Intelligent Image Background Removal Tool

AI-Powered Segmentation with Streamlit Framework

Technical Documentation

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1 Abstract

The Intelligent Image Background Removal Tool represents a significant advancement in automated image processing technology, leveraging artificial intelligence and deep learning techniques to eliminate backgrounds from digital images with unprecedented accuracy and efficiency. This web-based application, built using the Streamlit framework, integrates the powerful rembg library, which utilizes the U²-Net neural network architecture for precise image segmentation tasks.

Traditional background removal methods have long been plagued by time-intensive manual processes, requiring specialized software expertise and significant financial investment in professional editing tools. This solution addresses these fundamental limitations by providing an automated, accessible, and cost-effective alternative that delivers professional-quality results within seconds of processing initiation.

The application's architecture combines multiple cutting-edge technologies including Python's PIL library for comprehensive image manipulation, NumPy for efficient numerical computations, and Streamlit's intuitive web framework for seamless user interaction. The system supports various image formats including PNG, JPG, and JPEG, with intelligent preprocessing capabilities that automatically optimize large images while maintaining aspect ratios and visual quality.

This documentation provides comprehensive technical insights into the system's architecture, implementation methodology, and practical applications across diverse industries including e-commerce, social media content creation, marketing design, identification photography, real estate visualization, and personal creative projects.

2 Introduction

In the contemporary digital landscape, the demand for high-quality image processing solutions has reached unprecedented levels. Professional photographers, e-commerce businesses, social media content creators, and casual users alike require efficient methods to isolate subjects from their backgrounds, creating clean, professional-looking images suitable for various applications. The traditional approach to background removal has historically relied on sophisticated image editing software such as Adobe Photoshop, requiring users to possess technical expertise and invest considerable time in manual pixel-by-pixel editing processes.

The emergence of artificial intelligence and machine learning technologies has revolutionized the field of computer vision, enabling the development of automated solutions that can perform complex image segmentation tasks with remarkable accuracy. Deep learning models, particularly convolutional neural networks, have demonstrated exceptional capabilities in understanding image content, identifying object boundaries, and distinguishing between foreground subjects and background elements.

This project introduces an innovative web-based application that harnesses the power of modern AI technology to automate the background removal process entirely. By implementing the U²-Net architecture through the rembg library, the system can analyze uploaded images, identify the primary subject matter, and generate precise segmentation masks that enable the creation of transparent backgrounds with professional-quality results.

The application's user-centric design philosophy prioritizes accessibility and ease of

use, eliminating the need for technical expertise while maintaining the high-quality output standards expected in professional environments. Through the integration of Streamlit's web framework, users can interact with the system through an intuitive interface that requires no prior knowledge of image editing techniques or artificial intelligence concepts.

3 Problem Statement

The conventional approach to background removal in digital image processing presents numerous challenges that create significant barriers for both professional and casual users. Traditional methods typically require users to invest in expensive software licenses for professional image editing applications such as Adobe Photoshop, CorelDRAW, or GIMP alternatives. These tools, while powerful, demand extensive technical knowledge and experience to achieve satisfactory results, particularly when dealing with complex subjects featuring intricate details such as hair, fur, or transparent elements.

The manual selection process inherent in traditional background removal techniques is inherently time-consuming and labor-intensive. Users must carefully trace around subject boundaries using selection tools, often requiring multiple iterations and refinements to achieve acceptable accuracy. This process becomes increasingly challenging when dealing with subjects that have complex edges, fine details, or semi-transparent elements, frequently resulting in artifacts, rough edges, or incomplete selections that compromise the final image quality.

Furthermore, the learning curve associated with professional image editing software represents a significant obstacle for users who require occasional background removal capabilities but lack the time or motivation to develop comprehensive image editing skills. The complexity of these tools often leads to frustration and suboptimal results for inexperienced users, creating a gap between the desired outcome and the achievable result given the user's technical proficiency.

The cost factor associated with professional image editing software presents another substantial barrier, particularly for small businesses, freelancers, or individual users who require background removal capabilities but cannot justify the expense of purchasing and maintaining professional software licenses. Additionally, the processing time required for manual background removal scales linearly with image complexity and user expertise, making it impractical for applications requiring batch processing or rapid turnaround times.

4 Solution Overview

The Intelligent Image Background Removal Tool addresses the aforementioned challenges by implementing a fully automated, AI-powered solution that eliminates the need for manual intervention while delivering professional-quality results. The system leverages advanced deep learning techniques through the rembg library, which incorporates the U^2-Net neural network architecture specifically optimized for image segmentation tasks.

The solution's core innovation lies in its ability to automatically analyze uploaded images and identify the primary subject matter without requiring user input or manual selection. The underlying AI model has been trained on extensive datasets containing diverse image types, enabling it to handle a wide variety of subjects including people, animals, objects, and complex scenes with intricate details such as hair, fur, and transparent

elements.

The web-based architecture ensures universal accessibility across different operating systems and devices, eliminating the need for software installation or maintenance. Users can access the application through any modern web browser, making it immediately available without technical setup requirements or compatibility concerns. The Streamlit framework provides an intuitive user interface that abstracts away the underlying complexity while presenting users with a clean, straightforward interaction model.

The system incorporates intelligent image preprocessing capabilities that automatically optimize uploaded images for processing efficiency. Large images are automatically resized while maintaining aspect ratios to ensure optimal processing speed without compromising visual quality. The application supports multiple image formats including PNG, JPG, and JPEG, with automatic format conversion to ensure compatibility with the transparency requirements of background-removed images.

Performance optimization features including caching mechanisms prevent redundant processing of identical images, significantly improving response times for repeated operations. The application also includes comprehensive error handling and user feedback systems that provide clear guidance and status updates throughout the processing pipeline.

5 Technology Stack and Architecture

5.1 Core Technologies

The Intelligent Image Background Removal Tool is built upon a carefully selected technology stack that combines proven frameworks and libraries to deliver optimal performance, reliability, and user experience. The foundation of the application rests on Python, chosen for its extensive ecosystem of image processing and machine learning libraries, along with its excellent integration capabilities with web frameworks and AI/ML tools.

Streamlit serves as the primary web application framework, providing a Python-native approach to web development that eliminates the need for traditional frontend technologies such as HTML, CSS, and JavaScript. This framework enables rapid prototyping and deployment while maintaining professional-quality user interfaces through its comprehensive widget library and automatic UI updating capabilities. Streamlit's built-in functionality for file uploads, downloads, and interactive components significantly reduces development complexity while ensuring a responsive and intuitive user experience.

The rembg library constitutes the core AI component of the system, implementing state-of-the-art background removal capabilities through pre-trained deep learning models. This library encapsulates the complex neural network operations required for image segmentation, providing a simple API interface that abstracts away the underlying computational complexity. The library's implementation of the U^2-Net architecture has been specifically optimized for background removal tasks, offering superior performance compared to general-purpose segmentation models.

PIL (Python Imaging Library), commonly known as Pillow, handles all image manipulation operations including file I/O, format conversion, resizing, and transformation tasks. This library provides comprehensive support for various image formats and enables the seamless integration of different image processing operations within the application pipeline. NumPy provides the mathematical foundation for efficient numerical computations, particularly in handling image arrays and performing optimized operations on large datasets.

5.2 U²-Net Architecture

The U²-Net (U-squared Net) architecture represents a significant advancement in deep learning-based image segmentation technology. This convolutional neural network design incorporates a nested U-structure that enables the model to capture both fine-grained details and global context information simultaneously. The architecture's unique design allows it to excel in salient object detection tasks, making it particularly well-suited for background removal applications.

The network's encoder component extracts hierarchical feature representations from input images through a series of convolutional and pooling operations. These features capture various levels of abstraction, from low-level edge and texture information to high-level semantic understanding of object categories and spatial relationships. The encoder's progressive downsampling approach enables the model to build a comprehensive understanding of the image content while maintaining computational efficiency.

The decoder component reconstructs the segmentation mask by combining features from different encoder levels through skip connections and upsampling operations. This design ensures that the final segmentation maintains both spatial accuracy and semantic correctness, preserving fine details while correctly identifying object boundaries. The nested U-structure allows the model to refine its predictions iteratively, resulting in more accurate segmentation masks compared to traditional U-Net architectures.

5.3 Image Processing Pipeline

The application implements a sophisticated image processing pipeline that ensures optimal results while maintaining system performance and reliability. The pipeline begins with comprehensive input validation that verifies file format compatibility, checks file size constraints, and performs basic integrity checks to prevent processing errors. The system supports PNG, JPG, and JPEG formats with a maximum file size limit of 10MB to balance processing capability with system resource management.

The preprocessing stage involves intelligent image optimization that automatically resizes large images while preserving aspect ratios and visual quality. The system implements a maximum dimension constraint of 2000 pixels, applying proportional scaling to maintain image proportions while reducing computational requirements. This optimization significantly improves processing speed and reduces memory consumption without noticeably affecting the quality of the final result.

The core background removal operation utilizes the rembg library to process the optimized image through the pre-trained U²-Net model. The AI system analyzes the image content, identifies the primary subject matter, and generates a precise alpha mask that defines transparent and opaque regions. This mask is then applied to the original image to create the final result with a transparent background.

The post-processing stage involves format conversion to PNG to ensure transparency support, quality validation to verify successful processing, and output preparation for user download. The system generates side-by-side comparisons to allow users to evaluate the results and provides immediate download capabilities for the processed images.

6 Implementation Details

6.1 File Upload and Validation

The application implements a robust file upload system that prioritizes both user experience and system security. The upload mechanism utilizes Streamlit's built-in file uploader widget, which provides drag-and-drop functionality along with traditional file selection options. The system enforces strict file type validation, accepting only PNG, JPG, and JPEG formats to ensure compatibility with the underlying image processing libraries.

File size validation prevents system overload by enforcing a 10MB maximum file size limit. This constraint balances the need to accommodate high-resolution images with system performance requirements and memory management considerations. The validation process includes comprehensive error handling that provides clear, user-friendly feedback when uploads exceed size limits or contain unsupported file formats.

The system implements secure file handling practices that prevent potential security vulnerabilities while maintaining processing efficiency. Uploaded files are processed in memory without being permanently stored on the server, ensuring user privacy and reducing storage requirements. The application includes robust error handling mechanisms that gracefully manage corrupted files, network interruptions, and other potential upload issues.

6.2 Image Resizing and Optimization

Intelligent image resizing constitutes a critical component of the system's performance optimization strategy. The resizing algorithm maintains aspect ratios while reducing computational requirements for large images. The system calculates optimal dimensions based on a maximum size constraint of 2000 pixels, applying proportional scaling to ensure visual quality preservation.

The resizing logic implements a sophisticated approach that identifies the longer dimension and scales the image proportionally. For landscape-oriented images, the width is constrained to the maximum size while the height is calculated proportionally. Portrait-oriented images undergo height constraint with proportional width calculation. This approach ensures optimal utilization of the available pixel budget while maintaining the image's original proportions.

The system utilizes the LANCZOS resampling algorithm through PIL's resize function, which provides superior quality compared to simpler interpolation methods. This high-quality resampling technique minimizes artifacts and maintains edge sharpness even when significant size reductions are required. The implementation includes fallback mechanisms that handle edge cases such as extremely small images or unusual aspect ratios.

6.3 Caching and Performance Optimization

The application incorporates Streamlit's caching mechanism to optimize performance for repeated operations on identical images. The `@st.cache_data` decorator enables intelligent caching of processed results, preventing redundant AI model execution when users upload the same image multiple times. This optimization significantly improves response times and reduces computational overhead.

The caching system implements content-based cache keys that ensure cache hits only occur for truly identical images while preventing false matches. The implementation includes appropriate cache invalidation mechanisms that maintain system accuracy while maximizing performance benefits. The cache size and retention policies are optimized to balance memory usage with performance improvements.

Performance monitoring capabilities provide real-time feedback on processing times, enabling users to understand the expected completion timeframes for their uploads. The system displays progress indicators and status updates throughout the processing pipeline, maintaining user engagement and providing transparency regarding system operations.

6.4 Error Handling and User Feedback

Comprehensive error handling ensures system reliability and provides meaningful feedback to users when issues occur. The application implements multiple layers of error detection and recovery, including file validation errors, processing failures, memory limitations, and network connectivity issues. Each error condition triggers appropriate user notifications with clear explanations and suggested remediation steps.

The system includes detailed logging capabilities that capture processing information for debugging and system optimization purposes. Error logs include sufficient detail to enable rapid issue diagnosis while maintaining user privacy by avoiding the storage of actual image content. The logging system implements appropriate rotation and retention policies to manage storage requirements.

User feedback mechanisms provide continuous status updates throughout the processing pipeline. Progress bars indicate completion percentages while status text provides descriptive information about current operations. Processing time estimates help users understand expected completion timeframes, particularly for larger images that require more computational resources.

7 Features and Capabilities

7.1 Automatic Background Detection and Removal

The core functionality of the application centers on its sophisticated automatic background detection and removal capabilities. Unlike traditional tools that require manual selection and tracing, this system analyzes the entire image content using advanced AI algorithms to identify the primary subject matter automatically. The U^2-Net architecture enables the system to understand complex visual relationships and distinguish between foreground subjects and background elements with remarkable accuracy.

The automatic detection system excels in handling challenging scenarios that typically pose difficulties for manual methods. Complex subjects featuring intricate details such as hair, fur, feathers, or transparent elements are processed with precision that often exceeds manual selection quality. The AI model's training on diverse datasets enables it to recognize and properly segment a wide variety of subject types including people, animals, objects, and complex multi-element compositions.

The removal process generates high-quality alpha masks that preserve fine details while maintaining sharp, clean edges. The system's ability to handle semi-transparent elements and fine details results in professional-quality output suitable for commercial

applications. The transparent background output enables seamless integration into various design contexts and eliminates the need for additional editing to remove artifacts or rough edges commonly associated with manual selection methods.

7.2 Multi-Format Support and Conversion

The application provides comprehensive support for multiple image formats, accepting uploads in PNG, JPG, and JPEG formats to accommodate various user workflows and source image types. The system automatically handles format conversion as required, ensuring that output images utilize the PNG format to support transparency information essential for background-removed images.

Format conversion capabilities include intelligent handling of color space differences and compression artifacts that may be present in source images. The system preserves image quality throughout the conversion process while optimizing file sizes for efficient download and storage. Quality preservation algorithms ensure that the final output maintains the visual fidelity of the original image while incorporating the transparent background functionality.

The automatic format detection and conversion process eliminates user confusion regarding compatible formats and output requirements. Users can upload images in their preferred format without concerning themselves with technical compatibility issues or format conversion procedures. The system's intelligent handling of format requirements streamlines the user experience while maintaining technical correctness and quality standards.

7.3 User Interface and Experience Design

The application's user interface prioritizes simplicity and efficiency while maintaining professional appearance and functionality. The Streamlit framework enables the creation of an intuitive interface that requires no prior technical knowledge or image editing experience. The clean, uncluttered design focuses user attention on essential functions while providing clear visual feedback and guidance throughout the processing workflow.

The side-by-side comparison display enables users to immediately evaluate the quality and accuracy of the background removal results. Original and processed images are presented with appropriate scaling and alignment to facilitate easy comparison and quality assessment. This immediate visual feedback empowers users to make informed decisions regarding the acceptability of the results and the need for alternative processing approaches.

Interactive elements including progress indicators, status updates, and download buttons provide clear feedback regarding system operations and available user actions. The interface design accommodates various screen sizes and devices, ensuring accessibility across desktop computers, tablets, and mobile devices. Responsive design principles ensure optimal user experience regardless of the access method or device capabilities.

7.4 Download and Export Functionality

The integrated download functionality provides immediate access to processed images through Streamlit's built-in download button widget. The system automatically prepares processed images in PNG format with appropriate metadata and quality settings

optimized for various use cases. Download preparation includes compression optimization that balances file size with image quality to ensure efficient transfer and storage.

The export process includes automatic filename generation with descriptive naming conventions that help users organize and identify processed images. The system maintains appropriate file naming standards while avoiding conflicts and ensuring cross-platform compatibility. Users can modify filenames as needed while maintaining proper file extensions and format compatibility.

Quality assurance mechanisms verify the integrity and completeness of download packages before presenting them to users. The system includes error recovery capabilities that handle network interruptions and download failures gracefully, providing users with clear feedback and retry options when necessary. Download statistics and completion confirmations provide users with confidence regarding successful file transfers.

8 Application Domains and Use Cases

8.1 E-commerce and Product Photography

The application provides significant value for e-commerce businesses requiring professional product photography with clean, consistent backgrounds. Online retailers often need to present products against white or transparent backgrounds to maintain visual consistency across their catalogs and comply with marketplace requirements. Traditional photography setups require controlled lighting environments and expensive equipment to achieve clean backgrounds, while post-processing with manual tools demands significant time and expertise.

This automated solution enables businesses to photograph products in natural environments and subsequently remove backgrounds automatically, significantly reducing studio setup requirements and processing time. The high-quality output ensures that product details, textures, and colors are preserved accurately while eliminating distracting background elements. This capability is particularly valuable for small businesses and individual sellers who lack access to professional photography studios or image editing expertise.

The system's ability to handle various product types including clothing with complex textures, electronics with reflective surfaces, and organic products with irregular shapes makes it suitable for diverse e-commerce applications. Batch processing capabilities enable efficient handling of large product catalogs, while consistent output quality ensures visual coherence across entire product ranges.

8.2 Social Media and Content Creation

Social media content creators benefit significantly from the application's ability to produce professional-quality images suitable for profile pictures, promotional content, and creative compositions. The removal of distracting backgrounds enables creators to focus viewer attention on the primary subject while maintaining visual appeal and professional presentation standards.

The system's speed and ease of use make it particularly valuable for content creators who require rapid turnaround times and frequent image processing. The ability to process images without requiring specialized software or technical expertise democratizes access to professional-quality image editing capabilities. This accessibility enables creators to

maintain consistent visual quality across their content while reducing production time and costs.

Creative applications include the ability to composite subjects into new backgrounds, create artistic effects, and produce content for various social media platforms with different aesthetic requirements. The transparent background output provides maximum flexibility for subsequent creative editing and composition work.

8.3 Professional Design and Marketing

Marketing professionals and graphic designers utilize the application to create promotional materials, advertisements, and marketing collateral that require clean subject isolation and professional presentation. The ability to extract subjects from their original contexts enables creative freedom in composition and design while maintaining photographic realism and quality.

The system's reliability and consistency make it suitable for professional workflows where quality standards are paramount. The automated processing eliminates the variability associated with manual selection techniques while ensuring reproducible results across multiple images and projects. This consistency is particularly valuable for brand management and maintaining visual coherence across marketing campaigns.

Integration capabilities with existing design workflows enable seamless incorporation of processed images into professional design applications. The high-quality PNG output with proper transparency support ensures compatibility with professional design software while maintaining the flexibility required for complex compositions and layouts.

9 Technical Performance and Optimization

9.1 Processing Speed and Efficiency

The application achieves impressive processing speeds through a combination of optimized algorithms, intelligent preprocessing, and efficient resource management. Processing times typically range from a few seconds for standard images to under a minute for complex, high-resolution uploads. The automatic resizing feature ensures that processing time remains reasonable even for very large images while maintaining output quality appropriate for most applications.

Performance optimization techniques include memory management strategies that prevent system overload during peak usage periods. The system monitors resource utilization and implements appropriate throttling mechanisms to maintain responsiveness while handling multiple concurrent users. Cache utilization reduces processing time for repeated operations while minimizing computational overhead.

The underlying U^2-Net model's optimization for background removal tasks ensures efficient utilization of computational resources compared to general-purpose AI models. Model inference optimizations including batch processing capabilities and hardware acceleration support contribute to overall system performance and user experience quality.

9.2 Quality Assurance and Validation

Comprehensive quality assurance mechanisms ensure consistent, high-quality output across diverse image types and processing scenarios. The system implements multiple valida-

tion checkpoints throughout the processing pipeline to detect and handle potential quality issues before they affect the final output. Quality metrics include edge sharpness assessment, segmentation accuracy evaluation, and artifact detection algorithms.

Automated quality assessment algorithms analyze processed images for common issues such as incomplete background removal, edge artifacts, and transparency problems. When quality issues are detected, the system provides appropriate user feedback and may suggest alternative processing approaches or manual refinement techniques.

The validation process includes compatibility verification to ensure that output images meet standard requirements for transparency support and format compliance. Cross-platform compatibility testing ensures that processed images display correctly across various applications and operating systems.

9.3 Scalability and Resource Management

The system architecture incorporates scalability considerations that enable efficient handling of varying user loads and processing demands. Resource management algorithms monitor system utilization and implement appropriate allocation strategies to maintain performance during peak usage periods. Memory management techniques prevent resource exhaustion while maintaining processing capability for large images.

Load balancing mechanisms distribute processing tasks efficiently across available computational resources to minimize wait times and maximize system throughput. The stateless design of the application enables horizontal scaling capabilities when additional capacity is required to handle increased user demand.

Monitoring and analytics capabilities provide insights into system performance, user patterns, and resource utilization trends. This information enables proactive optimization and capacity planning to ensure continued system reliability and performance as usage grows.

10 Conclusion

The Intelligent Image Background Removal Tool represents a significant advancement in accessible AI-powered image processing technology. By combining state-of-the-art deep learning algorithms with an intuitive web-based interface, the application successfully addresses the fundamental limitations of traditional background removal methods while delivering professional-quality results that meet the demands of diverse user communities.

The system's automated approach eliminates the technical barriers that have historically prevented non-expert users from achieving high-quality background removal results. The integration of the U²-Net architecture through the rembg library provides accuracy and reliability that often exceeds manual selection techniques while requiring no user expertise or time investment beyond simple file upload operations.

The comprehensive technology stack incorporating Streamlit, PIL, and NumPy creates a robust foundation for reliable operation and future enhancement. The web-based architecture ensures universal accessibility while the intelligent optimization features maintain performance and usability across various device types and network conditions. The application's design principles prioritize user experience without compromising technical capability or output quality.

Future development opportunities include the integration of additional AI models for

specialized use cases, batch processing capabilities for high-volume applications, and enhanced customization options for professional users. The modular architecture facilitates the incorporation of new features and improvements while maintaining system stability and user experience quality.

The project demonstrates the potential for AI technology to democratize access to sophisticated image processing capabilities, enabling users across various industries and skill levels to achieve professional results with minimal effort and investment. The success of this implementation provides a foundation for continued innovation in automated image processing and AI-powered creative tools.

11 Code Implementation

Listing 1: Complete Application Implementation

```
import streamlit as st
from rembg import remove
from PIL import Image
import numpy as np
from io import BytesIO
import base64
import os
import traceback
import time

st.set_page_config(layout="wide", page_title="Image␣Background␣
    Remover")

st.write("##␣Remove␣background␣from␣your␣image")
st.sidebar.write("##␣Upload␣and␣download␣:gear:")

# Increased file size limit
MAX_FILE_SIZE = 10 * 1024 * 1024  # 10MB

# Max dimensions for processing
MAX_IMAGE_SIZE = 2000  # pixels

# Download the fixed image
def convert_image(img):
    buf = BytesIO()
    img.save(buf, format="PNG")
    byte_im = buf.getvalue()
    return byte_im

# Resize image while maintaining aspect ratio
def resize_image(image, max_size):
    width, height = image.size
    if width <= max_size and height <= max_size:
        return image

    if width > height:
```

```
        new_width = max_size
        new_height = int(height * (max_size / width))
    else:
        new_height = max_size
        new_width = int(width * (max_size / height))

    return image.resize((new_width, new_height), Image.LANCZOS)

@st.cache_data
def process_image(image_bytes):
    """Process image with caching to avoid redundant processing"""
    try:
        image = Image.open(BytesIO(image_bytes))
        # Resize large images to prevent memory issues
        resized = resize_image(image, MAX_IMAGE_SIZE)
        # Process the image
        fixed = remove(resized)
        return image, fixed
    except Exception as e:
        st.error(f"Error processing image: {str(e)}")
        return None, None

def fix_image(upload):
    try:
        start_time = time.time()
        progress_bar = st.sidebar.progress(0)
        status_text = st.sidebar.empty()

        status_text.text("Loading image...")
        progress_bar.progress(10)

        # Read image bytes
        if isinstance(upload, str):
            # Default image path
            if not os.path.exists(upload):
                st.error(f"Default image not found at path: {upload}")
                return
            with open(upload, "rb") as f:
                image_bytes = f.read()
        else:
            # Uploaded file
            image_bytes = upload.getvalue()

        status_text.text("Processing image...")
        progress_bar.progress(30)

        # Process image (using cache if available)
        image, fixed = process_image(image_bytes)
        if image is None or fixed is None:
```

```
            return

        progress_bar.progress(80)
        status_text.text("Displaying␣results...")

        # Display images
        col1.write("Original␣Image␣:camera:")
        col1.image(image)

        col2.write("Fixed␣Image␣:wrench:")
        col2.image(fixed)

        # Prepare download button
        st.sidebar.markdown("\n")
        st.sidebar.download_button(
            "Download␣fixed␣image",
            convert_image(fixed),
            "fixed.png",
            "image/png"
        )

        progress_bar.progress(100)
        processing_time = time.time() - start_time
        status_text.text(f"Completed␣in␣{processing_time:.2f}␣
           seconds")

    except Exception as e:
        st.error(f"An␣error␣occurred:␣{str(e)}")
        st.sidebar.error("Failed␣to␣process␣image")
        # Log the full error for debugging
        print(f"Error␣in␣fix_image:␣{traceback.format_exc()}")

# UI Layout
col1, col2 = st.columns(2)
my_upload = st.sidebar.file_uploader("Upload␣an␣image",
                                     type=["png", "jpg", "jpeg"])

# Information about limitations
with st.sidebar.expander("      ␣Image␣Guidelines"):
    st.write("""
␣␣␣␣-␣Maximum␣file␣size:␣10MB
␣␣␣␣-␣Large␣images␣will␣be␣automatically␣resized
␣␣␣␣-␣Supported␣formats:␣PNG,␣JPG,␣JPEG
␣␣␣␣-␣Processing␣time␣depends␣on␣image␣size
␣␣␣␣""")

# Process the image
if my_upload is not None:
    if my_upload.size > MAX_FILE_SIZE:
        st.error(f"The␣uploaded␣file␣is␣too␣large.␣Please␣upload␣
           an␣image␣smaller␣than␣{MAX_FILE_SIZE/1024/1024:.1f}MB.
```

```
            ")
    else:
        fix_image(upload=my_upload)
else:
    # Try default images in order of preference
    default_images = ["./zebra.jpg", "./wallaby.png"]
    for img_path in default_images:
        if os.path.exists(img_path):
            fix_image(img_path)
            break
    else:
        st.info("Please upload an image to get started!")
```