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AI-Based Image Background Removal

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ABSTRACT: Background removal is a fundamental task in image processing and computer vision, widely used in applications such as photo editing, e-commerce, and digital media. Traditional methods often require manual effort or server-side processing, leading to increased latency and privacy concerns. This paper presents an AI-based background removal system using deep learning techniques implemented entirely on the client side. The proposed system utilizes open-source models, namely MODNet and RMBG, for accurate foreground extraction. These models are converted into a browser-compatible format using TensorFlow.js and ONNX, enabling real-time execution directly in the frontend without the need for a backend server. The system allows users to upload images and perform background removal within a few seconds while maintaining high-quality output. Experimental results demonstrate that the proposed approach ensures efficient processing, improved data privacy, and reduced dependency on external APIs. The system effectively handles complex backgrounds and preserves fine object details, making it suitable for real-world applications. Future work includes optimizing model performance for low-end devices and extending support for real-time video processing.

Keywords — Deep Learning, Background Removal, Image Processing, Image Matting, MODNet, RMBG, Frontend AI, Real-Time Processing.

I. INTRODUCTION

Background removal is a fundamental task in the field of image processing and computer vision, which involves separating the foreground object from the background of an image. It plays a crucial role in various real-world applications such as photo editing, e-commerce product visualization, virtual meetings, and digital content creation. Accurate background removal becomes challenging when dealing with complex scenes, fine object details such as hair, or varying lighting conditions. Traditional approaches for background removal often rely on manual editing or classical image processing techniques, which are time-consuming and less effective in handling complex images. With the advancement of Artificial Intelligence (AI) and deep learning, automated methods have been developed to improve accuracy and efficiency. In particular, convolutional neural networks (CNNs) and image matting techniques have shown significant improvements in extracting foreground objects with high precision.

Recent research has focused on developing deep learning-based models such as MODNet and other matting approaches that can perform real-time background removal with better edge preservation and fine detail extraction. However, many existing systems depend on backend servers or external APIs for processing, which can introduce latency, increase computational costs, and raise privacy concerns related to user data.

In this paper, we propose an AI-based background removal system using deep learning techniques that operates entirely on the client side. The proposed system utilizes open-source models, including MODNet and RMBG, and executes them directly in the browser using TensorFlow.js after converting them into a compatible format. This eliminates the need for backend processing and enhances user privacy and system efficiency. The system is capable of generating high-quality

output within a few seconds and can handle complex backgrounds effectively.

II. LITERATURE REVIEW

Several deep learning-based approaches have been proposed for image matting and background removal in recent years, significantly improving the accuracy and efficiency of foreground extraction tasks.

In [1], a deep learning-based image matting method is introduced using a convolutional neural network (CNN) with an encoder-decoder architecture. The model predicts the alpha matte directly from the input image and trimap, enabling accurate foreground extraction even in complex scenarios.

In [2], a context-aware image matting technique is proposed that combines both local and global feature extraction using a dual-encoder network. This approach improves the quality of foreground and alpha estimation by leveraging contextual information.

Furthermore, in [3], a deep propagation-based image matting framework is presented, which integrates deep learning with pixel affinity propagation. This method enhances semantic-level similarity between pixels, leading to improved matting performance.

In [4], a high-resolution image matting approach is proposed to handle large-scale images using a patch-based strategy. The method maintains consistency across image patches and achieves high-quality results in real-world scenarios.

However, most existing methods rely on backend processing or require significant computational resources, which can introduce latency and raise privacy concerns. To address these limitations, the proposed system utilizes lightweight open-source models such as MODNet and RMBG, executed directly in the browser using TensorFlow.js. This approach eliminates the need for server-side processing while ensuring real-time performance and enhanced data privacy.

III. PROPOSED METHODOLOGY

A. System Overview

The proposed system is an AI-based background removal application that utilizes deep learning techniques to separate the foreground object from an image. The system is designed to operate entirely on the client side without relying on any backend server. It leverages open-source models such as MODNet and RMBG to achieve accurate and high-quality background removal. The implementation is performed using TensorFlow.js, enabling real-time processing directly in the browser.

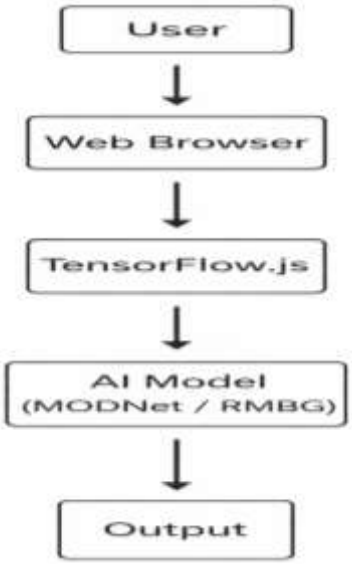

Fig 1. Overall System Architecture

B. Input Image Processing

The system allows users to upload an image through a web-based interface. Once the image is uploaded, it undergoes preprocessing steps such as resizing and normalization to ensure compatibility with the deep learning models. These steps help improve the efficiency and accuracy of the background removal process.

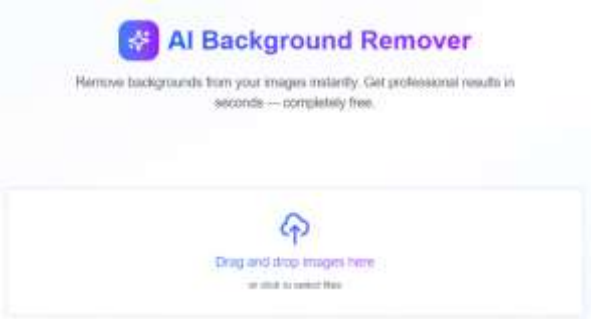

Fig 2. Input Image

C. AI Models for Background Removal

The proposed system utilizes two deep learning-based models: MODNet and RMBG. These models are designed for image matting and foreground extraction tasks. MODNet focuses on preserving fine details such as hair and edges, while RMBG provides efficient and fast background removal. Both models are capable of handling complex backgrounds and generating high-quality outputs.

D. Frontend-Based Model Execution

Unlike traditional systems that rely on backend servers, the proposed approach executes the models entirely on the frontend. The pre-trained models are converted into browser-compatible formats using ONNX and TensorFlow.js. This enables direct execution within the browser environment, eliminating the need for server-side processing. As a result, the system ensures improved data privacy, reduced latency, and enhanced performance.

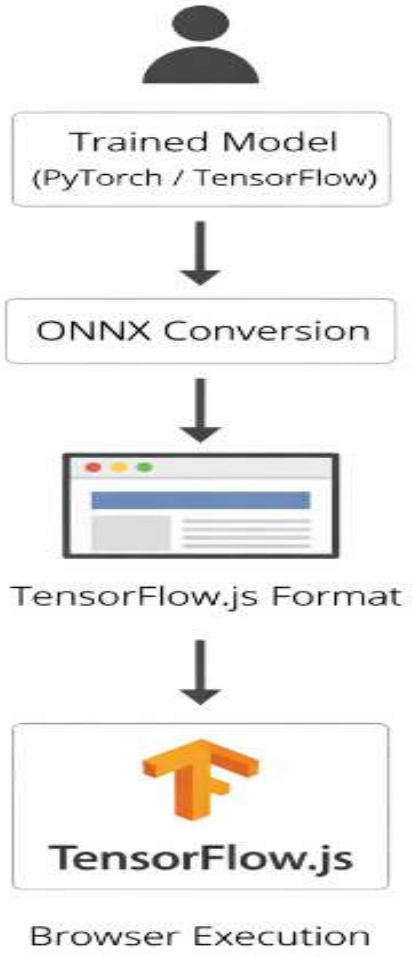

Fig 3. Model Conversion and Execution Flow

E. Background Removal Process

After preprocessing, the input image is passed to the selected deep learning model (MODNet or RMBG). The model processes the image and generates an alpha mask that separates the foreground from the background. Based on this mask, the background is removed, and the foreground object is extracted with high precision.

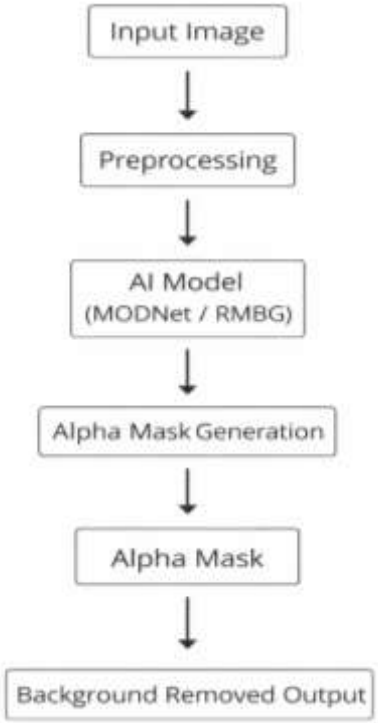

Fig 4. Background Removal Workflow

F. Output Generation

The final output is generated in the form of an image with the background removed. The system produces results within a few seconds while maintaining high visual quality. The output preserves fine object details and can be used in various applications such as image editing and digital media creation.

Fig 5. Before / After Result

G. System Workflow

The overall workflow of the proposed system can be summarized as follows:

Input Image → Preprocessing → AI Model (MODNet/RMBG) → Background Removal → Output Image

This workflow ensures efficient and real-time background removal without requiring backend processing.

IV. RESULTS AND DISCUSSION

The proposed AI-based background removal system was evaluated using multiple images with varying levels of background complexity. The system was tested on both simple and complex backgrounds, including images with fine details such as hair and irregular object boundaries. The results indicate that the system effectively separates the foreground from the background while preserving important visual details.

The output generated by the system demonstrates high-quality foreground extraction with minimal loss of edge details. The use of deep learning models such as MODNet and RMBG enables accurate segmentation and improves the overall visual quality of the output images. The system performs well even in challenging scenarios involving complex textures and lighting conditions.

The processing time of the proposed system is efficient, with results generated within a few seconds. Since the entire computation is performed on the client side using TensorFlow.js, the system supports real-time background removal without requiring backend processing. This significantly reduces latency and improves user experience.

One of the key advantages of the proposed approach is enhanced data privacy. Unlike traditional systems that rely on server-side processing or external APIs, the proposed system processes images directly in the browser. This eliminates the need to upload user data to external servers, ensuring better security and privacy.

Table 1 presents a comparison between traditional methods and the proposed approach, demonstrating improvements in processing time and output quality.

However, the system may experience performance limitations on low-end devices due to the computational requirements of running deep learning models in the browser. Despite this limitation, the proposed system provides an efficient and practical solution for real-time background removal with high accuracy and improved privacy.

Table 1. Performance comparison of Background Removal Methods

Method	Processing Time	Output Quality	Backend Required
Traditional Method	High	Low	Yes
MODNet	Medium	High	No
RMBG	Low	High	No

V. CONCLUSION

In this paper, an AI-based background removal system using deep learning techniques has been presented. The proposed system utilizes open-source models such as MODNet and RMBG to achieve accurate and efficient foreground extraction. Unlike traditional approaches, the system operates entirely on the client side using TensorFlow.js, eliminating the need for backend processing and external APIs. The results demonstrate that the system is capable of producing high-quality output while preserving fine details such as edges and hair regions. The processing time is low, and the system is suitable for real-time applications. Additionally, the client-side execution enhances data privacy and reduces latency, making the system more secure and efficient. Overall, the proposed approach provides a practical and effective solution for background removal in various real-world applications such as image editing and digital content creation. Future work can focus on optimizing the model for low-end devices and extending the system to support real-time video background removal.

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