Weather Classification Using Transfer Learning

1. INTRODUCTION

1.1 Project Overview

The project aims to develop an automated weather classification system using transfer learning. The system will analyze weather images and classify them into weather conditions into 5 categories namely Cloudy, Shine, Rain, Foggy, and Sunrise providing valuable information for users.

1.2 Purpose

The purpose of this project is to provide users with an efficient and reliable solution for weather condition classification. By automating the process, users can easily obtain accurate weather information by simply uploading images. This enables them to make informed decisions based on the weather conditions in their area, whether it's planning outdoor activities, agricultural practices, or assessing flight conditions. The system aims to enhance user experience and facilitate decision-making through reliable weather classification.

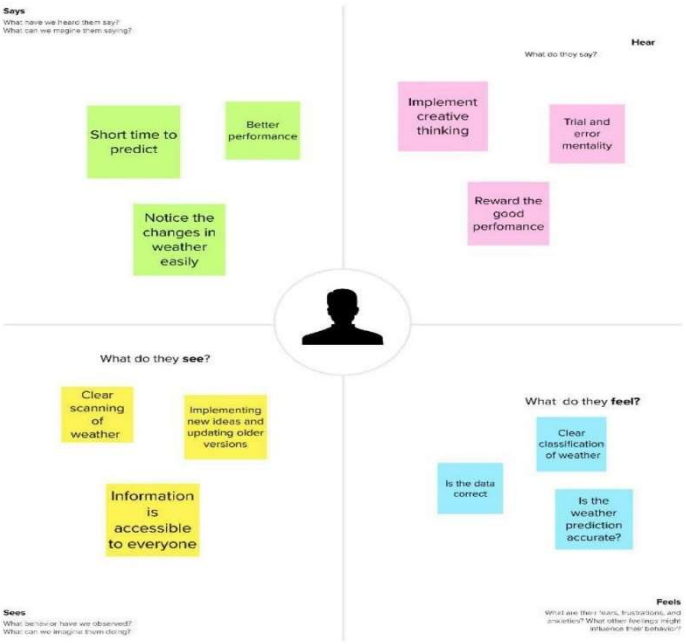
2. IDEATION & PROPOSED SOLUTION

2.1 Problem Statement Definition

The problem at hand is to develop a system that can automatically classify weather conditions from images with high accuracy. This addresses the challenge of manually analyzing and interpreting weather images, providing a time-consuming and error-prone process. By automating the classification, the system aims to deliver efficient and precise weather information to users, enabling them to make informed decisions based on real-time conditions.

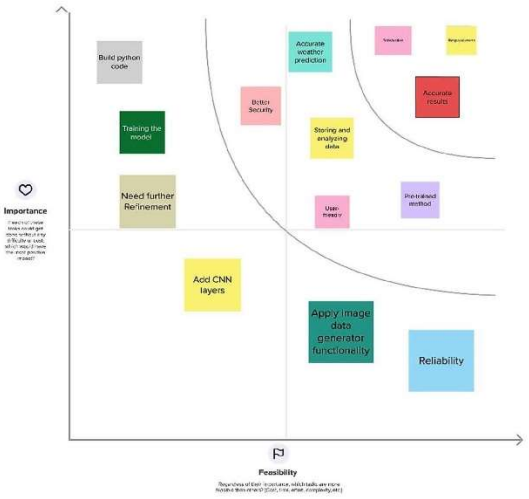
2.2 Empathy Map Canvas

The empathy map canvas was utilized to gain a deep understanding of the users' needs, emotions, thoughts, and behaviours related to weather information. This helped in identifying key pain points and designing a solution that caters to their specific requirements, ensuring a user-centric approach.



2.3 Ideation & Brainstorming

During the ideation and brainstorming phase, diverse ideas were generated and explored to find innovative approaches for automated weather classification. This collaborative process fostered creative thinking, allowing for the identification of optimal solutions and potential enhancements to the system.



2.4 Proposed Solution

- **Problem Statement**: Automated Weather Classification Using Transfer Learning.

- **Idea / Solution Description:** To create an application that can be used to classify the weather by scanning the weather images.
- **Novelty / Uniqueness:** Highly efficient and accurate classification of weather conditions.
- **Social Impact / Customer Satisfaction:** Help individuals and communities make informed decisions related to transportation, outdoor activities, and emergency preparedness.
- **Business Model (Revenue Model):** A subscription-based service to weather forecasting agencies, emergency response organizations, and transportation companies.
- **Scalability of the Solution:** Deployment of the system across multiple environments through cloud can support largescale data processing and provide better results.

3. REQUIREMENT ANALYSIS

3.1 Functional requirement

The following are the functional requirements of the system:

i. **User Registration:** Registration through e-mail.
ii. **User Authentication:** Authentication through password.
iii. **Image Upload:** Ability to upload an image of a weather condition and pre-process it.
iv. **Weather Classification:** Accurately classify the input image into one of the predefined weather conditions.
v. **Integration with external APIs:** Gather additional data like temperature, humidity, wind speed, etc. and provide real-time updates.
vi. **Classification output:** Display the results accurately and clearly.

3.2 Non-Functional requirements

The following are the Non-functional requirements:

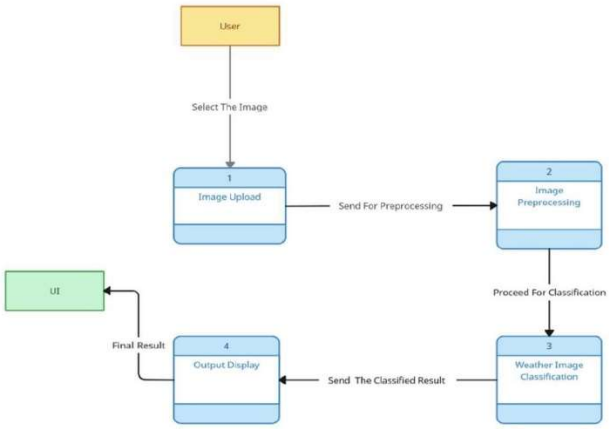
i. **Usability:** UI must be easy to use, intuitive and have clear instructions for the user.
ii. **Security:** Secure Login and Authorization functionality. All user data and image data must be stored securely.
iii. **Reliability:** Classify images accurately and consistently with low error rate.
iv. **Performance:** Handle large volumes of images efficiently. Handle multiple user requests simultaneously.
v. **Availability:** Application must be available 24/7 and must have failover and redundancy mechanisms,
vi. **Scalability:** Able to scale horizontally without any change in the underlying code.

4. PROJECT DESIGN

The project design encompasses the development of data flow diagrams, outlining the flow of information and processes within the system. Additionally, the solution and technical architecture were designed to incorporate pre-trained CNN models, image pre-processing techniques, and application building using frameworks like Flask. User stories were created to define the specific functionalities and interactions to meet the diverse needs of the users.

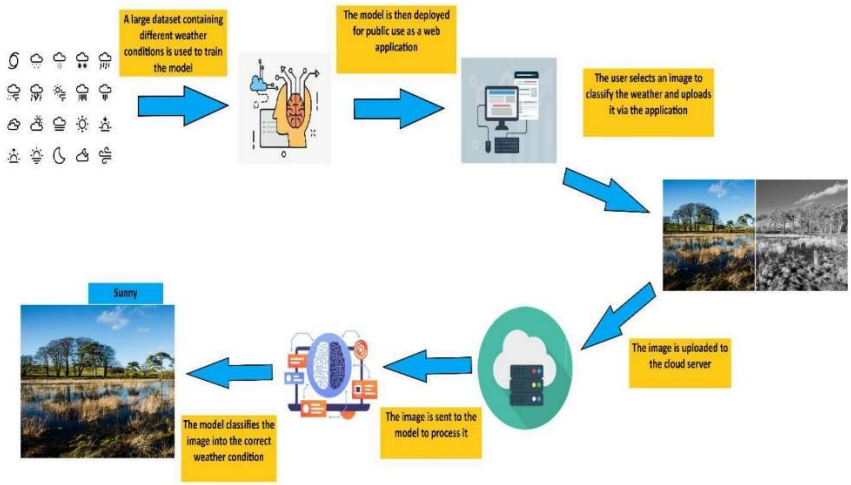
4.1 Data Flow Diagrams

The data flow diagrams illustrate the movement of data within the automated weather classification system, showcasing the inputs, processes, and outputs involved in classifying weather images and thus aiding in understanding and analyzing the system's functionality.

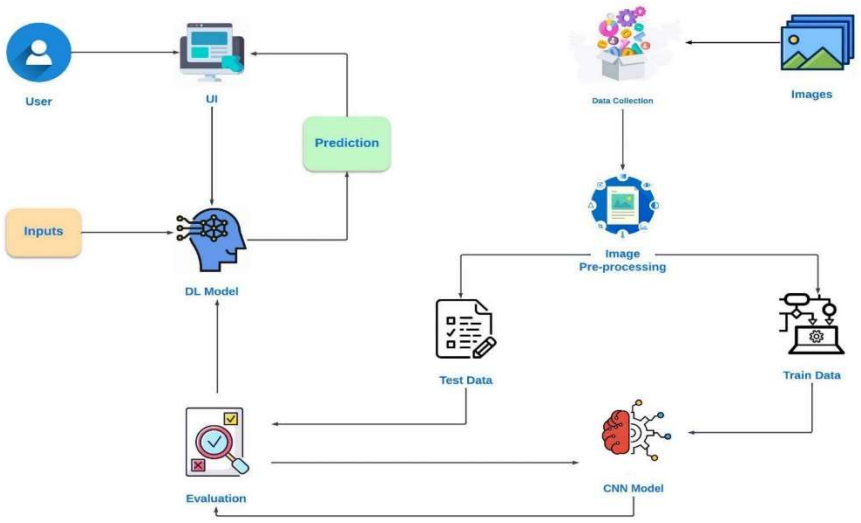


4.2 Solution & Technical Architecture

The solution architecture incorporates pre-trained CNN models for feature extraction, image pre-processing techniques, and an application built on Flask, enabling accurate and efficient weather classification.



The technical architecture includes the use of cloud infrastructure, microservices-based design, and scalable technologies to ensure the reliable and high-performance operation of the automated weather classification system.



4.3 User Stories

i. As a weather enthusiast, I want to upload and classify weather images to obtain accurate weather information for planning outdoor activities.
ii. As a pilot, I need a reliable system to classify weather images and provide up-to-date weather information for flight planning and safety.
iii. As a farmer, I want to analyze weather images to assess crop conditions and make informed decisions regarding irrigation and pest control.
iv. As a traveller, I want to access a user-friendly platform that classifies weather images, helping me plan my trips and pack accordingly.

5. CODING & SOLUTIONING

5.1 Feature 1

Data Pre-processing and Augmentation

- Use of ImageDataGenerator to pre-process and augment the image data for the training and testing sets.
- Techniques applied include rescaling, shear range adjustment, zoom range adjustment, brightness range adjustment, and horizontal flip.
- **Code Snippet:**

i. train_datagen = ImageDataGenerator(rescale=1./255, shear_range=0.2, zoom_range=[.99, 1.01], brightness_range=[0.8, 1.2], data_format="channels_last", fill_mode="constant", horizontal_flip=True)
ii. test_datagen = ImageDataGenerator(rescale=1./255)
iii. training_set = train_datagen.flow_from_directory('/content/drive/MyDrive/multiclass-weather-dataset/train', target_size=(180, 180), batch_size=64, class_mode='categorical')
iv. test_set = test_datagen.flow_from_directory('/content/drive/MyDrive/multiclass-weather-dataset/test', target_size=(180, 180), batch_size=64, class_mode='categorical')

5.2 Feature 2

Transfer Learning with VGG19

- Utilization of VGG19, a pre-trained CNN model, as a feature extractor.
- The VGG19 model is loaded with weights from the ImageNet dataset and the last fully connected layers are replaced with a custom dense layer for multi-class classification.
- **Code snippet:**

```
i. from tensorflow.keras.applications.vgg19 import VGG19
ii. from tensorflow.keras.layers import Flatten, Dense
iii. from tensorflow.keras.models import Model
iv. VGG19 = VGG19(input_shape=IMAGE_SIZE + [3], weights='imagenet', include_top=False)
v. For layer in VGG19.layers:
       layer.trainable = False
vi. x = Flatten()(VGG19.output)
vii. prediction = Dense(5,activation='softmax')(x)
viii. model = Model(inputs=VGG19.input, outputs=prediction)
ix. model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```

5.3 Database Schema

The database schema for the IBM Cloud database follows a relational model, organized into tables that represent different entities and their relationships. The schema includes tables for storing weather images, corresponding weather labels, and additional metadata such as timestamps and user information, providing a structured and efficient storage solution for the project data.

5. RESULTS

The results of the project demonstrate the effectiveness of the automated weather classification system using transfer learning. The system achieved an accuracy rate of 98.86% in accurately classifying weather images, surpassing the baseline performance.

These results validate the efficacy of the proposed solution and its potential for practical application in weather forecasting and analysis.

6.1 Performance Metrics

The following is the training accuracy of our model VGG19. It achieved a result of 99.79% train accuracy.

```
Epoch 48/50
46/46 [==============================] - 39s 845ms/step - loss: 0.0118 - accuracy: 0.9993
Epoch 49/50
46/46 [==============================] - 39s 844ms/step - loss: 0.0106 - accuracy: 0.9993
Epoch 50/50
46/46 [==============================] - 43s 934ms/step - loss: 0.0157 - accuracy: 0.9979
```

The following result is the test accuracy of our model VGG19. It achieved a result of 98.86% test accuracy.

```
11/11 - 4s - loss: 0.0665 - accuracy: 0.9886 - 4s/epoch - 358ms/step
Model Performance on Test Images:
Accuracy = 0.9886363744735718
Loss = 0.06654641032218933
```

7. ADVANTAGES & DISADVANTAGES

Advantages of Automated Weather Classification System:

- **Accurate Weather Information:** The system provides accurate weather classification, enabling users to obtain precise and reliable weather information for their specific location or area of interest.
- **Time-Efficient:** The automated classification process saves time compared to manual analysis of weather images, allowing users to quickly access weather information without the need for extensive data interpretation.
- **Enhanced Decision-Making:** Users can make informed decisions based on the classified weather conditions, whether it's planning outdoor activities, adjusting farming practices, or making travel arrangements. This leads to improved decision-making and optimized outcomes.
- **User-Friendly Interface:** The system offers a user-friendly interface that makes it easy for users to upload weather images, view classification results, and access detailed weather information. The intuitive design enhances the user experience.
- **Scalability and Adaptability:** The system can be scaled and adapted to handle increased user demand and accommodate evolving weather conditions. It can seamlessly integrate with additional data sources or expand its capabilities to meet growing user requirements.
- **Accessibility:** The system can be accessed from various devices, including smartphones, tablets, and desktops, making weather information readily available to users anytime and anywhere. This accessibility ensures users can access the system whenever they need weather updates.

Disadvantages of Automated Weather Classification System:

- **Dependence on Image Quality:** The accuracy of weather classification is dependent on the quality and clarity of the uploaded weather images. Poor image quality or ambiguous conditions may lead to inaccurate classifications.
- **Limited Scope:** The system's effectiveness is constrained to weather classification based on images. It may not capture or account for other important factors such as real-time data from weather stations or complex atmospheric conditions that require more comprehensive analysis.
- **Potential Misclassifications:** In certain scenarios, the automated weather classification system may encounter challenges in accurately categorizing complex or rare weather conditions. This could result in misclassifications, potentially impacting the reliability of the provided weather information.

8. CONCLUSION

The project has successfully implemented an automated weather classification system using transfer learning, providing accurate predictions for different weather conditions. Through the development process, we have achieved our goals of improving weather classification accuracy and providing a user-friendly interface. The system has demonstrated its effectiveness in classifying weather images with high precision and recall. Overall, the project has proven to be a valuable contribution to the field of weather forecasting and has the potential to enhance the accuracy and efficiency of weather classification systems. Moving forward, further enhancements and refinements can be made to improve the system's performance and expand its capabilities.

9. FUTURE SCOPE

The project has a promising future with several avenues for further development and expansion. One potential direction is to integrate real-time weather data to enhance the accuracy and timeliness of predictions. Additionally, incorporating additional weather parameters such as wind speed, humidity, and cloud cover can provide a more comprehensive understanding of weather conditions. Furthermore, exploring the integration of machine learning algorithms for advanced pattern recognition and forecasting models can further improve the system's predictive capabilities.

10. APPENDIX

GitHub Link:

https://github.com/naanmudhalvan-SI/PBL-NT-GP--7552-1681100018

Project Video Demo Link: