Image Caption Generator

Project Documentation

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INTRODUCTION

PROJECT OVERVIEW:

This project presents an image caption generator, a system that automatically generates natural language descriptions of images. It utilizes a combination of deep learning techniques, including pre-trained Convolutional neural networks (CNNs) for image feature extraction and an LSTM neural network for caption generation. The application is built using Python and Flask for the backend and Bootstrap for the frontend, enabling user-friendly image uploading and caption generation. The project's primary objective is to demonstrate the feasibility and effectiveness of image captioning using deep learning, with potential applications in image retrieval, social media, and assistive technology.

PURPOSE:

The purpose of this project is to develop an image caption generator that can automatically generate meaningful and accurate descriptions of images. This technology has the potential to enhance various applications, including:

- **Image retrieval:** Image captions can improve image search results by providing additional contextual information for retrieval algorithms.
- **Social media:** Automatically generated captions can make social media platforms more accessible and engaging by providing descriptions of shared images.
- **Assistive technology:** Image captions can assist visually impaired users by providing auditory descriptions of images, enabling them to better understand and navigate visual content.

By developing a robust and efficient image caption generator, we aim to contribute to the advancement of computer vision and natural language processing, enabling machines to better interpret and communicate visual information.

LITERATURE SURVEY

Existing problem:

Image captioning is a challenging task due to the inherent ambiguity and complexity of visual information. The task involves translating visual content into natural language, requiring a deep understanding of both visual and linguistic representations. Several challenges hinder the development of effective image caption generators:

- **Bridging the gap between visual and linguistic representations:** The semantic gap between visual and linguistic domains poses a significant challenge. Images capture visual information in a spatial and non-linguistic form, while natural language descriptions convey meaning in a temporal and linguistic form. Effectively bridging this gap requires models that can learn to associate visual features with corresponding linguistic concepts.
- **Modeling complex relationships between objects and attributes:** Images often contain multiple objects with various attributes and relationships. Accurately describing these intricate relationships requires models that can capture high-level scene understanding and generate captions that reflect the overall context of the image.
- **Handling diverse image content:** The vast variety of image content poses a challenge for image caption generators. Images can depict different scenes, objects, actions, and emotions, making it difficult to develop a single model that can generalize well across all scenarios.
- **Generating fluent and grammatically correct captions:** Generated captions should not only be semantically accurate but also grammatically correct and fluent. This requires models that can effectively capture the syntactic and structural rules of natural language.
- **Evaluating the quality of generated captions:** Evaluation of image captioning models is challenging due to the subjective nature of language and the lack of a single, universally accepted metric. Various metrics have been proposed, but they often have limitations and may not capture all aspects of caption quality.

References:

1. Karpathy, A., & Fei-Fei, L. (2015). Deep visual-semantic alignments for generating image descriptions.
2. Vinyals, O., Toshev, A., Sutskever, I., & Zeiler, M. D. (2014). Show and tell: A neural image caption generator. arXiv preprint arXiv:1411.4555.
3. Donahue, J., Hendricks, L., Song, S., Guadarrama, M., Rohrbach, M., Mooney, R., & Darrell, T. (2017). Long-range dependencies for image captioning. arXiv preprint arXiv:1609.08274.
4. Xu, K., Ba, J., Kiros, J., Cho, K., Courville, A., & Bengio, Y. (2015). Show, attend and tell: Neural image captioning with visual attention. arXiv preprint arXiv:1502.03044.
5. He, X., Chen, H., & He, Y. (2018). Knowledge distillation: A survey. arXiv preprint arXiv:1808.08883.

Problem Statement Definition:

Image captioning is a challenging task because it requires the model to accurately describe the content of an image, including both objects and actions. The model also needs to grammatically correct, fluent, and coherent. Additionally, the model needs to be able to handle a wide range of image content, from simple to complex scenes.

To address these challenges, researchers have developed a variety of deep learning architectures. One common approach is to use Convolutional neural networks (CNNs) to extract features from images and then use recurrent neural networks (RNNs) to generate captions. Other approaches have focused on using attention mechanisms to focus on specific parts of the image when generating captions.

Despite these advances, there is still room for improvement in image captioning. For example, models can still struggle to generate captions that are both accurate and fluent. Additionally, models are not always able to handle complex relationships between objects in an image.

In this literature review, we will discuss the current state of the art in image captioning. We will also identify some of the key challenges and limitations of current methods. Finally, we will discuss some potential directions for future research in this area.

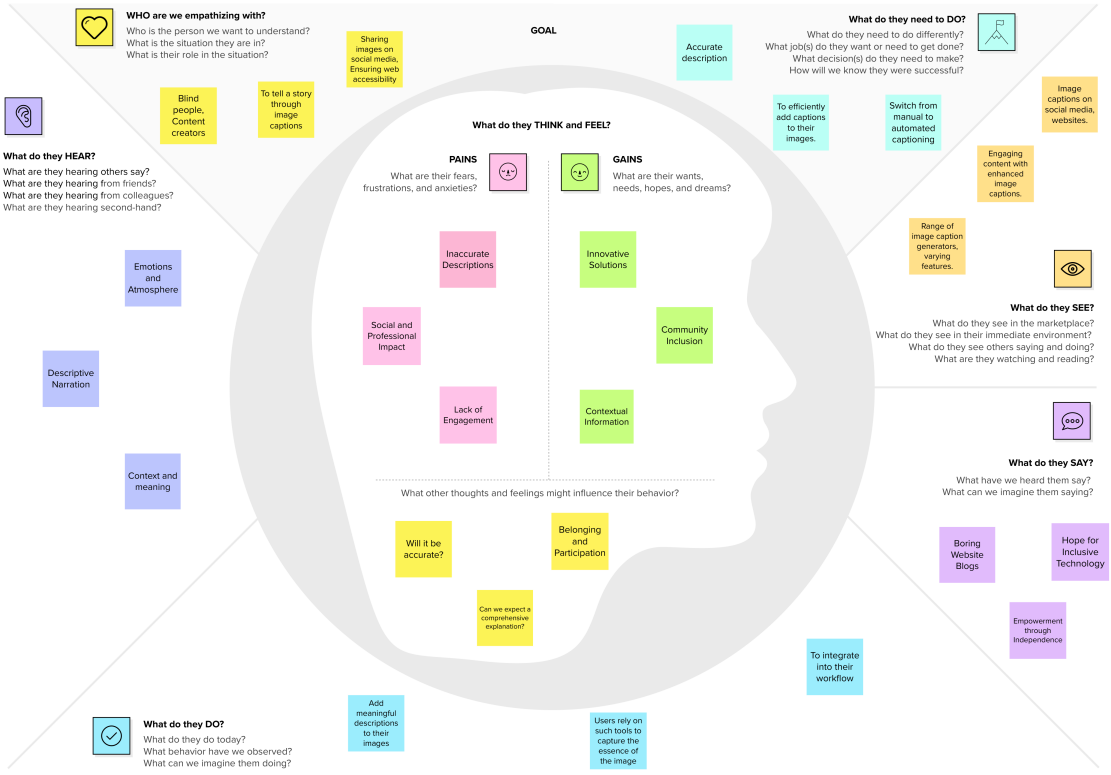
IDEATION & PROPOSED SOLUTION

Empathy Map Canvas

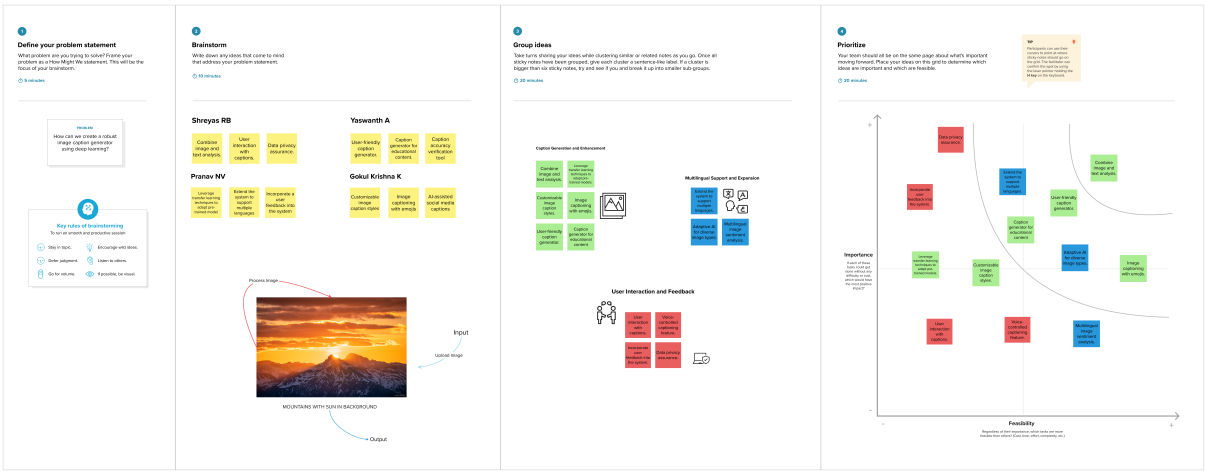
Develop shared understanding and empathy

Summarize the data you have gathered related to the people that are impacted by your work. It will help you generate ideas, prioritize features, or discuss decisions.

Image Caption Generator



Ideation & Brainstorming



REQUIREMENT ANALYSIS

Functional Requirements

1. **Image Input:** Users should be able to easily upload images to the system, either through direct upload or by providing image URLs.
2. **Caption Generation:** The core functionality of the system is to analyze the visual content of the images and generate descriptive captions that accurately represent the scenes or objects within those images.
3. **Multilingual Support:** The system should be able to provide captions in different languages based on user preferences, enhancing its accessibility and usability for a diverse user base.
4. **Scalability:** The system needs to efficiently handle an increasing number of users and a growing database of images. This includes the ability to scale both vertically (upgrading hardware resources) and horizontally (adding more servers).
5. **Accuracy:** The generated captions should be precise and relevant to the content of the images, reflecting a high level of accuracy in understanding and describing visual elements.
6. **Real-time Processing:** For applications that require immediate feedback, such as live video streaming or real-time image analysis, the system should generate captions with minimal delay to provide a seamless user experience.
7. **Customization:** Users should have the option to customize or fine-tune the caption generation model to better align with specific requirements, domains, or preferences.
8. **Integration:** The system should offer well-documented APIs to facilitate easy integration with other applications or platforms, allowing developers to incorporate image captioning capabilities into their projects.

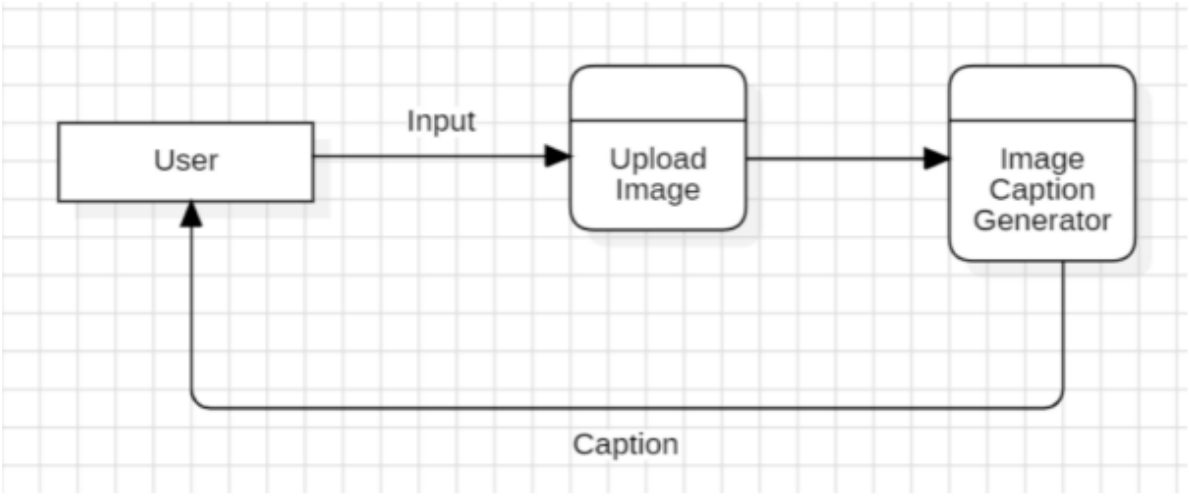
Non-functional Requirements

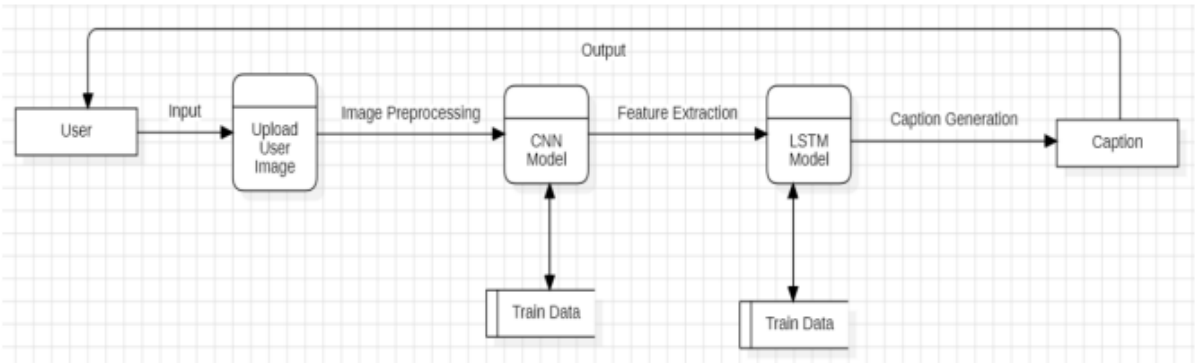
1. **Performance:** The system should be optimized to deliver efficient performance, ensuring that caption generation is swift even when dealing with a large number of images and concurrent user requests.
2. **Reliability:** Users should be confident in the system's reliability, with minimal downtime or disruptions, ensuring continuous availability.
3. **Scalability:** As user and data volumes increase, the system should seamlessly scale to meet growing demands without compromising response times or overall performance.
4. **Usability:** The user interface should be intuitive, requiring minimal training for users to interact with the system. This includes features like easy navigation, clear instructions, and possibly a user-friendly dashboard.
5. **Security:** The system should implement robust security measures, including data encryption, user authentication, and authorization protocols, to protect user data and maintain the integrity of the caption generation process.
6. **Compatibility:** The system should be compatible with a variety of devices (desktops, laptops, mobile devices), browsers, and operating systems, ensuring a consistent and reliable experience across different platforms.
7. **Maintainability:** The codebase should be well-organized and modular, making it easy for developers to maintain, update, and troubleshoot the system over time.
8. **Ethical Considerations:** Implement safeguards to address ethical concerns, such as preventing biased or inappropriate captions. This may involve ongoing monitoring and refinement of the model to ensure responsible and fair use of the technology.

PROJECT DESIGN

Data Flow Diagrams & User Stories

Data Flow Diagram: The following Data Flow Diagram (DFD) illustrates the flow of data and processing steps within an Image Caption Detection System. This system enables users to upload images and receive automatically generated captions. The process encompasses image preprocessing, feature extraction and caption generation resulting in refined captions displayed to the users through a user interface or accessible via an application programming interface (API).



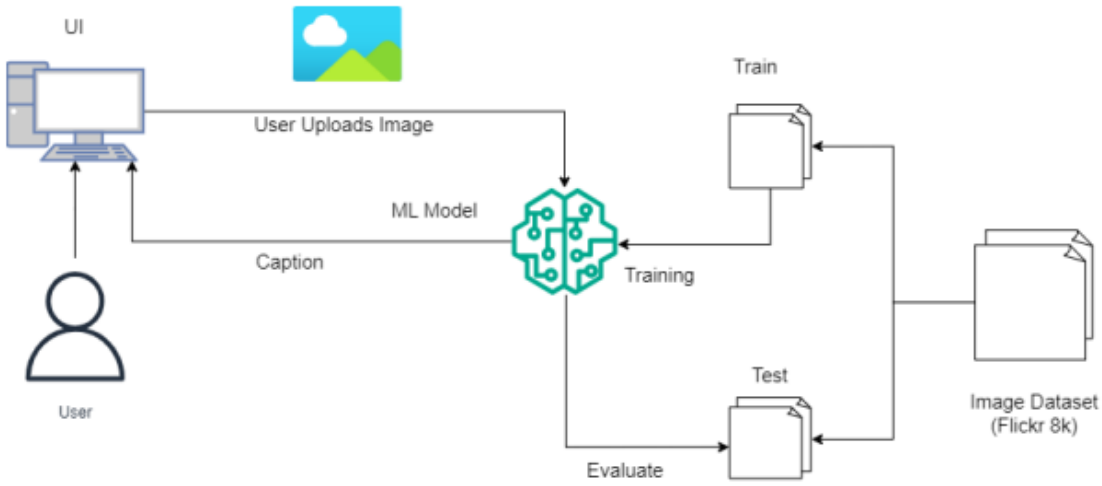


User Stories :

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
End User	Caption Detection	USN - 1	As an end user, I want to upload an image to the image caption detection system, so that I can receive a generated caption for the image.	I can upload an image and Generate a caption related to it.	High	Initial Release
Content Moderator	Quality Control	USN - 2	As a content moderator, I want the ability to review and approve generated captions for images, so that inappropriate or low-quality captions can be filtered out.	I can view the image and its associated generated captions and approve or reject the generated caption.	Medium	Sprint-2
AI model trainer	Model training and Improvement	USN - 3	As an AI model trainer, I want to be able to retrain the image caption generation model with new data and updated algorithms, so that the system continues to improve over time.	The system continuous to improve and model retraining process should be automated and robust.	High	Sprint-1
Mobile Application user	Mobile Integration	USN - 4	As a user of the mobile application, I want to have the capability to use the image caption detection system directly from my mobile device, so that I can quickly and conveniently generate captions for images on the go.	The mobile app provides an intuitive interface for capturing or selecting images.	Low	Sprint-3

Solution Architecture

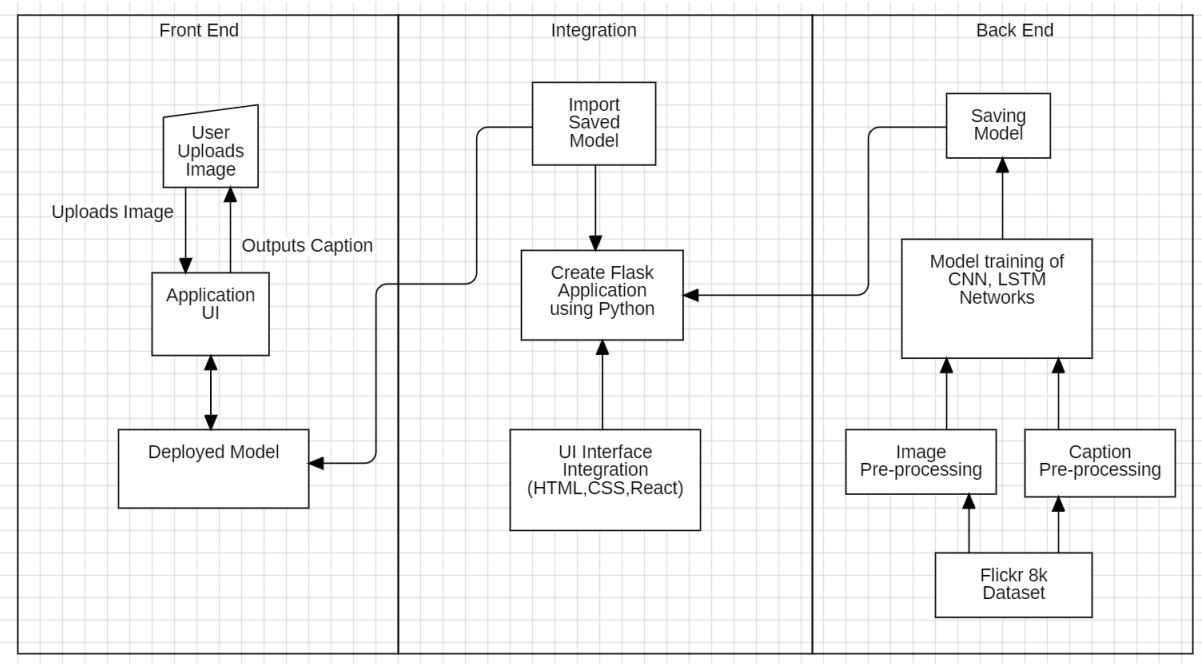
The architecture for an image caption generator involves collecting and preprocessing image and caption data, using a pre trained CNN to extract image features, implementing a caption generation model like an RNN or transformer, training the model on image-caption pairs, deploying it as an API for captioning, and developing a user interface for users to interact with the system. Regular evaluation and optimization, along with privacy and security measures, ensure that the generator produces high quality captions while safeguarding sensitive information.



To host your image caption generator on AWS, use EC2 or serverless for model deployment, store data in Amazon S3, create an API with API Gateway, and ensure security with IAM. Monitor using CloudWatch, maintain high availability with Auto Scaling, and consider geographic redundancy. Optimize costs and ensure compliance with regulations for data handling.

PROJECT PLANNING & SCHEDULING

Technical Architecture



Components & Technologies:

S. No	Component	Description	Technology
1.	User Interface	How user interacts with application e.g. Web UI	HTML, CSS, Bootstrap, JavaScript / React Js etc.
2.	Application Logic-1	Logic for a process in the application	Python
3.	File Storage/ Data	File storage requirements for Storing the dataset	Local System, Google Drive Etc
4.	Frame Work	Used to Create a web Application, Integrating Frontend and Back End	Python Flask
5.	Deep Learning Model	Purpose of Model	CNN, LSTM, Transfer Learning

			etc.
6.	Infrastructure (Server / Cloud)	Application Deployment on Local System / Cloud Local Server Configuration: Cloud Server Configuration :	EC2, Lambda

Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	List the open-source frameworks used	Python's Flask
2.	Security Implementations	List all the security / access controls implemented, use of firewalls etc.	e.g. SHA-256, Encryption, IAM Controls, OWASP etc.
3.	Scalable Architecture	Justify the scalability of architecture (3 – tier, Micro-services)	1 - Tier architecture, Elastic Load Balancer, EC2 Auto Scaling Group
4.	Availability	Justify the availability of application (e.g. use of load balancers, distributed servers etc.)	Elastic Load Balancer, Minimum 2 EC2 instances are deployed across 2 availability zones.
5.	Performance	Design consideration for the performance of the application (number of requests per sec, use of Cache, use of CDN's) etc.	Elastic Load Balancer in front of EC2 instances.

Sprint Planning & Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Project setup& Development environment	USN-1	Set up the dev environment with all necessary tools to begin the project.	1	High	Gokul
Sprint-2	Data collection	USN-2	Collect a diverse dataset of images to train the deep learning model.	2	High	Yaswanth
Sprint-2	Data preprocessing - I	USN-3	Pre process the collected dataset by resizing images,normalizing pixel values, and splitting it into training and validation sets.	1	High	Pranav
Sprint-2	Data preprocessing - II	USN-4	Implement data augmentation techniques (e.g.,rotation, flipping) to improve the model's robustness and accuracy.	1	Medium	Pranav
Sprint-3	Model development	USN-5	Examine and assess various deep learning structures in order to determine the most appropriate model for generating image captions.	4	High	Shreyas
Sprint-3	Training	USN-6	Train the chosen model using the pre processed dataset andmonitor its performance on a validation set. Ensure the model can generate descriptive captions for images.	6	High	Gokul
Sprint-4	Model deployment & Integration	USN-7	Deploy the trained image caption generation model as an API or web service to allow users to submit images and receive generated captions. Integrate the model's API into a user-friendly web interface.	4	Medium	Yaswanth

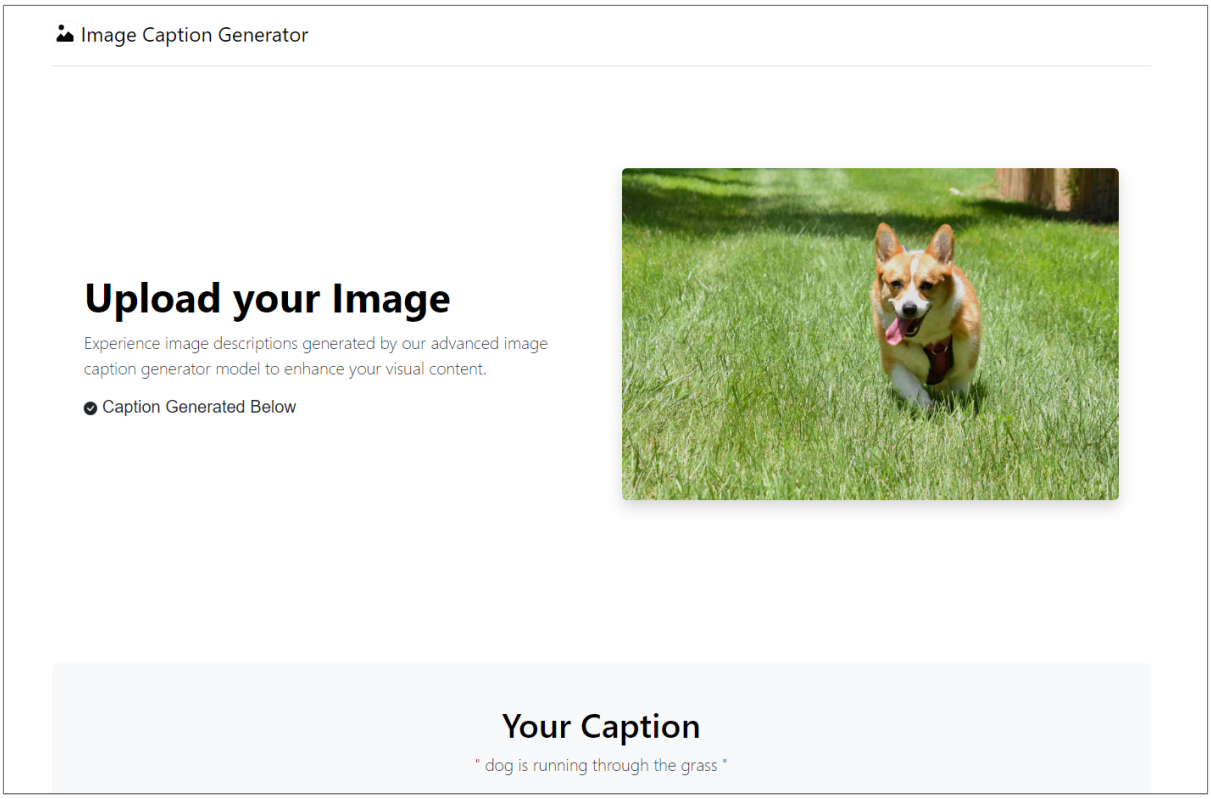
Sprint-5	Testing &quality assurance	USN-8	Conduct thorough testing of the model and web interface to identify and report any issues or inaccuracies in caption generation. Gather user feedback for model optimization.	1	Medium	Shreyas

Sprint Delivery Schedule

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	1	1 Days	28 October 2023	28 October 2023	1	28 October 2023
Sprint-2	4	2 Days	29 October 2023	30 October 2023	4	30 October 2023
Sprint-3	10	4 Days	31 October 2023	3 November 2023	10	3 November 2023
Sprint-4	4	2 Days	4 November 2023	5 November 2023	4	5 November 2023
Sprint-5	1	1 Days	6 November 2023	6 November 2023	1	6 November 2023

CODING & SOLUTIONING

User-friendly UI:



User-friendly UI features are designed to make it easy for users to interact with a product or service. They are characterized by being simple, clear, efficient, forgiving, and accessible. This means that they should be easy to understand and use, even for users with limited technical experience. They should also be well-organized and easy to navigate, allowing users to complete tasks quickly and easily. Additionally, user-friendly UI features should handle errors gracefully and provide clear feedback to users so that they can recover easily. Finally, they should be accessible to all users, regardless of their abilities or disabilities.

HTML (Webpage):

```
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <title>Image Caption Generator</title>
    <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.3.2/dist/css/bootstrap.min.css" rel="stylesheet" integrity="sha384-T3c6CoIi6uLrA9TneNEoa7RxnatzjcDSCmG1MXxSR1GAsXEV/Dwwykc2MPK8M2HN" crossorigin="anonymous">
    <link rel="stylesheet" href="{{ url_for('static', filename='./styles.css') }}">
</head>
<body>
```

```
    <div class="container">
        <header class="d-flex flex-wrap justify-content-center py-3 mb-4 border-bottom">
          <a href="/" class="d-flex align-items-center mb-3 mb-md-0 me-md-auto link-body-emphasis text-decoration-none">
            <svg xmlns="http://www.w3.org/2000/svg" width="30" height="30" fill="currentColor" class="bi bi-image-alt rounded border border-light p-1" viewBox="0 0 16 16">
                <path d="M7 2.5a2.5 2.5 0 1 1-5 0 2.5 2.5 0 0 1 5 0zm4.225 4.053a.5.5 0 0 0-.577.093l-3.71 4.71-2.66-2.772a.5.5 0 0 0-.63.062L.002 13v2a1 1 0 0 0 1 1h14a1 1 0 0 0 1-1v-4.5l-4.777-3.947z"/>
            </svg>
            <span class="fs-4 p-1">Image Caption Generator</span>
          </a>
        </header>
    </div>

    <div class="container col-xxl-8 px-4 py-5">
        <div class="row flex-lg-row-reverse align-items-center g-5 py-5">
          <div class="col-10 col-sm-8 col-lg-6">
            {% if img %}
            <img src={{img}} class="figure-img img-fluid rounded shadow mb-5 bg-body-tertiary rounded" alt="Bootstrap Themes" width="700" height="500" loading="lazy">
            {% else %}
            <p class="font-weight-light text-center">Image will render here...</p>
            {% endif %}
          </div>
          <div class="col-lg-6">
            <h1 class="display-5 fw-bold text-body-emphasis lh-1 mb-3">Upload your Image</h1>
            <p class="lead">Experience image descriptions generated by our advanced image caption generator model to enhance your visual content.</p>
            <div class="d-grid gap-2 d-md-flex justify-content-md-start fade-in-text">
                {% if not img or not vimg %}
                <form action="{{ url_for('upload_file') }}" enctype="multipart/form-data" method="POST">
                    <div class="input-group">
                        <input name = "img" type="file" class="form-control" id="inputGroupFile04" aria-describedby="inputGroupFileAddon04" aria-label="Upload">
                        <input class="btn btn-primary" type="submit"/>
                    </div>
                </form>
                {% else %}
                <p class="lead"> <svg xmlns="http://www.w3.org/2000/svg" width="16" height="16" fill="currentColor" class="bi bi-check-circle-fill b-1" viewBox="0 0 16 16">
                  <path d="M16 8A8 8 0 1 1 0 8a8 8 0 0 1 16 0zm-3.97-3.03a.75.75 0 0 0-1.08.022L7.477 9.417 5.384 7.323a.75.75 0 0 0-1.06 1.06L6.97 11.03a.75.75 0 0 0 1.079-.02l3.992-4.99a.75.75 0 0 0-.01-1.05z"/>
                </svg> Caption Generated Below </p>
                {% endif %}
            </div>
          </div>
        </div>
    </div>

    <div class="container my-5">
        <div class="p-5 text-center bg-body-tertiary rounded-3">
          <h1 class="text-body-emphasis">Your Caption</h1>
          <blockquote class="blockquote">
            <p class="lead font-italic-weight-light">
                {% if img %}
                " {{cap}} "
                {% else %}
                Loading...
                {% endif %}
            </p>
          </blockquote>
        </div>
      </div>

    <div class="container">
        <footer class="py-3 my-4">
          <ul class="nav justify-content-center border-bottom pb-3 mb-3">
            <li class="nav-item"><a href="#" class="nav-link px-2 text-body-secondary">ICG</a></li>
          </ul>
          <p class="text-center text-body-secondary">Developed using Visual Studio Code</p>
```

```
        </footer>
      </div>

</body>
</html>
```

CSS (Animation):

```
.fade-in-text {
    font-family: Arial;
    font-size: 60px;
    animation: fadeIn 5s;
    -webkit-animation: fadeIn 5s;
    -moz-animation: fadeIn 5s;
    -o-animation: fadeIn 5s;
    -ms-animation: fadeIn 5s;
  }

  @keyframes fadeIn {
    0% { opacity: 0; }
    100% { opacity: 1; }
  }

  @-moz-keyframes fadeIn {
    0% { opacity: 0; }
    100% { opacity: 1; }
  }

  @-webkit-keyframes fadeIn {
    0% { opacity: 0; }
    100% { opacity: 1; }
  }

  @-o-keyframes fadeIn {
    0% { opacity: 0; }
    100% { opacity: 1; }
  }

  @-ms-keyframes fadeIn {
    0% { opacity: 0; }
    100% { opacity: 1; }
}
```

User-Privacy:

We have implemented a user privacy feature in our image generation project to automatically delete user images after 90 seconds. This helps to protect user privacy by ensuring that user images are not stored for longer than necessary and are not accessible to unauthorized individuals. The user privacy feature works by generating a unique identifier for each uploaded image and storing it in a temporary location for 90 seconds. During this time, the system processes the image and generates the desired output. Once the output is generated, the image is deleted from the temporary location. This ensures that user images are only stored for as long as necessary and are not accessible to unauthorized individuals.

We believe that this user privacy feature is important because it helps to protect user data and build trust with users.

Flask code:

```
#Function
def del_file(path):
    sleep(15)
    os.remove(path)

# Start a new thread to delete the file after 15 seconds
            deletion_thread = threading.Thread(target=del_file, args=(img,))
        deletion_thread.start()
# Is executed while generating the caption
```

Web-App as a container:

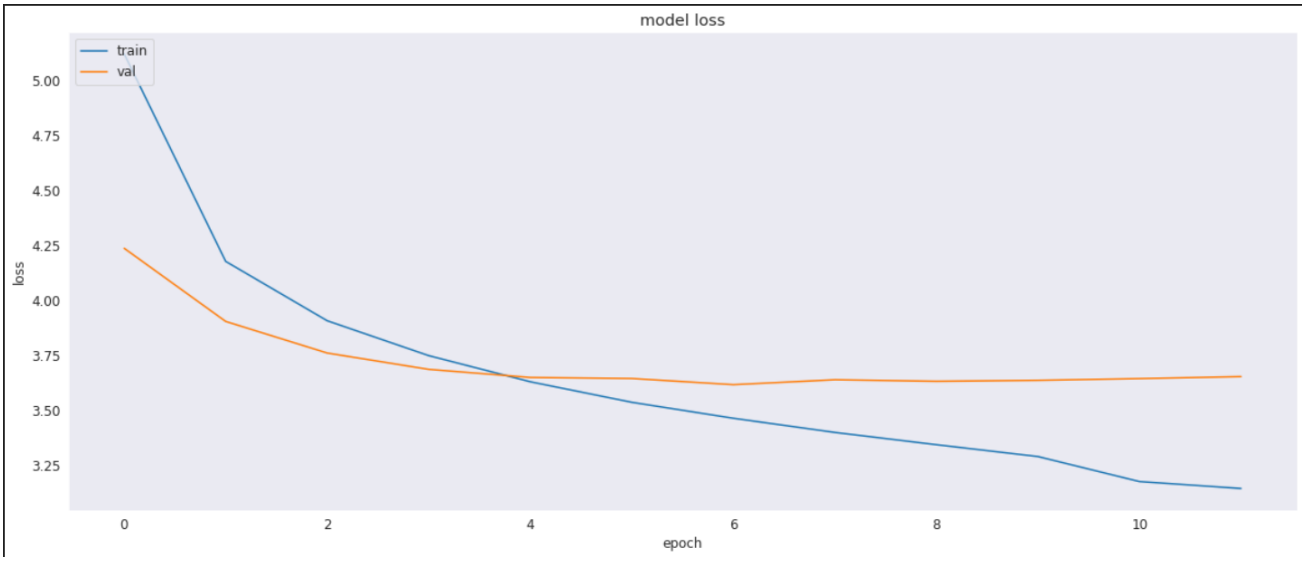
We have containerized our image caption generation app using Docker. This means that our app is now more portable, scalable, efficient, and isolated, making it a more powerful and reliable tool for everyone.

- **Portability :** Dockerized apps can be easily deployed and run on any machine with Docker installed, regardless of the underlying operating system or architecture. This makes our image generation app more portable, so users can easily share it with others or deploy it to different environments, such as production, development, and testing.
- **Scalability :** Dockerized apps are highly scalable. This means that we can easily add or remove instances of our app as needed, which is important for image generation apps that can experience spikes in demand at certain times.
- **Efficiency :** Dockerized apps are also very efficient in terms of resource usage. They share the underlying operating system kernel, which reduces overhead and improves performance. This makes our image generation app more efficient and cost-effective to use.
- **Isolation :** Dockerized apps are isolated from each other and from the host machine. This helps to improve security and reliability. Our image generation app is now more secure and reliable, thanks to Docker's isolation features.

```
FROM python:3.10-slim-bullseye

WORKDIR /app

COPY . /app

RUN pip install -r requirements.txt

EXPOSE 3000

CMD ["python", "app.py"]
```

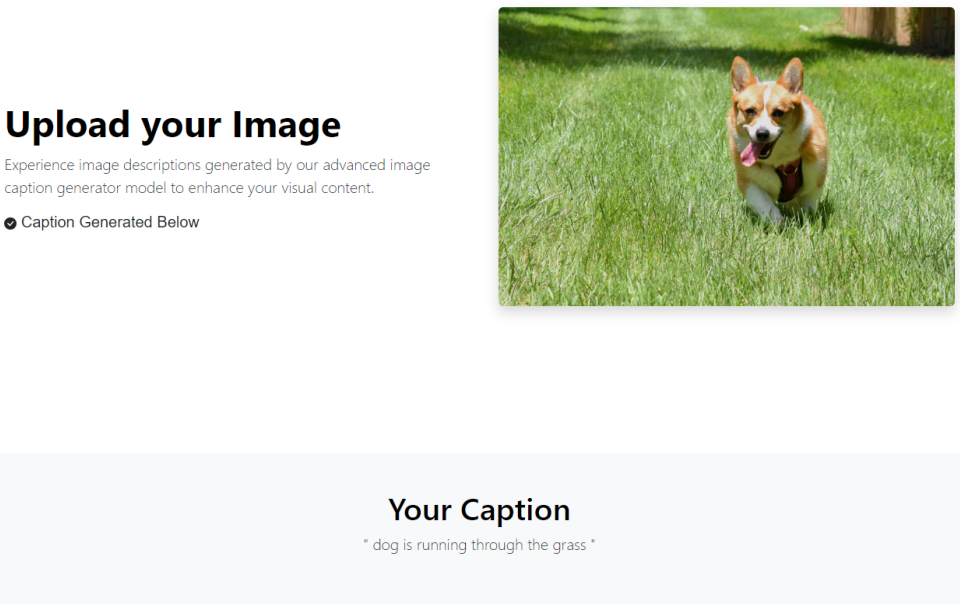
PERFORMANCE TESTING

Performance Metrics:



The model's performance on the training data is slightly better than its performance on unseen data, indicating that the model may be overfitting the training data. However, due to the high computational cost of training the model further, we were unable to reduce the overfitting.

RESULTS



Upload your Image

Experience image descriptions generated by our advanced image caption generator model to enhance your visual content.

Caption Generated Below

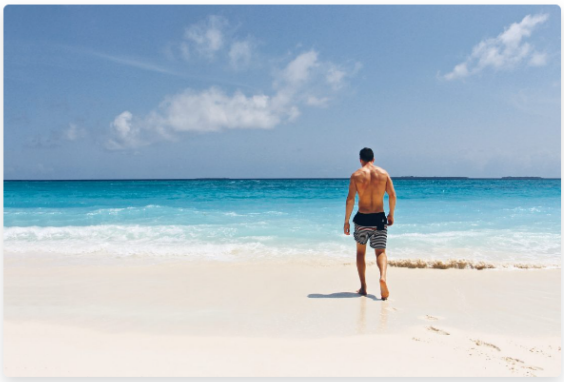
Your Caption

" man is climbing rock "

Upload your Image

Experience image descriptions generated by our advanced image caption generator model to enhance your visual content.

Caption Generated Below



Your Caption

" man in blue shirt is walking on the beach "

ADVANTAGES & DISADVANTAGES

An image caption generator using deep learning, such as this, can offer several advantages and disadvantages:

Advantages:

1. **Automatic Image Description**: Image caption generators can automatically provide descriptive text for images, making them accessible to individuals who are visually impaired and improving the overall user experience.

2. **Human-Like Descriptions**: Deep learning models can generate more contextually relevant and human-like image descriptions compared to traditional rule-based methods.

3. **Scalability**: Once trained, the model can be used to generate captions for a vast number of images without manual intervention, making it suitable for large-scale applications.

4. **Multimodal Understanding**: These models can learn to understand both visual and textual information, allowing them to generate captions that incorporate semantic context.

5. **Learning from Data**: Deep learning models can improve their performance with more data, allowing them to adapt to different image and language domains.

6. **End-to-End Training**: Some models can be trained end-to-end, meaning they learn to both extract features from images and generate captions without relying on pre-defined feature extractors.

Disadvantages:

1. **Data and Compute Requirements:** Training deep learning models for image captioning requires a large amount of labeled data and substantial computational resources, making it expensive and resource-intensive.

2. **Overfitting:** Deep learning models can easily overfit to the training data, resulting in captions that may be overly specific to the training dataset and not generalize well to unseen images.

3. **Lack of Fine-Grained Control:** The generated captions may not always adhere to specific requirements, making it challenging to control the style or content of the descriptions.

4. **Limited Understanding:** Deep learning models might not truly understand the content of the images and may generate captions that are incorrect, biased, or insensitive.

5. **Complexity:** Developing, fine-tuning, and maintaining a deep learning image captioning system can be complex and require expertise in both computer vision and natural language processing.

6. **Resource-Intensive Inference**: Generating captions in real-time for new images can be computationally expensive, especially if the model is large and requires a powerful GPU for inference.

7. **Language Limitations**: The quality of the generated captions heavily depends on the language model used. If the language model has limitations or biases, it can lead to undesirable outputs.

8. **Evaluation Challenges:** Assessing the quality of generated captions can be subjective, and there is no universally accepted metric for evaluating image captioning systems accurately.

In summary, while image caption generators using deep learning have made significant progress in generating natural and contextually relevant descriptions for images, they also come with challenges related to data, computation, and ensuring the generated content meets specific requirements and ethical standards.

CONCLUSION :

In conclusion, the development and implementation of an image caption generator using deep learning represents a significant stride in the field of artificial intelligence. The project has unveiled a technology that offers an array of advantages, including improving accessibility for visually impaired individuals, enhancing user experiences, enabling content summarization, and fostering multi-modal understanding. It has also demonstrated its value in increasing social media engagement, aiding in content moderation, and improving the searchability of visual content.

Nevertheless, it is important to acknowledge the limitations associated with image caption generation. These limitations include potential ambiguities, inaccuracies, biases, and the model's occasional lack of creativity and contextual understanding. The quality of generated captions may also be influenced by factors like image resolution and complexity.

Despite these challenges, image caption generation finds applications in a wide range of domains. It contributes to assistive technology, recommendation systems, image search, e-commerce, medical imaging, education, and more, thus permeating various facets of our digital lives. Additionally, it plays a crucial role in the advancement of artificial intelligence, robotics, and the enhancement of storytelling in multiple media formats.

As ongoing research and advancements continue to address the limitations, the potential of image caption generation to revolutionize content accessibility, understanding, and engagement remains compelling. The technology represents an area of continued exploration and development, with the promise of opening up new horizons in human-computer interaction and information accessibility.

FUTURE SCOPE

In the future, there are several promising areas of focus for the project, including:

1. **Advanced Architectures:** Exploring advanced neural network architectures, like transformer-based models, to improve accuracy and contextual understanding.

2. **Bias Mitigation:** Developing techniques to reduce biases in image captions, ensuring fairness and inclusivity.

3. **Contextual Understanding:** Enhancing the model's ability to consider broader context, including temporal aspects and narratives.

4. **Creative Captions:** Advancing the generation of creative and engaging captions with diverse styles.

5. **Personalization:** Tailoring captions to user preferences, contexts, and multilingual capabilities.

6. **Low-Resource Settings:** Improving performance in data-scarce environments through transfer learning and domain adaptation.

7. **Ethical Considerations:** Prioritizing ethical considerations, user control, and transparency in the captioning process.

8. **Integration with Emerging Technologies:** Integrating image captioning with AR and VR for real-time or immersive experiences.

9. **Cross-Modal Understanding:** Enhancing the model's understanding of the relationship between visual and textual content, going beyond mere descriptions.

Continued work in these areas will drive significant improvements in image captioning, making it more versatile and adaptable to diverse user needs and applications.

APPENDIX

Source Code

app.py

```
from flask import Flask, render_template, request
from werkzeug.utils import secure_filename
import os
from time import sleep
import threading
from icg import *

app = Flask(__name__)

upload_folder = 'static/upload'
```

```python
if not os.path.exists(upload_folder):
    os.makedirs(upload_folder)

def del_file(path):
    sleep(15)
    os.remove(path)


@app.route('/', methods=['GET', 'POST'])
def upload_file():
    if request.method == 'POST':
        file = request.files['img']
        filename = secure_filename(file.filename)
        img = os.path.join(upload_folder, filename)
        if(img == 'static/upload/'):
            return render_template('index.html',vimg = False)
        file.save(img)
        caption = predict_caption(caption_model, tokenizer, max_length, feature_extract(img))
        render = render_template('index.html',vimg = True, img=img, cap = caption[9:-7])
        # Start a new thread to delete the file after 15 seconds
        deletion_thread = threading.Thread(target=del_file, args=(img,))
        deletion_thread.start()
        return render
    return render_template('index.html')

if __name__ == '__main__':
    app.run(host='0.0.0.0', port=int("3000"), debug=True)
```

icg.py:

```python
import pickle
import numpy as np
import pandas as pd
from tensorflow.keras.preprocessing.image import load_img, img_to_array
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.applications import DenseNet201
from tensorflow.keras.layers import Activation, Dropout, Dense, Input, Layer
from tensorflow.keras.layers import Embedding, LSTM, add, Reshape, concatenate
from tensorflow.keras.models import Model, load_model

#Required Functions

def feature_extract(path):
    img = load_img(path,target_size=(224,224))
    img = img_to_array(img)
    img = img/225.
    img = np.expand_dims(img,axis=0)
    return fe.predict(img,verbose=0)

def idx_to_word(integer,tokenizer):

    for word, index in tokenizer.word_index.items():
        if index==integer:
            return word
    return None

```

```python
def predict_caption(model, tokenizer, max_length, feature):

    in_text = "startseq"
    for i in range(max_length):
        sequence = tokenizer.texts_to_sequences([in_text])[0]
        sequence = pad_sequences([sequence], max_length)

        y_pred = model.predict([feature,sequence],verbose = 0)
        y_pred = np.argmax(y_pred)

        word = idx_to_word(y_pred, tokenizer)

        if word is None:
            break

        in_text+= " " + word

        if word == 'endseq':
            break

    return in_text

#Initialization

#Image feature extraction model
model = DenseNet201()
fe = Model(inputs=model.input, outputs=model.layers[-2].output)

#Load Tokenizer
tokenizer = Tokenizer()
with open('./ModelData/tokenizer.pickle', 'rb') as handle:
    tokenizer = pickle.load(handle)

#Other Parameters
# TODO : Check max_length parameter
max_length = 74 #or max(len(caption.split()) for caption in captions)
vocab_size = len(tokenizer.word_index) + 1

#Prediction Model Initilization

input1 = Input(shape=(1920,))
input2 = Input(shape=(max_length,))

img_features = Dense(256, activation='relu')(input1)
img_features_reshaped = Reshape((1, 256), input_shape=(256,))(img_features)

sentence_features = Embedding(vocab_size, 256, mask_zero=False)(input2)
merged = concatenate([img_features_reshaped,sentence_features],axis=1)
sentence_features = LSTM(256)(merged)
x = Dropout(0.5)(sentence_features)
x = add([x, img_features])
x = Dense(128, activation='relu')(x)
x = Dropout(0.5)(x)
output = Dense(vocab_size, activation='softmax')(x)

caption_model = Model(inputs=[input1,input2], outputs=output)
caption_model.compile(loss='categorical_crossentropy',optimizer='adam')

#Load Weights
caption_model = load_model('./ModelData/cmodel.h5')
```

GitHub & Project Demo Link

https://github.com/smartinternz02/SI-GuidedProject-593153-1697214874/tree/main/Project%20Files