Image Generation using Stable Diffusion & Comfy UI

A Project Report

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by

Anushka Khadapkar, 21305040anushka@viva-technology.org

Under the Guidance of

Abdul Aziz Md

Master Trainer, Edunet Foundations

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ABSTRACT

Artificial intelligence has revolutionized image generation, with Stable Diffusion emerging as a powerful deep-learning model for generating high-quality images from text prompts. However, effectively utilizing Stable Diffusion requires an efficient and user-friendly interface. This project focuses on setting up and running ComfyUI, a graphical user interface designed to simplify the deployment and usage of Stable Diffusion models.

The primary objective of this project was to enable seamless integration of Stable Diffusion with ComfyUI, allowing users to generate AI-driven images with minimal technical complexity. The setup process involved downloading and installing ComfyUI, acquiring Stable Diffusion models from Hugging Face, and configuring the models within the ComfyUI environment. Additionally, the project explored different execution methods, utilizing both CPU and GPU to optimize performance.

The methodology followed a structured approach, beginning with the installation of essential software, ensuring proper model placement, and finally running ComfyUI in a local environment. By leveraging a web-based interface, users could interact with Stable Diffusion models effortlessly. The project emphasized model efficiency, hardware utilization, and user accessibility, ensuring smooth image generation workflows.

Key results demonstrated that GPU execution significantly enhanced processing speed, making it the preferred option for handling complex image generation tasks. The project successfully validated the integration of Stable Diffusion models with ComfyUI, providing an interactive and effective AI-powered image generation setup.

In conclusion, this project contributes to the growing accessibility of AI-driven image generation by simplifying the deployment of Stable Diffusion models using ComfyUI. The structured setup process ensures that users, even with limited technical expertise, can efficiently utilize these models. Future advancements could focus on integrating additional AI models and improving performance for broader applications in digital art, design, and creative industries.

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CHAPTER 1

Introduction

1.1Problem Statement:

In recent years, artificial intelligence has significantly advanced in the field of image generation, with models like Stable Diffusion offering the ability to create diverse and high-quality images from textual descriptions. However, utilizing these models effectively often requires complex setups, programming knowledge, and command-line interactions, making them less accessible to users with limited technical expertise. The challenge is to develop a robust, user-friendly image generation system that simplifies the deployment and customization of Stable Diffusion while maintaining high-quality outputs.

This project aims to integrate Stable Diffusion with ComfyUI, an intuitive graphical user interface, to provide a seamless and accessible image generation experience. The primary challenges addressed in this project include:

1. Enhancing user control over image parameters – Users should be able to adjust critical aspects such as image style, resolution, prompt interpretation, and model variations without requiring in-depth technical knowledge. A well-structured interface should allow easy modifications while maintaining creative flexibility.
2. Streamlining the image generation workflow – The system should offer a simple yet powerful workflow where users can generate, modify, and fine-tune images efficiently. The integration of Stable Diffusion into ComfyUI should eliminate the need for extensive manual configurations, reducing the complexity of the setup process.
3. Ensuring alignment with user-provided prompts and aesthetics – One of the key challenges in AI-generated imagery is maintaining coherence between user input prompts and the final output. The system must improve prompt-to-image accuracy, allowing users to create visually appealing and contextually relevant images that match their expectations.

By addressing these challenges, this project aims to democratize AI-driven image generation, making it accessible to a broader audience, including artists, designers, content creators, and enthusiasts who wish to explore AI-powered creativity without requiring advanced programming skills.

1.2Motivation:

The rapid advancements in artificial intelligence have revolutionized the field of image generation, enabling the creation of stunning visuals based on text prompts. Stable Diffusion stands out as a powerful AI model capable of generating high-quality, diverse images, but its adoption is often hindered by technical barriers, including complex installations, manual configurations, and command-line execution. To bridge this gap,

ComfyUI offers a graphical user interface (GUI) that simplifies the interaction with Stable Diffusion, making AI-driven creativity more accessible.

This project was chosen to eliminate the technical complexity associated with setting up and using Stable Diffusion by integrating it with ComfyUI, allowing users to generate AI-powered images effortlessly. By providing a streamlined, user-friendly solution, this project empowers individuals with minimal technical expertise to explore AI-generated art, design, and visualization.

Potential Applications & Impact

1. Creative Industries: Graphic designers, digital artists, and content creators can leverage this system to generate unique visuals, concept art, and storyboards, reducing the time and effort needed for manual artwork.
2. Marketing & Advertising: AI-generated images can help businesses create customized promotional materials, social media content, and brand visuals tailored to their audience.
3. Education & Research: Educators and researchers can use this system to demonstrate AI-powered creativity, explore machine learning models, and study AI's impact on art and design.
4. Entertainment & Gaming: Game developers and animators can utilize AI-generated assets for character design, environment creation, and visual storytelling, accelerating the production process.
5. Personalized Content Creation: Users can create personalized images for blogs, social media, or personal projects without requiring advanced graphic design skills.
6. By making AI-powered image generation more intuitive and widely accessible, this project has the potential to democratize digital creativity, allowing a diverse range of users to harness the power of AI for their artistic and professional needs.

1.3Objective:

The primary objective of this project is to integrate Stable Diffusion with ComfyUI to create an accessible, efficient, and user-friendly AI-powered image generation system. This project aims to simplify the setup, customization, and execution of Stable Diffusion models, enabling users to generate high-quality images effortlessly. The specific objectives include:

1. Setup and Configuration – To successfully download, install, and configure ComfyUI and Stable Diffusion models, ensuring a seamless integration process.
2. Enhancing User Accessibility – To eliminate the need for complex command-line interactions by providing a graphical user interface (GUI) that allows users to easily modify parameters such as image style, resolution, and prompts.
3. Optimizing Performance – To enable both CPU and GPU execution of Stable Diffusion within ComfyUI, ensuring that users can leverage their hardware efficiently for faster image generation.

4. Streamlining the Workflow – To establish a structured and intuitive workflow that enables users to generate and fine-tune AI-generated images without requiring in-depth technical expertise.
5. Ensuring Prompt-to-Image Accuracy – To improve the alignment between user-provided text prompts and the generated images, enhancing the relevance and aesthetic quality of AI-generated outputs.
6. Expanding Creative Applications – To explore and demonstrate real-world use cases of AI-generated images in domains such as art, design, marketing, education, gaming, and content creation.

By achieving these objectives, this project ensures that Stable Diffusion's powerful capabilities can be harnessed by a wider audience, making AI-driven creativity more accessible, efficient, and user-friendly.

1.4Scope of the Project:

This project focuses on the integration, setup, and utilization of Stable Diffusion with ComfyUI to enable AI-powered image generation through a user-friendly interface. The project aims to simplify the installation, configuration, and execution of Stable Diffusion models while ensuring ease of use for individuals with minimal technical expertise.

Scope

1. Stable Diffusion Model Integration:
   a) Setting up ComfyUI as the interface for using Stable Diffusion models.
   b) Supporting multiple Stable Diffusion variants (e.g., SD 1.5, SDXL).
      a) Enabling both checkpoint (.ckpt) and SafeTensor (.safetensors) formats.
2. User-Friendly Image Generation:
   a) Providing an intuitive GUI for generating images.
   b) Allowing customization of key parameters (style, resolution, prompts, and model settings).
   c) Enabling easy modifications and experimentation with different model configurations.
3. Performance Optimization:
   a) Supporting CPU and GPU execution for flexibility in hardware utilization.
   b) Ensuring efficient processing for improved image generation speed.
4. Applications in Various Domains:
   a) Use in art, design, marketing, content creation, gaming, and education.
   b) Demonstrating how AI-generated images can enhance creative workflows.

Limitations

1. Hardware Dependency:
   a) Performance is hardware-dependent, with GPU execution significantly faster than CPU.
   b) Requires sufficient computational power to generate high-resolution images efficiently.

2. Model Constraints:
   a) Generated images are limited by the quality and biases of the pre-trained Stable Diffusion models.
   b) Fine-tuning models or training custom models is not included in this project.
3. Limited Real-Time Processing:
   a) Image generation may take several seconds to minutes, depending on hardware and model complexity.
   b) No support for real-time AI-generated animations or interactive modifications beyond standard UI adjustments.
4. Ethical Considerations:
   a) Stable Diffusion models may generate biased or inappropriate content based on user inputs.
   b) Users need to follow ethical AI usage guidelines to ensure responsible content creation.

This project establishes a strong foundation for AI-powered image generation while acknowledging hardware limitations, model constraints, and ethical concerns. Future enhancements could focus on custom model fine-tuning, real-time processing, and advanced creative workflows.

CHAPTER 2

Literature Survey

2.1Review relevant literature:

The field of AI-driven image generation has evolved significantly in recent years, with models like Stable Diffusion, DALL·E, and MidJourney revolutionizing the way images are created from text prompts. This section reviews existing research and developments related to Stable Diffusion, ComfyUI, and AI-based image synthesis.

1.Stable Diffusion: A Breakthrough in AI Image Generation

Stable Diffusion, developed by Stability AI, is an open-source deep-learning model based on latent diffusion models (LDMs). Unlike earlier models such as DALL·E (by OpenAI), Stable Diffusion is designed to be efficient, customizable, and locally deployable, allowing users to run AI-powered image generation on personal hardware. Rombach et al. (2022) introduced latent diffusion models (LDMs), which improve upon traditional diffusion models by reducing computational costs while maintaining high image quality. Unlike earlier generative adversarial networks (GANs) such as BigGAN (Brock et al., 2019), Stable Diffusion uses denoising-based latent space transformations to generate high-resolution images. Compared to Transformer-based models like DALL·E 2 (Ramesh et al., 2022), Stable Diffusion provides greater flexibility, allowing users to fine-tune models, use different checkpoint versions, and integrate control mechanisms such as ControlNet and LoRA.

2. User-Friendly AI Image Generation: The Role of ComfyUI

While Stable Diffusion is powerful, its implementation often requires complex command-line interfaces and manual configuration. To address this, ComfyUI was developed as a node-based, user-friendly graphical interface that simplifies AI image generation workflows. Traditional Stable Diffusion interfaces like Automatic1111 WebUI provide customization but can be difficult for beginners to navigate. ComfyUI, on the other hand, introduces a modular, visual workflow, similar to Blender's node-based system, allowing users to configure and control image generation without writing complex code. Prior research on usability in AI systems (Shneiderman, 2020) highlights the importance of intuitive graphical interfaces in enhancing accessibility and adoption.

3. Performance and Optimization of AI Image Models

Efficient execution of Stable Diffusion models depends on hardware capabilities, particularly GPU acceleration. Studies on AI model optimization (Vaswani et al., 2017) emphasize the importance of hardware-aware AI execution for faster image generation. Research shows that NVIDIA CUDA acceleration significantly improves image generation

speed compared to CPU-based execution. Benchmarks from Stability AI's research papers indicate that higher VRAM availability (8GB+ recommended) leads to better performance when generating complex, high-resolution images.

4. Ethical Considerations in AI Image Generation

AI-generated imagery presents ethical challenges, including biases in training data, deepfake concerns, and misuse of AI-generated content. Studies by Mitchell et al. (2023) highlight the need for responsible AI deployment, ensuring models are used for ethical purposes while minimizing biases in generated content. Open-source initiatives like Hugging Face's AI ethics guidelines emphasize transparency, fairness, and accountability in AI-generated media.

The literature review demonstrates that Stable Diffusion is a cutting-edge AI model, but its usability can be improved through tools like ComfyUI. This project builds upon previous research by integrating Stable Diffusion with an intuitive UI, making AI-powered creativity more accessible and efficient. Additionally, it acknowledges the performance considerations and ethical challenges associated with AI-generated imagery, contributing to the responsible and user-friendly adoption of AI-driven image generation.

2.2Existing models, techniques, or methodologies:

Several existing models, techniques, and methodologies have been developed to enhance AI-powered image generation, with Stable Diffusion being one of the most prominent. Stable Diffusion, developed by Stability AI, is based on latent diffusion models (LDMs), which optimize computational efficiency while maintaining high-quality image synthesis. This model differs from traditional Generative Adversarial Networks (GANs), such as BigGAN, which rely on adversarial training and often require extensive computational power. Another key approach in AI-driven image generation is Transformer-based architectures, such as DALL·E (OpenAI), which leverages autoregressive and diffusion-based methods to generate highly detailed images from textual descriptions. Unlike Stable Diffusion, models like DALL·E 2 use CLIP embeddings to improve semantic coherence between text and image outputs.

To enhance usability, several interfaces have been developed for Stable Diffusion, including Automatic1111 WebUI and InvokeAI, which provide customizable options for generating AI-generated art. However, these interfaces still require significant technical expertise to operate. This challenge led to the development of ComfyUI, a node-based, modular workflow system that simplifies user interactions with AI models. ComfyUI allows users to visually adjust parameters such as image resolution, style, sampling method, and control mechanisms (e.g., ControlNet, LoRA fine-tuning). Furthermore, optimization techniques like xFormers memory-efficient attention and CUDA acceleration improve inference speed, making AI image generation faster and more efficient.

Beyond Stable Diffusion, ControlNet and LoRA (Low-Rank Adaptation) provide additional methodologies to enhance AI-generated images. ControlNet allows users to guide image composition using edge detection, pose estimation, and depth mapping, ensuring greater control over structure and details. On the other hand, LoRA fine-tuning is a technique that enables efficient model adaptation with fewer computational resources, making it possible to train personalized AI models for specific artistic styles. These advancements collectively contribute to making AI-powered image generation more accessible, efficient, and customizable, addressing the challenges faced by users who seek greater control and ease of use in digital content creation.

2.3The gaps or limitations in existing solutions

Despite significant advancements in AI-powered image generation, existing solutions have several gaps and limitations that hinder accessibility, usability, and efficiency. This project aims to address these shortcomings by integrating Stable Diffusion with ComfyUI, providing a more user-friendly and customizable AI image generation system.

1. Complex Setup and Configuration

   Gap: Many existing tools, such as Stable Diffusion's command-line interface or Automatic1111 WebUI, require manual configuration and technical knowledge for installation, model selection, and environment setup.

   Solution: This project simplifies the installation process by providing a structured step-by-step setup guide, allowing users to install ComfyUI and load Stable Diffusion models without requiring advanced coding skills.

2. Lack of an Intuitive User Interface

   Gap: Traditional AI-based image generation tools often have complex UI designs that are not beginner-friendly. For instance, while Automatic1111 WebUI offers advanced customization, it has a steep learning curve for users unfamiliar with AI workflows.

   Solution: By using ComfyUI's node-based graphical interface, this project makes AI image generation interactive and visual, enabling users to customize parameters like resolution, style, and prompts with ease.

3. Limited User Control Over Image Outputs

   Gap: Standard AI image generators often lack precise control mechanisms, leading to unpredictable results that may not align with user expectations. Existing solutions like Stable Diffusion without ControlNet often struggle with maintaining structural consistency in generated images.

   Solution: This project leverages ComfyUI's modular workflow to integrate ControlNet and LoRA fine-tuning, allowing users to guide image composition through pose

estimation, depth mapping, and edge detection for more structured and controlled outputs.

4. Performance Bottlenecks and Hardware Limitations

   Gap: AI image generation can be resource-intensive, and many tools are optimized primarily for high-end GPUs, making it difficult for users with limited hardware to generate images efficiently.

   Solution: This project supports both CPU and GPU execution, ensuring that users with different hardware configurations can still utilize AI-powered image generation. Additionally, memory-efficient techniques like xFormers optimization help improve performance on lower-end systems.

5. Ethical and Bias Concerns in AI-Generated Content

   Gap: AI-generated images may reflect biases present in the training data, and inappropriate or misleading content can be produced if not monitored carefully. Existing platforms often lack built-in safeguards for ethical AI usage.

   Solution: This project promotes responsible AI usage by guiding users on ethical considerations and providing recommendations to avoid generating harmful or biased content. It also emphasizes user control to ensure generated images align with the intended artistic and ethical guidelines.

By addressing these gaps, this project enhances the accessibility, usability, and efficiency of AI-powered image generation. Through ComfyUI's intuitive interface, structured workflow, and model optimization techniques, users can experience a more controlled, seamless, and user-friendly AI-driven creativity process without the need for extensive technical expertise.

CHAPTER 3

Proposed Methodology

3.1 System Design

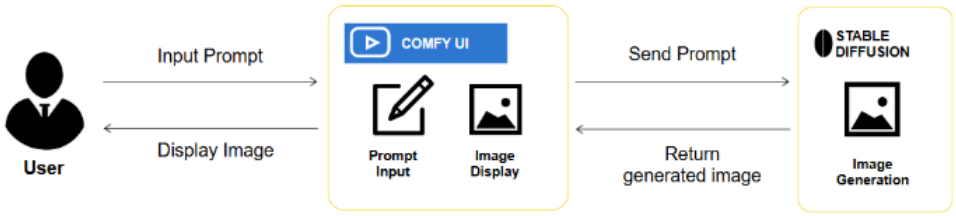

Fig. 3.1.1. System Architecture

The architecture diagram illustrates the workflow of an AI-based image generation system using Stable Diffusion and ComfyUI. The system is designed to allow users to generate high-quality images based on text prompts, leveraging a streamlined and user-friendly interface. The architecture consists of three main components: User, ComfyUI, and Stable Diffusion, each playing a crucial role in the image generation process.

The process begins with the user, who inputs a textual description of the desired image. This input prompt is sent to ComfyUI, a graphical user interface that simplifies interaction with the Stable Diffusion model. ComfyUI provides an easy-to-use platform where users can enter prompts, adjust parameters such as resolution and style, and preview generated images. This interface acts as a bridge between the user and the backend AI model, ensuring seamless communication and control.

Once the user submits the input, ComfyUI processes the prompt and forwards it to the Stable Diffusion model for image generation. Stable Diffusion is a deep learning model trained to create high-quality images based on textual descriptions. It leverages latent diffusion techniques to iteratively refine images, ensuring that the output aligns with the given prompt. The model runs either on a CPU or a GPU, with GPU acceleration significantly enhancing processing speed and output quality.

After processing the input, Stable Diffusion returns the generated image to ComfyUI, where it is displayed for the user. The user can then review the image, make modifications to the input prompt if needed, and generate new variations. This architecture enables an interactive and iterative image creation process, allowing users to refine their outputs until they achieve the desired visual results.

Overall, this system architecture simplifies AI-powered image generation, making it accessible even to users with minimal technical expertise. The integration of Stable

Diffusion with ComfyUI provides a smooth workflow, enhanced user control over image generation, and a responsive interface for real-time interaction, making it an efficient tool for creative applications.

3.2 Requirement Specification

The successful execution of this project requires specific hardware, operating system compatibility, and software dependencies. Below is a detailed breakdown of the prerequisites and required libraries for running ComfyUI with Stable Diffusion.

3.2.1 Hardware Requirements:

To efficiently run ComfyUI and Stable Diffusion, the following hardware specifications are required:

- **Operating System**: Windows 10/11, macOS, or any Linux distribution
- **Processor (CPU)**: A modern multi-core processor (Intel i5/i7 or AMD Ryzen 5/7)
- **Graphics Card (GPU)**:
- **NVIDIA GPU (Recommended)**: RTX 3060 or higher with CUDA support
- **Minimum VRAM**: 6GB (8GB+ recommended for better performance)
- **CPU-only execution** is possible but significantly slower.
- **Memory (RAM)**:
  - Minimum: **16 GB**
  - Recommended: **32 GB** for smoother processing
- **Storage**: At least **10GB of free space** for model files, dependencies, and image generation

3.2.2 Software Requirements:

The following software and dependencies must be installed:

- Python: Version **3.8 or higher** should be installed.
- **PIP**: The Python package manager for installing required libraries.
- **NumPy** – For numerical computations and array manipulations.
- **PyTorch** – Core deep learning framework for **Stable Diffusion** operations.
- **Transformers** – Provides the architecture for **Stable Diffusion model inference**.
- **Pillow** – Image processing and handling library.
- **Flask** – A lightweight Python framework for serving the **ComfyUI web interface**.
- **Requests** – Used for making **API calls** and handling HTTP requests.
- **TQDM** – Provides a progress bar for tracking operations.
- **Filelock** – Helps manage file access and prevents conflicts.
- **Gradio** – Enables a user-friendly web interface for AI models.
- **Omegaconf** – A flexible configuration management library.

CHAPTER 4

Implementation and Result

4.1 Snap Shots of Result:

Fig. 4.1.1 Notebook & Pen

This image captures the essence of creativity and the power of words. A pen resting on an open notebook symbolizes the beginning of new ideas, stories, or personal reflections. Writing has always been a timeless tool for expression, preserving thoughts before they fade. Whether it's a journal entry, poetry, or brainstorming for an innovative project, the simplicity of ink on paper represents the foundation of knowledge and imagination.

Fig. 4.2.2 Mountain & Lake Landscape

This breathtaking landscape showcases the harmony between nature's elements. The towering snow-capped mountains stand as a symbol of strength and resilience, while the

still waters of the lake create a mesmerizing reflection of the sky. The golden hues of the setting sun add warmth to the scene, reminding us of nature's ever-changing beauty. This image evokes a sense of peace, adventure, and the deep connection between humans and the natural world, encouraging one to pause and embrace the serenity of the wilderness.

4.2 GitHub Link for Code:

https://github.com/Anukhadapkar9999/Image-Generation-using-Stable-Diffusion-Comfy-UI.git

CHAPTER 5

Discussion and Conclusion

5.1 Future Work:

While the current implementation of Stable Diffusion with ComfyUI provides a robust framework for AI-based image generation, several areas can be explored for further enhancement. One major improvement is the integration of real-time image editing capabilities, allowing users to refine generated images dynamically instead of re-entering prompts multiple times. Additionally, incorporating advanced AI-driven style customization can enable users to generate images with more precise artistic control, such as adjusting lighting, texture, or specific artistic influences.

Another key area for improvement is optimization for low-end hardware, as the current system heavily relies on high-end GPUs for efficient processing. Implementing model quantization techniques or cloud-based inference can make the system more accessible to users with limited computational resources. Furthermore, multimodal input support, where users can provide both text and rough sketches as input, could enhance the model's ability to generate more accurate and context-aware images.

Security and ethical considerations are also essential for future development. Implementing robust content moderation mechanisms can prevent the misuse of AI-generated images, ensuring responsible AI usage. Additionally, enhanced user feedback mechanisms can help improve the model's adaptability by learning from user preferences over time. By focusing on these aspects, future iterations of this project can enhance usability, accessibility, and ethical considerations while pushing the boundaries of AI-powered creativity.

5.2 Conclusion:

The integration of Stable Diffusion with ComfyUI has successfully created a user-friendly and efficient AI-based image generation system, making advanced generative AI accessible to a broader audience. By providing an intuitive interface, the project enables users, even those with minimal technical expertise, to generate high-quality, customized images through simple text prompts. The seamless workflow between ComfyUI and Stable Diffusion enhances user experience, allowing for greater control over image parameters such as style, resolution, and composition.

This project has demonstrated the potential of AI in creative fields, offering applications in digital art, content creation, and design. It has also streamlined the image generation process, making it more accessible and interactive. Additionally, the project highlights

the importance of real-time customization, computational efficiency, and ethical considerations in AI-driven content creation.

Moving forward, enhancements such as real-time editing, multimodal inputs, and optimized performance for low-end hardware can further refine the system's capabilities. Overall, this project represents a significant step in democratizing AI-powered image generation, providing a versatile and scalable tool for creative professionals and enthusiasts alike.

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