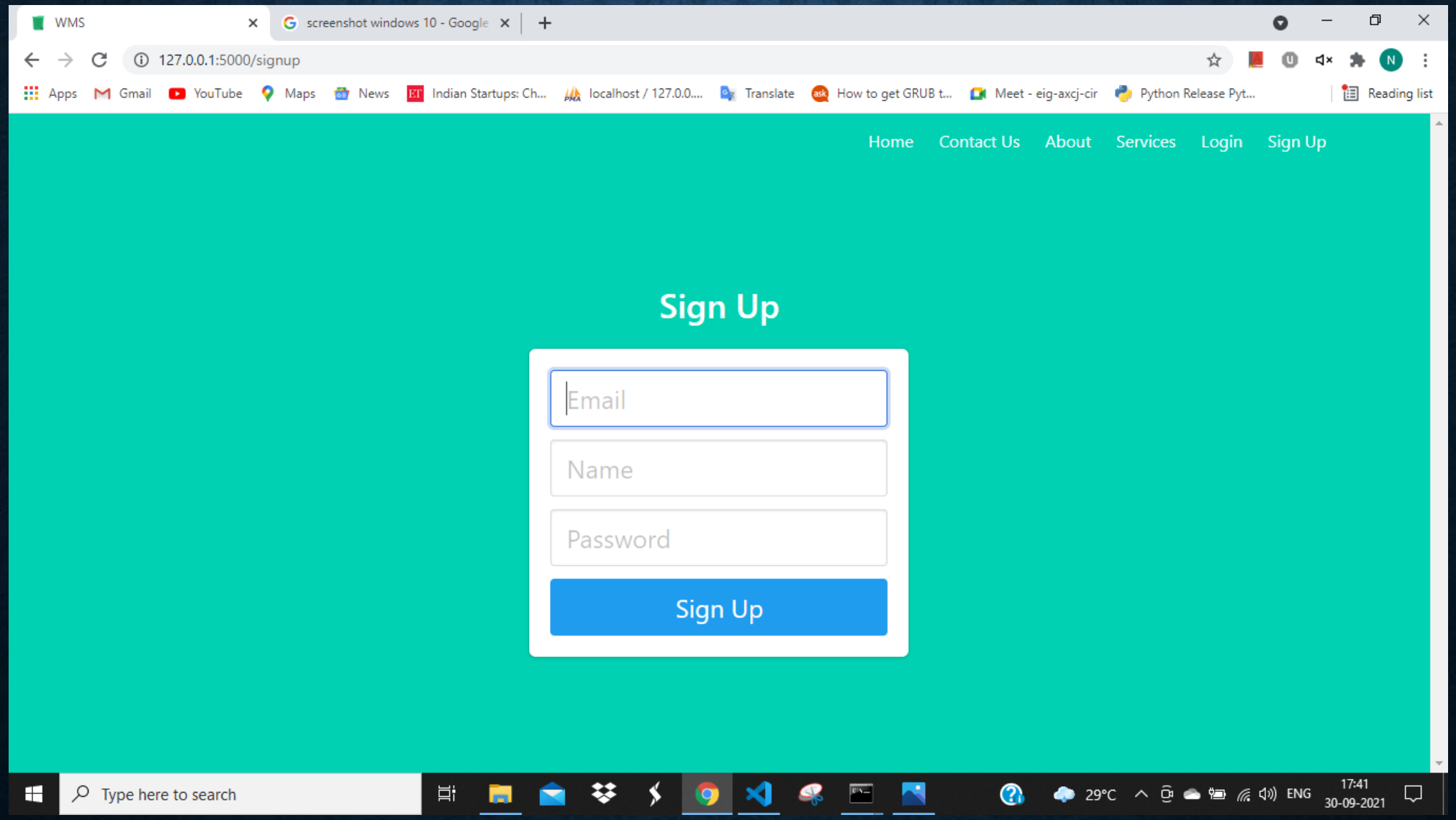
PROGRESS SO FAR.....

- So, after successfully creating our classification model using deep learning algorithm called CNN and using ResNet50 model to classify different waste articles, now we are trying to improve our classification model or classifier by collecting more images of waste articles so that it can predict the waste category more accurately.
- Besides collecting images, we have started to deploy our classification model on a web-based application using python framework called Flask which is full stack framework for web development.
- We have successfully created an authentication system for our website so that the user can register and login/logout in into our site to use our classifier for waste classification.
- Also, we have created a web page for our classifier and in that we have started writing down the backend code to use our feature to upload an image by the user and to predict the result based on the waste category. The following slides contain screenshots of our site.

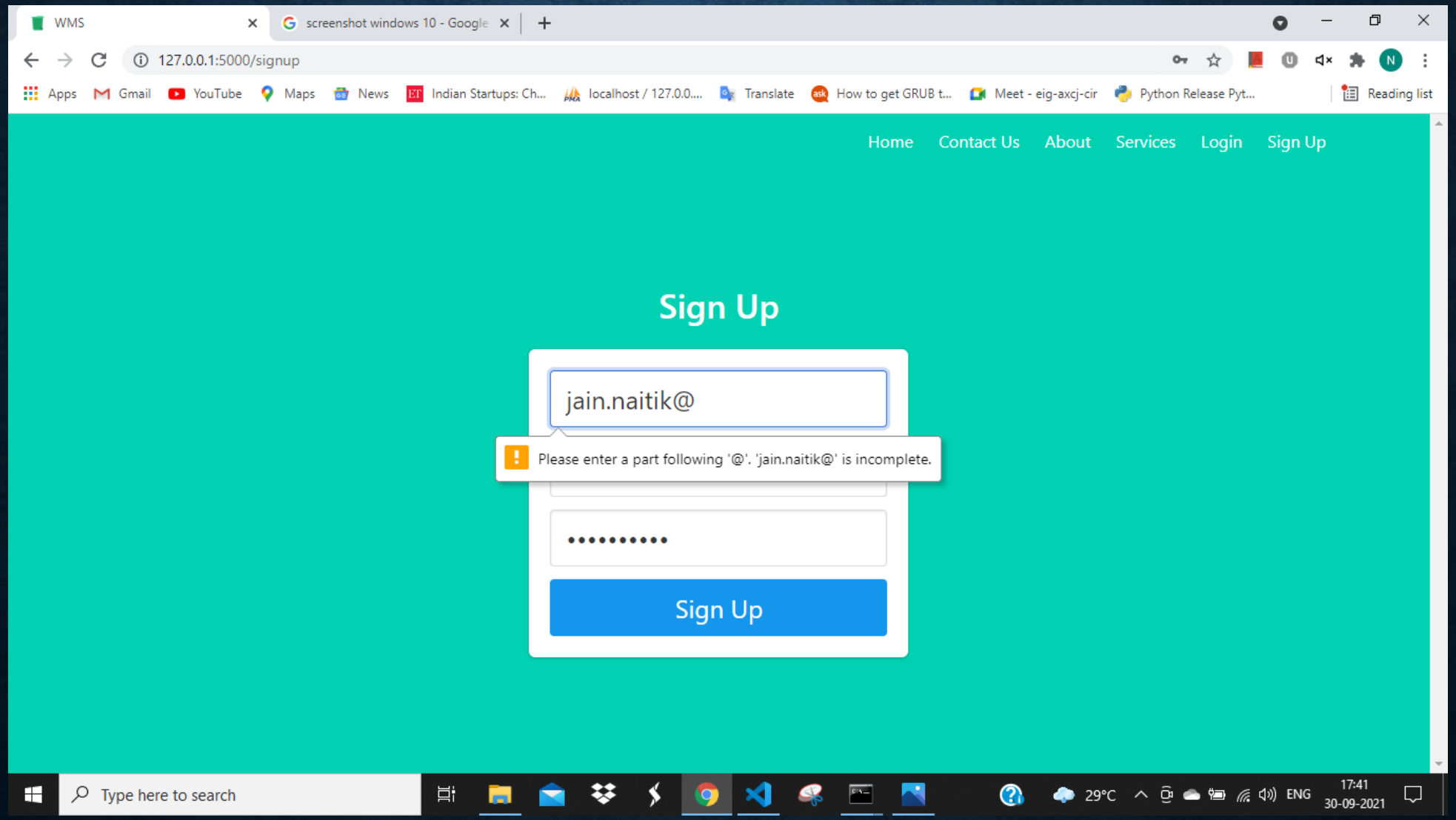
HOME/INDEX PAGE



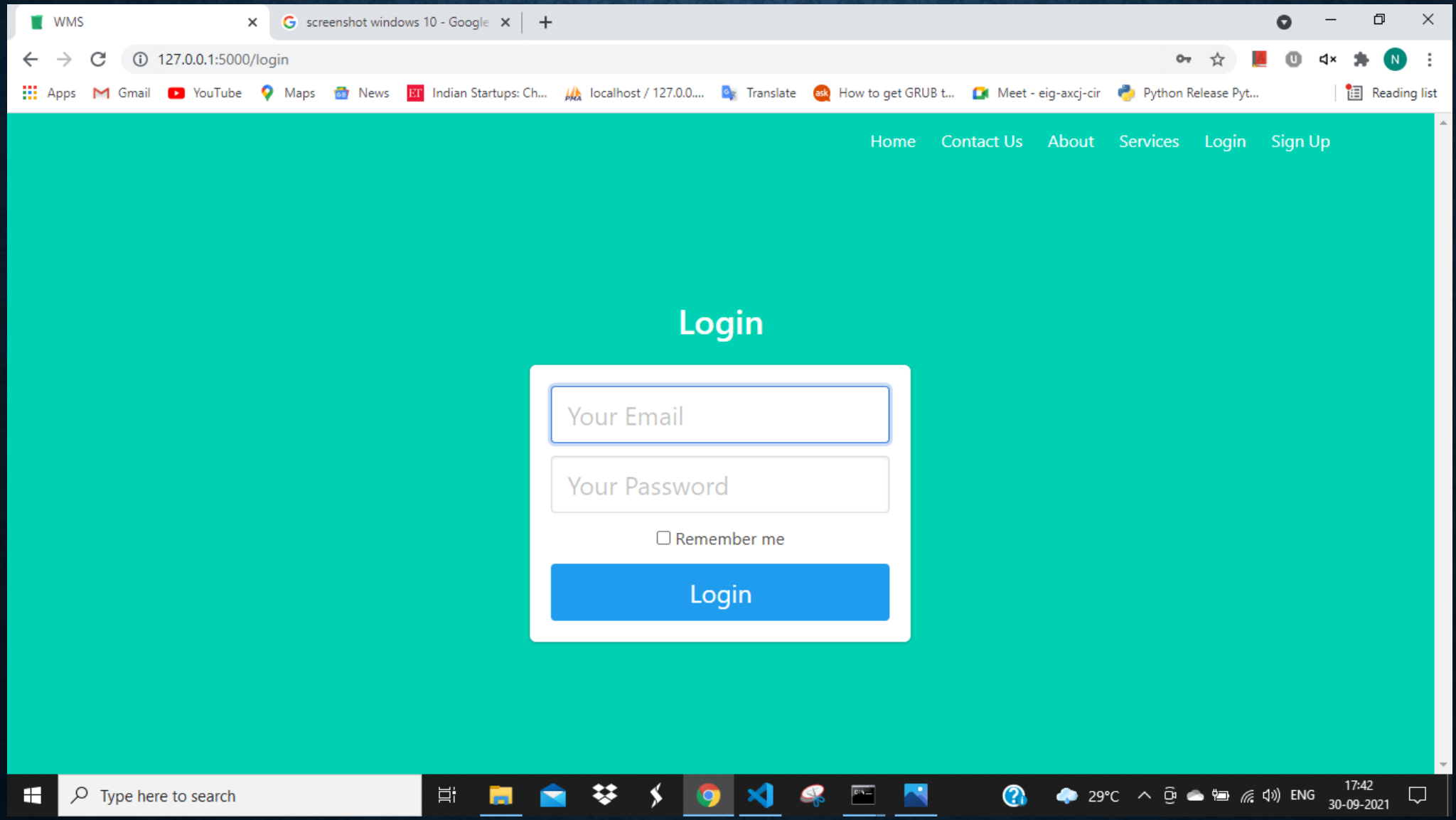
SIGN-UP/REGISTER PAGE



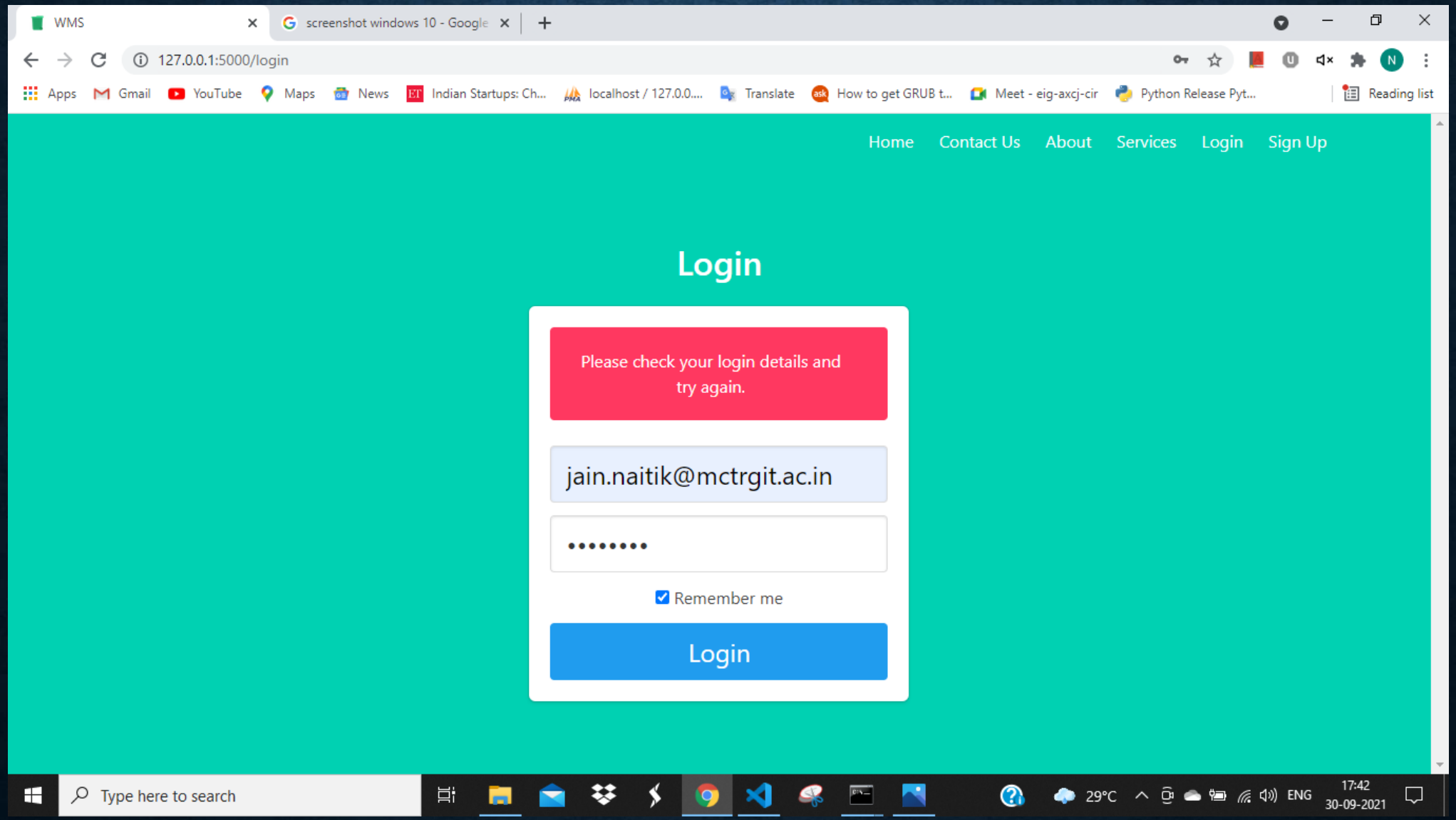
INVALID DETAILS ERROR WHLE SIGN-UP



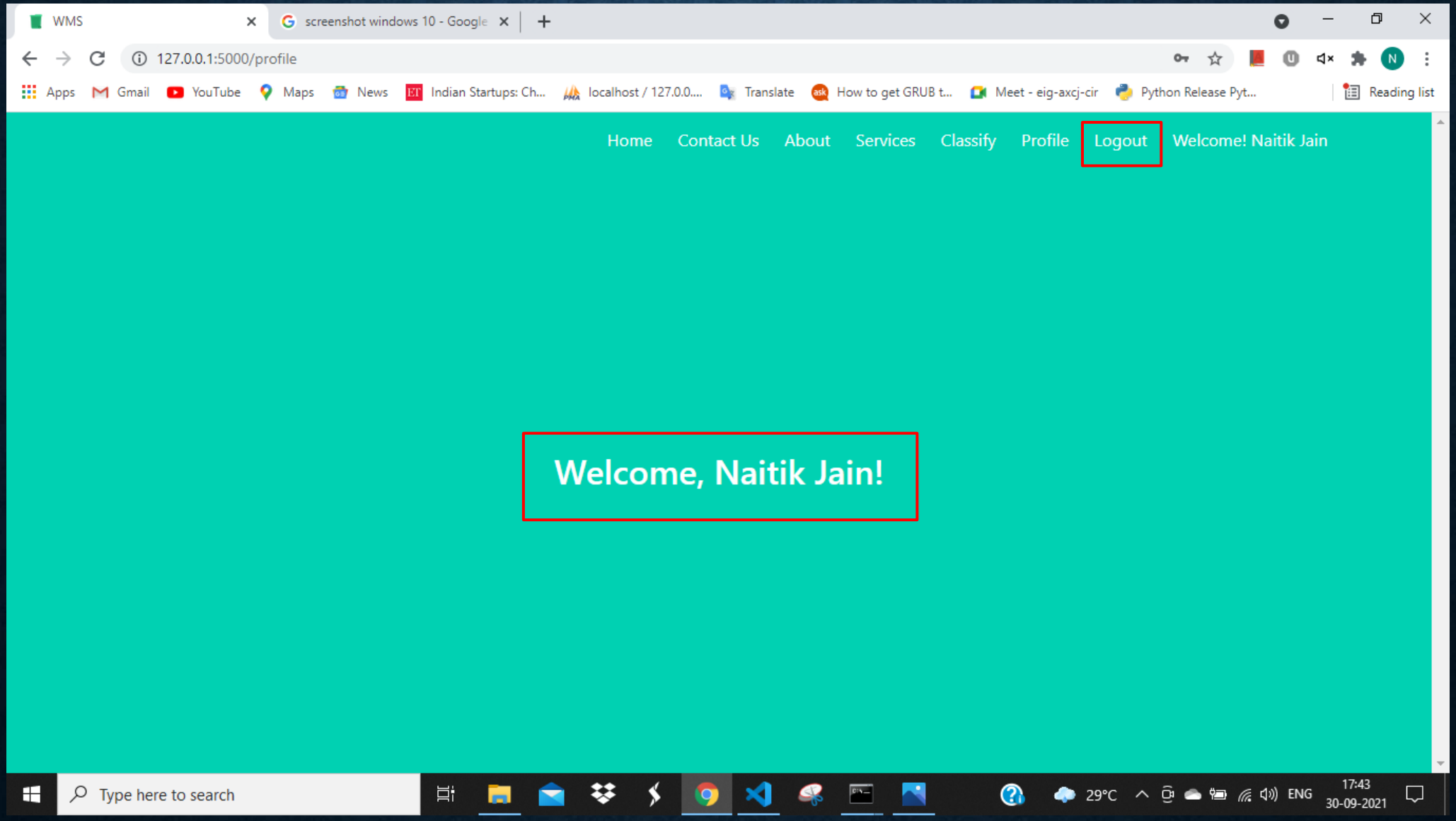
SIGN-IN/LOGIN PAGE



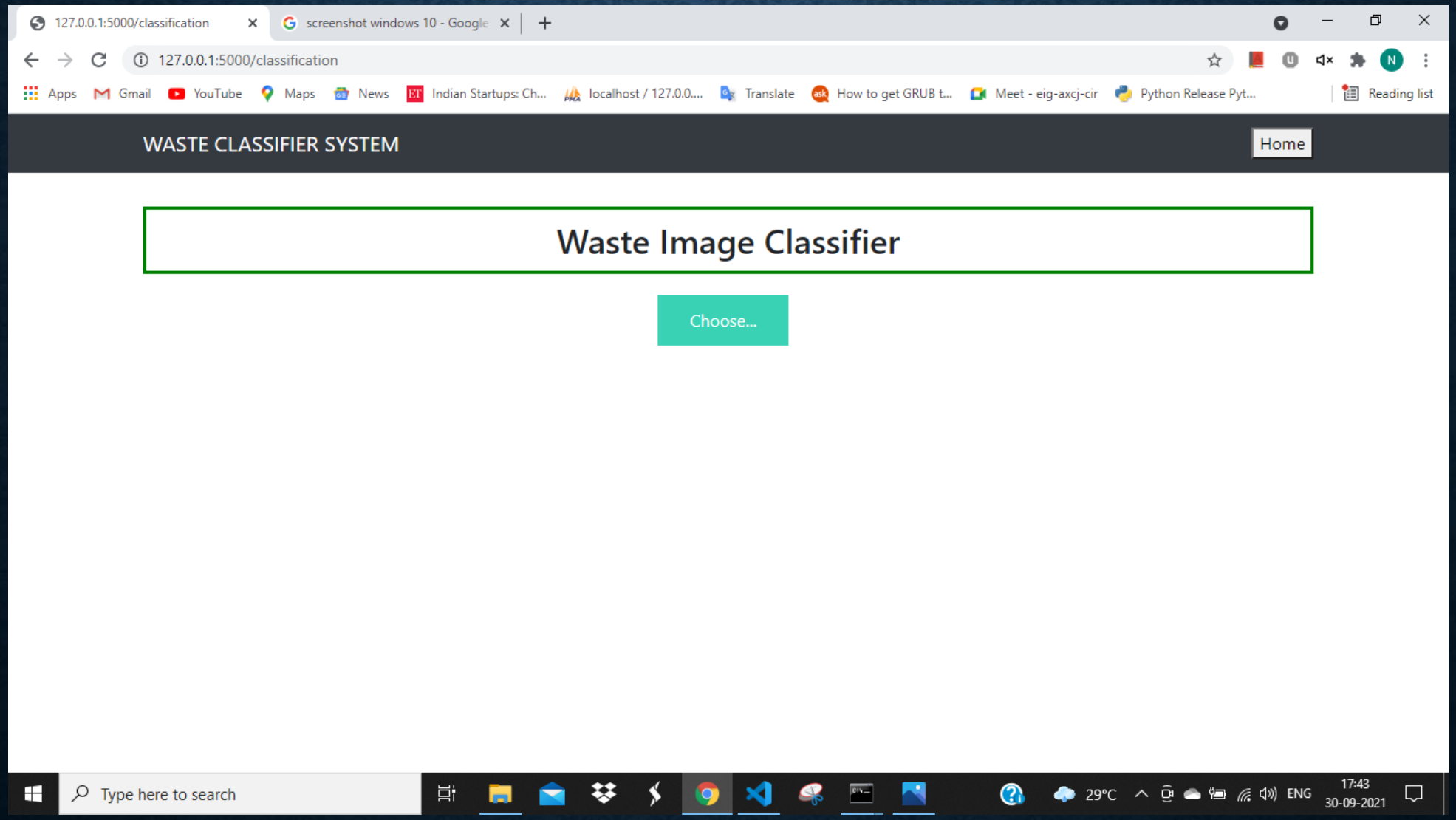
INAVLID CREDENTIALS



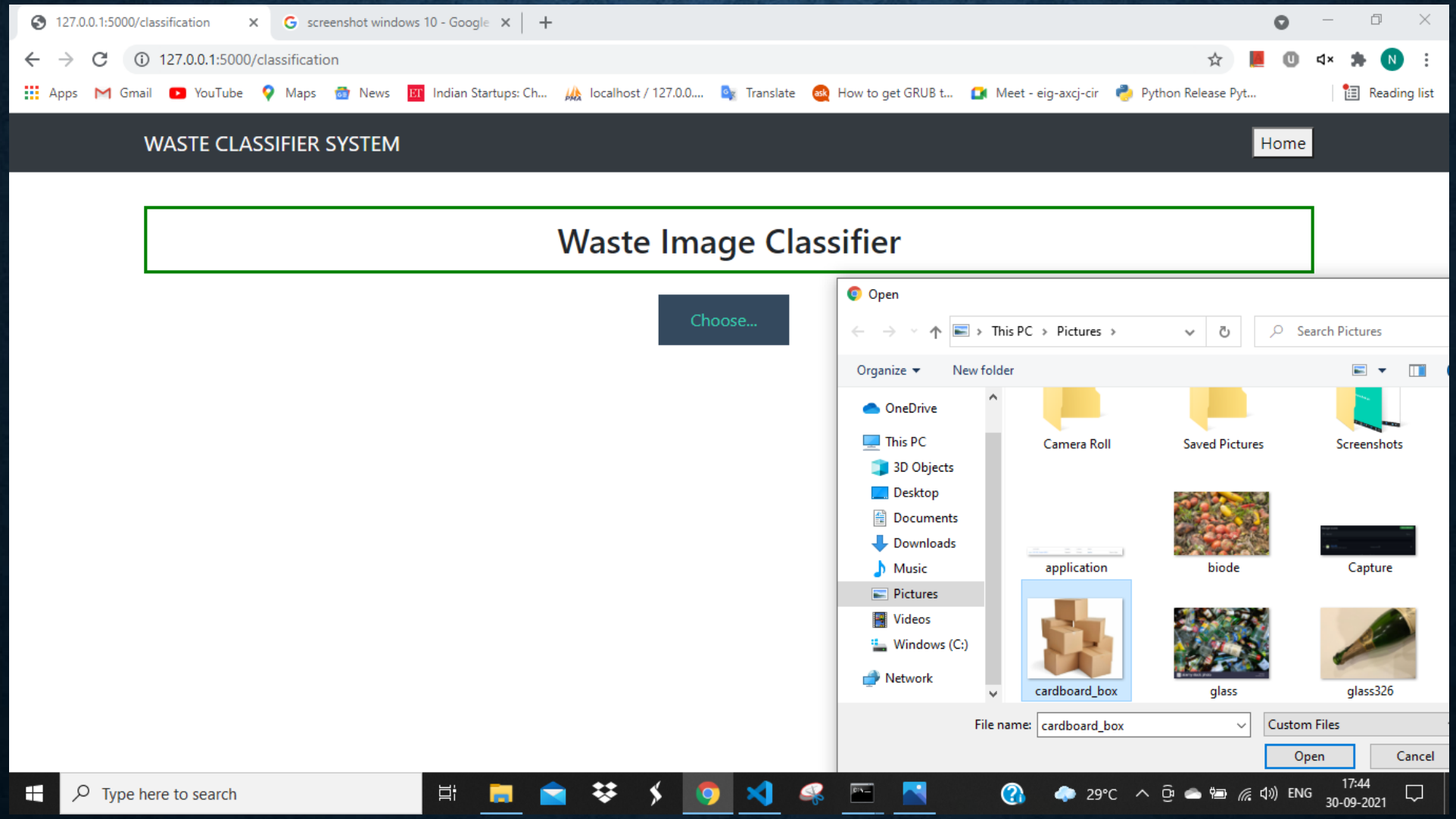
INDEX PAGE AFTER LOGIN



CLASSIFIER SYSTEM WEB PAGE



BUTTON TO UPLOAD AN IMAGE



PLAN AHEAD/FUTURE WORK

- We have deployed our classification model on a web-based application using python framework such as flask or similar technologies.
- We have also provide an authentication system such as register/login/logout in our application so that user can login any-time and use our model conveniently.
- We also plan to create a contact us web page where user can mail his query or questions regarding the disposal of waste so that we can solve it as soon as possible.
- We aim to create a disposal system via waste generator and waste collector option so that it would be easy to collect the waste for disposal.
- We also aim provide a forum for users to discuss issues regarding the system.
- We aim to provide an user-friendly/interactive system for our users.

CORE TECHNICAL PAPERS

A. 2016 IEEE International Conference on Technological Innovations in ICT For Agriculture and Rural Development (TIAR 2016) 978-1-5090-0615-1/16/$31.00

- ©2016 IEEE 65 AN AUTOMATIC CLASSIFICATION METHOD FOR ENVIRONMENT FRIENDLY WASTE SEGREGATION USING DEEP LEARNING
- https://ieeexplore.ieee.org/document/7801215/

B. Chapter 83 Automatic Classification of Solid Waste Using Deep Learning V. P. Brintha, R. Rekha, J. Nandhini, N. Sreekaarthick, B. Ishwaryaa, and R. Rahul

- © Springer Nature Switzerland AG 2020 L. Ashok Kumar et al. (eds.), Proceedings of International Conference on Artificial Intelligence, Smart Grid and Smart City Applications,
- https://link.springer.com/chapter/10.1007%2F978-3-030-24051-6_83
- https://ieeexplore.ieee.org/document/8876924

OTHER TECHNICAL PAPERS

- Automatic classification of solid waste using deep learning, Springer, 2020

  V. P. Brintha, R. Rekha, J. Nandhini, N. Sreekaarthick, B. Ishwaryaa, et al.

- An automatic classification method for environment, IEEE,2016

  S.Sudha M.Vidhyalakshmi ,K.Pavithra ,K.Sangeetha

- Intelligent waste classification system using deep learning CNN, SMPM,2019

  Olugboja Adedeji, Zenghui Wang

- Automation of Waste Sorting with Deep Learning , IEEE WVC,2019,

  Joao Sousa , Ana Rebelo, Jaime S. Cardoso

CONCLUSION

- This kind of system is a step forward to make the existing system of classification easier by using technology. It is an efficient system which saves time, and due to it being automated, it provides a quick and easy solution.
- The classification of trash into various recycling categories is possible through machine learning and computer vision algorithms.

THANK YOU