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AI Embedded QR Code Generator and Decoder

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Abstract – *This research paper presents the design, implementation, and integration of an enhanced QR code system that not only generates and decodes QR codes from diverse data inputs but also embeds these QR codes within AI-generated artistic images. The project has two major features: first, a robust QR code application that handles multiple data types—including text, URLs, emails, WiFi credentials, and contact information—and provides accurate decoding from images; and second, an advanced AI module that leverages deep learning models (Stable Diffusion with ControlNet) to generate artistic images that incorporate scannable QR codes. This integrated approach enhances both the functional and aesthetic aspects of QR code usage, broadening the application range from secure data sharing to creative marketing solutions.*

Key Words*: *QR Code, Stable Diffusion, ControlNet, AI-Generated Images, Computer Vision.

1.INTRODUCTION

QR codes have become a ubiquitous tool for encoding and sharing information in today's digital landscape. Traditional QR codes are widely used for simple tasks such as encoding text, URLs, emails, WiFi credentials, and contact information. However, as the demand for enhanced functionality and creative presentation grows, there is an opportunity to expand the role of QR codes beyond their conventional uses.

This project is about developing an all-in-one QR code system that provides two major functionalities:

A. Standard QR Code Generation and Decoding:

Users can generate QR codes from a variety of inputs such as text, URLs, emails, WiFi configurations, and contact details. The system decodes QR codes from uploaded images, ensuring that data is accurately retrieved even after undergoing preprocessing steps. Customization options, such as color selection, allow for a personalized user experience.

B. AI-Embedded QR Code Generation:

By integrating state-of-the-art image synthesis models, the project embeds QR codes into AI-generated images. The use of Stable Diffusion, a text-to-image model, in combination with ControlNet—a tool for guiding image generation—ensures that the artistic modifications do not compromise the scannability of the QR code. This feature opens up new possibilities in creative marketing and secure data sharing by blending functionality with visual appeal.

2.REVIEW OF LITERATURE

A. QR Code Technology

QR codes were invented in 1994 by Denso Wave to improve data storage and rapid scanning capabilities. Over time, they have been adopted for diverse applications ranging from industrial use to marketing and secure data sharing. Python libraries such as qrcode and pyzbar have simplified QR code generation and decoding, respectively.

B. Computer Vision and Image Processing

Advanced computer vision techniques, particularly through libraries like OpenCV, facilitate accurate detection and preprocessing of QR codes. These techniques ensure that QR codes remain scannable even when incorporated into images with varying quality and complexity.

C. Deep Learning and AI-Generated Images

Diffusion models, such as Stable Diffusion, have transformed the field of text-to-image synthesis by iteratively reducing noise to generate high-quality images from textual prompts. ControlNet further enhances this process by imposing additional constraints (like structural outlines) that help maintain essential features—such as the scannable structure of QR codes—within the generated images. The specialized QR Code Monster model, available from Hugging Face, is integrated to ensure that the artistic augmentation does not compromise the QR code functionality.

D. NLP and Transformer Models:

The incorporation of Natural Language Processing (NLP) via transformer models (from Hugging Face) assists in accurately processing and generating text-based prompts. This aids in both the generation of QR codes from diverse inputs and the effective synthesis of image content that complements the QR code structure.

3.PROBLEM STATEMENT

Traditional QR code systems, while efficient for data encoding and decoding, offer limited aesthetic flexibility and are not designed to incorporate complex, creative data presentations.

There exists a gap in current technologies for combining the practicality of QR codes with the visual appeal and enhanced functionality offered by AI-generated imagery. The challenge is to develop an integrated system that maintains QR code functionality across varied input types while enabling creative customization through AI-driven image synthesis.

4. OBJECTIVES

A. Develop a Comprehensive QR Code Application:

Enable users to generate QR codes from multiple input formats (text, URLs, emails, WiFi credentials, and contact information). Provide robust decoding functionality that processes and extracts data from QR codes in uploaded images.

B. Integrate AI-Driven Image Synthesis:

Utilize Stable Diffusion for high-quality text-to-image synthesis. Implement the ControlNet extension to condition the image generation process, ensuring that QR codes remain scannable while being artistically enhanced.

C. Optimize Image Processing and User Experience:

Employ computer vision techniques for effective image preprocessing. Develop an intuitive front-end interface using Streamlit, enabling easy customization and seamless integration of both traditional and AI-enhanced QR code features.

5. PROPOSED SYTEM AND METHODOLOGY

A. QR Code Generation and Decoding Module:

This module is designed to handle a variety of data inputs:

- Data Input Handling: Users can select from text, URL, email, WiFi, and contact information options. For instance, email QR codes are generated using a "mailto" format that includes subject and body, while contact details are formatted as a vCard.
- QR Code Generation: The system uses the qrcode Python library to generate QR codes with customization options (e.g., color).
- QR Code Decoding: Images uploaded by users are processed using OpenCV and decoded using pyzbar, ensuring reliable data extraction.of resumes in pdf format for shortlisting applications.

B. AI-Embedded QR Code Module:

This module leverages deep learning to blend functionality with creativity:

- Stable Diffusion Integration: The text-to-image model generates artistic images from user-provided prompts.
- ControlNet Extension: By conditioning the generation on the input QR code, ControlNet maintains the QR code's structural integrity while allowing for creative modifications.
- QR Code Monster Model: A specialized model from Hugging Face fine-tunes the balance between artistic enhancement and scannability.
- User Interaction: Through an intuitive Streamlit interface, users upload their QR code image, input an artistic prompt, and adjust parameters (like control weight and high-resolution settings) to generate the final AI-enhanced image.

C. Front-End Interface:

- Streamlit Interface: The user-friendly interface consolidates QR code generation, decoding, and AI-embedded image generation, providing a cohesive experience.

6.IMPLEMENTATION

A. Software and Libraries:

- Backend: Python (with libraries such as qrcode, numpy, OpenCV, pyzbar, and Hugging Face transformers).
- Front-End: Streamlit for developing an interactive web application.
- AI Modules: Stable Diffusion and ControlNet (using an open-source web UI like Automatic1111's implementation).

B. Workflow:

- QR Code Generation: Users select the input type (text, URL, email, WiFi, or contact). The system generates a customized QR code and offers an option to download the image.
- QR Code Decoding: Users upload an image containing a QR code. The system preprocesses and decodes the image to extract the embedded data.
- AI-Enhanced QR Code Generation: Users upload a QR code image and specify an artistic prompt. Using Stable Diffusion with ControlNet, the system generates an image that creatively embeds the QR code while ensuring it remains scannable.

C. Flow Diagram:

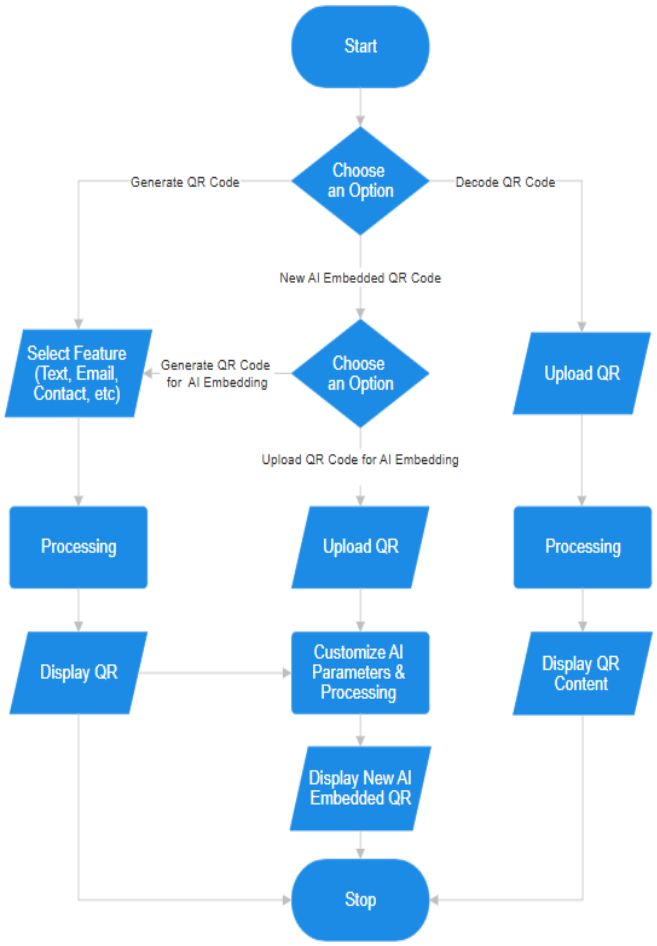

Fig - 1: Flow of the Project

D. Results

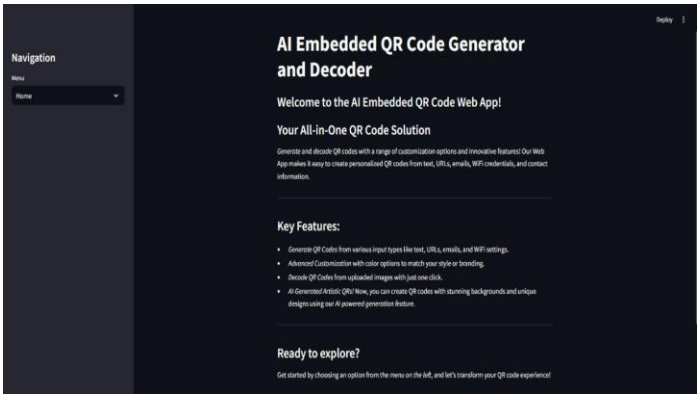

Fig - 2: Home Page

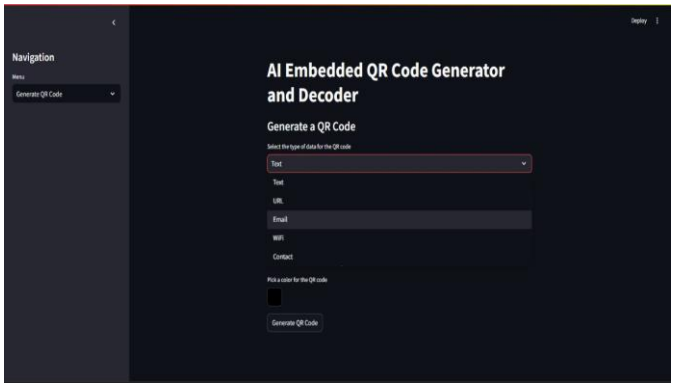

Fig - 3: Generate QR Code Page

Fig - 4: Decode QR Code Page

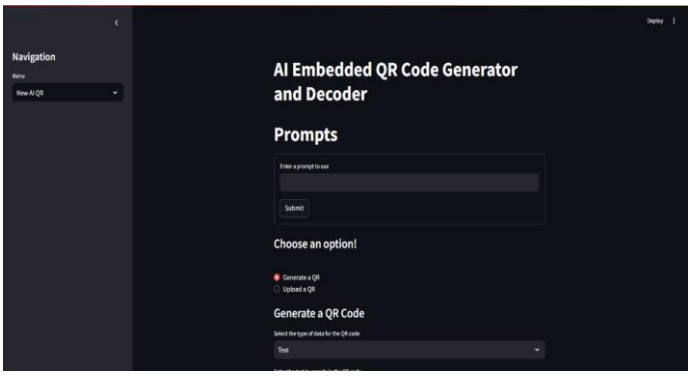

Fig - 5: New AI QR Code Page

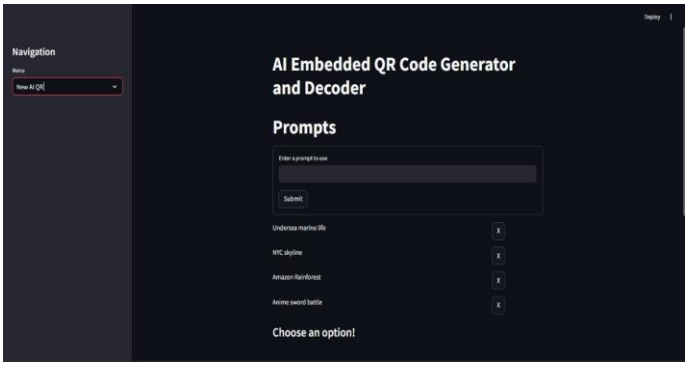

Fig - 6: AI Personalized Prompts

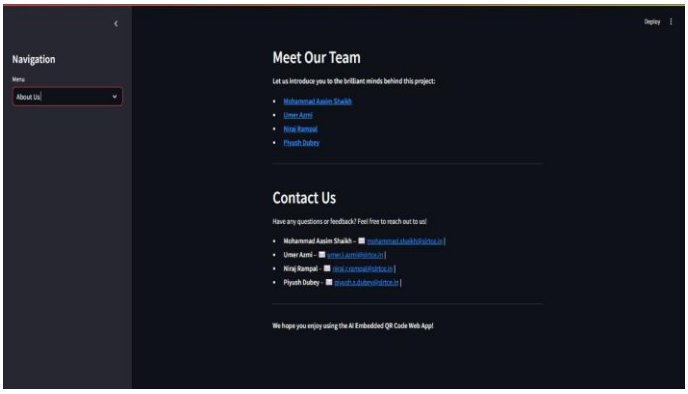

Fig - 7: About Page

7. CHALLENGES AND SOLUTIONS

A. Handling Diverse Data Inputs

To support multiple data formats, custom parsing functions were implemented for text, URLs, emails, WiFi, and contact details, ensuring proper formatting for QR code generation.

B. Ensuring Image Quality and QR Code Integrity

High-resolution image generation and precise parameter tuning (using preprocessing, denoising, and control weight adjustments) were necessary to maintain the balance between artistic creativity and functional QR code structure.

C. Balancing Artistic Enhancement with Functionality

ControlNet parameters (control weight, starting and ending control steps) were carefully calibrated to ensure that while the generated images are visually appealing, the QR code's scannable integrity is preserved.

D. User Interface Usability

An intuitive and responsive interface was developed with Streamlit, incorporating user feedback to ensure accessibility and ease of navigation for both technical and non-technical users.

8. CONCLUSIONS

This project demonstrates the successful integration of traditional QR code functionalities with advanced AI-driven image synthesis. By combining a versatile QR code generator/decoder with the creative capabilities of Stable Diffusion and ControlNet, the system enhances both utility and visual appeal. This dual approach can be applied in various fields—from secure data sharing and creative marketing to innovative communication channels.

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