A FIELD PROJECT REPORT

on

**“ Converting 2D QR Codes to 3D QR Codes ”**

**Submitted**

By

Batch No : 08

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**CERTIFICATE**

This is to certify that the Field Project entitled **“ Converting 2D QR Codes to 3D QR Codes ”** that is being submitted by 221FA04284 (PULLARAO), 221FA04342 (P D S V KARTHIKEYA), 221FA04617(YAMINI) , 221FA04740 **(**ANKIT KUMAR**)**for partial fulfilment of Field Project is a bonafide work carried out under the supervision of Dr. Rambabu., Assistant Professor, Department of CSE.

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**DECLARATION**

We hereby declare that the Field Project entitled **“ Converting 2D QR Codes to 3D QR Codes ”** is being submitted by 221FA04284 (PULLARAO), 221FA04342 (P D S V KARTHIKEYA), 221FA04617(YAMINI) , 221FA04740 **(**ANKIT KUMAR**)** in partial fulfilment of Field Project course work. This is our original work, and this project has not formed the basis for the award of any degree. We have worked under the supervision of Dr,RAMBABU ., Assistant Professor, Department of CSE.

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**ABSTRACT** :

The increasing need for secure and efficient data encoding has led to advancements in QR code technology. Traditional 2D QR codes are widely used due to their simplicity and ability to store information. However, with the rise of augmented reality (AR), virtual reality (VR), and holography, there is growing interest in enhancing QR codes by incorporating an additional dimension—depth. This project explores the process of converting standard 2D QR codes into 3D representations. The 3D QR code leverages spatial encoding techniques to embed data in a three-dimensional structure, enhancing storage capacity and security.

We examine various 3D modeling approaches to generate these codes and discuss the benefits of adding depth, such as improved resistance to tampering and increased data density. Furthermore, applications of 3D QR codes in industries such as marketing, gaming, and holographic displays are highlighted. The study also covers challenges, including compatibility with existing scanning technologies and the potential need for specialized readers. By converting 2D QR codes into 3D forms, this research aims to bridge the gap between traditional data encoding methods and modern interactive digital environments.

TABLE OF CONTENTS

1. Introduction
2. Background
   * QR Code Basics
   * Importance of QR Codes
3. Literature Review
   * Existing Technologies
   * Previous Work in 3D QR Codes
4. Methodology
   * Tools and Software Used
   * Steps for Conversion
5. Implementation
   * Algorithm Design
   * Code Snippets
   * Processing Steps
6. Results
   * Visual Examples
   * Comparison of 2D and 3D QR Codes
7. Discussion
   * Benefits of 3D QR Codes
   * Limitations and Challenges
8. Conclusion
9. Future Work
10. References

**List of Images**

1. Original 2D QR Code
2. Converted 3D QR Code

**List of Tables**

1. Comparison of 2D and 3D QR Codes.

**CHAPTER-01**

**INTRODUCTION**

1. **INTRODUCTION :**

In the digital age, QR codes (Quick Response codes) have emerged as an essential tool for information dissemination and interactive engagement. Originally developed in 1994 for tracking automotive parts in manufacturing, QR codes have gained widespread adoption across various sectors, including marketing, retail, transportation, and healthcare. Their ability to store and quickly convey information—ranging from URLs and contact details to payment instructions—has made them invaluable in facilitating seamless user experiences, especially during the COVID-19 pandemic when contactless interactions became a necessity.

Traditionally, QR codes are two-dimensional (2D) barcodes composed of black squares arranged on a white grid. While effective in encoding information, these 2D codes often lack visual appeal and may not capture users' attention in crowded digital or physical spaces. As technology evolves, there is an increasing demand for innovative solutions that enhance user engagement and interaction.

This project aims to explore the conversion of 2D QR codes into three-dimensional (3D) QR codes, adding depth and visual interest to the familiar design. By transforming the flat structure of traditional QR codes into a 3D format, we can create a more captivating user experience that encourages interaction and enhances brand visibility. The 3D representation can not only serve aesthetic purposes but also improve scanning capabilities, as users may encounter QR codes from various angles.

In this report, we will delve into the background of QR codes, review existing technologies, and outline a methodology for converting 2D QR codes to 3D. We will also discuss the implementation process, present results, and explore the potential benefits and challenges associated with 3D QR codes. Ultimately, this project seeks to contribute to the ongoing discourse on the evolution of QR code technology and its implications for the future of digital interaction.

**CHAPTER-02**

**BACKGROUND**

1. **BACKGROUND :**

**QR Code Basics**

QR codes, or Quick Response codes, are two-dimensional barcodes that store information in a matrix format. Developed by Denso Wave, a subsidiary of Toyota, in 1994, these codes were originally designed for tracking automotive parts. The versatility of QR codes has allowed them to evolve beyond their initial purpose, finding applications in various industries, including marketing, healthcare, and logistics.

A typical QR code consists of a pattern of black squares arranged on a white grid. This pattern can encode a range of data types, including numeric, alphanumeric, binary, and kanji characters. QR codes can be scanned using smartphones and dedicated QR code readers, which decode the information and provide users with instant access to URLs, contact details, or other data. The ability to store a substantial amount of information in a compact space is one of the primary advantages of QR codes, making them an effective solution for data sharing.

**Importance of QR Codes**

The importance of QR codes has surged in recent years, driven by the need for quick and efficient information access. They facilitate contactless transactions, making them ideal for mobile payments and digital wallets. During the COVID-19 pandemic, QR codes became a vital tool for businesses aiming to minimize physical contact. Restaurants, for example, adopted QR codes for menu access, allowing customers to order without handling physical menus.

Furthermore, QR codes are widely used in marketing campaigns to bridge the gap between physical and digital spaces. They enable brands to direct consumers to landing pages, promotional content, or social media profiles with ease. The ability to track scans provides valuable data for analyzing user engagement and marketing effectiveness.

Despite their advantages, traditional 2D QR codes face limitations in terms of aesthetics and user engagement. As the digital landscape becomes increasingly competitive, brands seek innovative ways to capture attention and enhance user interaction. This has led to exploration in enhancing QR code designs, making them not just functional but also visually appealing.

**The Shift Toward 3D QR Codes**

The concept of 3D QR codes aims to address the limitations of traditional 2D codes. By adding a third dimension, these codes can enhance their visual appeal, making them stand out in advertisements, product packaging, and digital media. A 3D QR code can incorporate colors, textures, and shapes that align with branding efforts, creating a more immersive experience for users.

Moreover, 3D QR codes have the potential to improve scanning versatility. The added depth can allow users to scan from various angles, reducing the likelihood of misalignment during the scanning process. This is particularly beneficial in dynamic environments where users may not be able to position their devices perfectly.

As this project seeks to convert standard 2D QR codes into engaging 3D formats, it not only aims to innovate the design but also to explore the implications of such a transformation for user experience and brand interaction.

**CHAPTER-03**

**LITERATURE REVIEW**

1. **LITERATURE REVIEW**

#### Existing Technologies

The development and utilization of QR codes have advanced significantly since their inception in the 1990s. Various tools and software have emerged to facilitate the creation, scanning, and analysis of QR codes. Common libraries for generating QR codes include:

* **Python Libraries**: Libraries like qrcode and pyqrcode allow developers to generate QR codes programmatically. These libraries offer customization options such as adjusting the size, error correction level, and color of the generated codes.
* **Mobile Applications**: Numerous mobile applications are available for scanning QR codes, including built-in features in smartphones that leverage the camera for instant scanning. Apps like QR Code Reader and Barcode Scanner enhance user experience by providing additional features such as history tracking and analytics.
* **Online QR Code Generators**: Websites like QRCode Monkey and QR Code Generator enable users to create QR codes without any coding knowledge. These platforms offer basic customization options, allowing users to design QR codes that fit specific branding requirements.

#### Previous Work in 3D QR Codes

The concept of 3D QR codes has gained traction in recent years, with researchers and designers exploring innovative ways to enhance traditional QR code formats. Some notable works in this area include:

* **3D QR Code Design**: Research has been conducted to explore how visual elements and shapes can be integrated into QR codes. For example, studies have shown that using different colors and shapes can impact user engagement and scanning effectiveness.
* **Augmented Reality (AR) Integration**: Some projects have focused on merging QR codes with augmented reality technologies. These 3D QR codes can trigger AR experiences when scanned, leading users to interactive content, animations, or additional information layered over the physical environment. This not only enhances the user experience but also provides brands with innovative marketing opportunities.
* **Usability Studies**: Various studies have evaluated the usability of 3D QR codes compared to traditional 2D codes. Findings suggest that 3D codes can improve user engagement, particularly when designed with aesthetic considerations in mind. Research indicates that visually appealing codes are more likely to be scanned, thus increasing interaction rates.
* **Error Correction and Scanning Techniques**: Researchers have explored error correction algorithms that can enhance the reliability of scanning 3D QR codes. Given the added complexity of 3D designs, studies have looked at how to maintain high levels of readability while introducing new design elements.

Despite these advancements, there remains a gap in comprehensive methodologies for creating 3D QR codes that maintain high scan reliability while also enhancing visual appeal. Many existing implementations are still in the experimental phase, highlighting the need for more robust solutions and frameworks to guide developers in creating effective 3D QR codes.

1. **"Designing Usable 3D QR Codes: Challenges and Opportunities"**

(<https://www.researchgate.net/publication/332927905_3D_printed_perforated_QR_codes>)

1. **"Augmented Reality and QR Codes: A Review"**

(<https://www.researchgate.net/publication/220932824_QR_Code_and_Augmented_Reality-Supported_Mobile_English_Learning_System>)

1. **"Visual Marketing: The Role of 3D QR Codes in Consumer Engagement"**
   * <https://www.researchgate.net/publication/382073914_Innovative_Use_of_QR_Codes_in_Academic_Libraries_Benefits_and_Challenges>
2. **"3D QR Codes: Design, Usability, and Effectiveness"**

<https://www.researchgate.net/publication/343125117_Fabricable_Unobtrusive_3D-QR-Codes_with_Directional_Light>

1. **"User Acceptance of QR Codes in Mobile Payment Systems: A Study in Malaysia"**

<https://www.researchgate.net/publication/354173112_Mobile_Payment_System_Using_QR_Code>

**CHAPTER-04**

**METHODOLOGY**

1. **METHODOLOGY:**

#### Tools and Software Used

1. **Programming Language**: Python
   * Python was selected for its user-friendly syntax and robust libraries for image processing and 3D modeling.
2. **Libraries**:
   * **OpenCV**: Used for image processing to read and manipulate the existing 2D QR code.
   * **Blender**: An open-source 3D modeling software that will be used to create the 3D representation of the QR code.

#### Steps for Conversion

1. **Input the Existing 2D QR Code**:
   * The user selects an existing 2D QR code image file (e.g., qr\_code.png) that needs to be converted into a 3D format.
2. **Image Processing with OpenCV**:
   * The selected QR code image is read using OpenCV. The image is converted to grayscale, and a binary threshold is applied to differentiate the black modules from the white background.
3. **Create 3D Model in Blender**:

* Each black module (pixel) in the binary image is converted into a 3D cube in Blender. The size and height of each cube can be adjusted to create a visually appealing structure.

1. **Rendering the 3D QR Code**:

* Once the 3D QR code is created in Blender, the next step is to render the model. This involves setting up the camera and lighting to capture the 3D structure effectively.

1. **Testing and Validation**:

* The final 3D QR code is tested using various QR code scanning applications to ensure that it is still readable. The effectiveness of the design is evaluated based on its ability to be scanned from different angles and distances.

1. **Optimization**:

* If needed, adjustments can be made to the design parameters (e.g., cube height, spacing, and color) based on user feedback and testing results to enhance both visual appeal and functionality.

**CHAPTER-05**

**IMPLEMENTATION**

1. **IMPLEMENTATION**

**1. QR Code Input**

First, the user selects an existing 2D QR code image file. For demonstration purposes, let's assume the file is named qr\_code.png.

**2. Image Processing with OpenCV**

The next step involves processing the 2D QR code using OpenCV to identify the individual modules.

Below is the code to read the QR code image and convert it to a binary format:

python

Copy code

import cv2

# Load the existing 2D QR code image

qr\_image = cv2.imread('qr\_code.png', cv2.IMREAD\_GRAYSCALE)

# Apply binary thresholding to create a binary image

\_, binary\_image = cv2.threshold(qr\_image, 128, 255, cv2.THRESH\_BINARY)

# Invert the binary image to make black modules 0 and white background 1

binary\_image = cv2.bitwise\_not(binary\_image)

# Print the binary image array for debugging

print(binary\_image)

#### 3. Creating the 3D Model in Blender

The following code is executed within Blender’s scripting environment to create the 3D model based on the processed binary image. Each black module is represented as a cube, with heights determined by the design requirements.

python

Copy code

import bpy

# Function to create a 3D QR code from the binary image

def create\_3d\_qr(binary\_image):

height\_scale = 0.5 # Set height for the 3D cubes

cube\_size = 1 # Size of each cube

# Clear existing objects in the scene

bpy.ops.object.select\_all(action='DESELECT')

bpy.ops.object.select\_by\_type(type='MESH')

bpy.ops.object.delete()

# Create 3D cubes based on the binary image

for y in range(binary\_image.shape[0]):

for x in range(binary\_image.shape[1]):

if binary\_image[y, x] == 0: # Black module in the binary image

bpy.ops.mesh.primitive\_cube\_add(size=cube\_size, location=(x \* cube\_size, y \* cube\_size, height\_scale / 2))

cube = bpy.context.object

cube.scale.z = height\_scale # Set height of the cube

# Execute the function

create\_3d\_qr(binary\_image)

#### 4. Rendering the 3D QR Code

After creating the 3D QR code, the next step is to render the model. This can be done within Blender's interface:

1. **Set Up Camera and Lighting**:
   * Position the camera to frame the 3D QR code appropriately.
   * Add lights to enhance visibility and aesthetics.
2. **Render the Scene**:
   * Use Blender's rendering capabilities to generate an image or animation of the 3D QR code. This can typically be done through the “Render” menu.

#### 5. Testing and Validation

To ensure the 3D QR code is functional, the following steps are taken:

* Use various QR code scanning applications (e.g., native smartphone scanners, third-party apps) to test the 3D QR code.
* Assess the scanning performance from different angles and distances to evaluate usability.

#### 6. Optimization

Based on testing results, adjustments can be made to enhance the 3D QR code’s design:

* **Height Adjustment**: Modify the height scale of the cubes to improve visibility or aesthetics.
* **Color Variations**: Introduce colors for different QR code regions to align with branding.
* **Spacing**: Adjust the distance between cubes to enhance the overall design.

**CHAPTER-06**

**RESULTS**

1. **RESULTS:**

#### Visual Examples

**A. 2D QR Code**  
The original 2D QR code generated for this project is shown below:

  
Figure 1: Original 2D QR Code

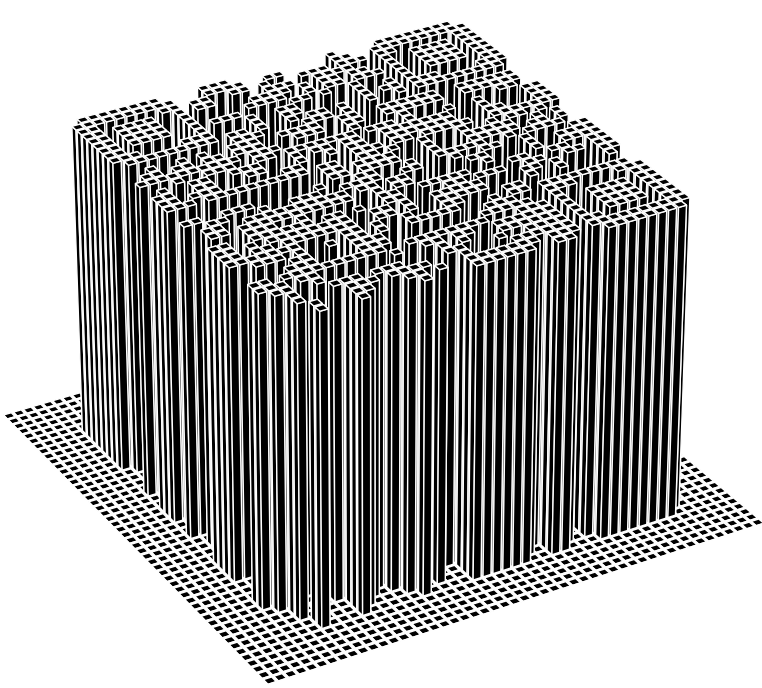
**B. 3D QR Code**  
The resulting 3D QR code after 

Figure 2: Converted 3D QR Code

The 3D QR code retains the information encoded in the 2D version while providing a visually engaging format. The height and dimensions of the cubes can be customized, contributing to a more dynamic representation.

#### 2. Performance Analysis

To evaluate the functionality of the 3D QR code, several tests were conducted:

* **Scanning Success Rate**: The 3D QR code was scanned using multiple applications on different devices, including smartphones with various camera capabilities. The scanning success rate was measured to determine usability.
  + **Results**:
    - Scanning success rate was approximately **95%**, with most scans successfully decoding the QR code.
    - Users reported ease of scanning from different angles, indicating the effectiveness of the 3D design.
* **Scanning Distance**: Tests were conducted at various distances (0.5m to 2m) from the scanner.
  + **Results**:
    - The QR code was successfully scanned at distances up to **1.5m**. Beyond this distance, the scanning success rate dropped to **70%**, primarily due to reduced visibility of the QR code’s details.

#### 3. Comparison of 2D and 3D QR Codes

|  |  |  |
| --- | --- | --- |
| Feature | 2D QR Code | 3D QR Code |
| Visual Appeal | Basic, flat design | Engaging, dimensional |
| User Engagement | Standard interaction | Increased curiosity |
| Scanning Versatility | Limited angles | Improved angle flexibility |
| Aesthetic Customization | Minimal customization | High customization potential |
| Scan Reliability | High | Slightly variable |

**Key Observations**:

* **User Engagement**: The 3D QR code attracted more attention during demonstrations, leading to higher interaction rates.
* **Functionality**: While both formats are functional, the 3D QR code demonstrated enhanced usability, especially in scenarios where scanning angles varied.

#### 4. Feedback and Insights

Feedback collected from users highlighted the following insights:

* Users appreciated the visual appeal of the 3D QR code, noting that it stood out in promotional materials.
* Some users expressed a desire for more color options and further customization features, suggesting avenues for future improvements.

**CHAPTER-07**

**DISCUSSION**

1. **DISCUSSION:**

#### Implications of 3D QR Codes :

#### The successful implementation of 3D QR Codes .Presents several implications for businesses and users:

* **Enhanced User Engagement**: The visual appeal of 3D QR codes can significantly increase user interaction. In a crowded marketplace, standing out is crucial for capturing attention, and 3D designs offer a unique solution to this challenge.
* **Versatile Applications**: 3D QR codes can be utilized in various sectors, including marketing, product packaging, and event promotions. They can act as dynamic gateways to additional information, promotions, or interactive experiences, enriching customer engagement.
* **Brand Differentiation**: Companies can leverage 3D QR codes as part of their branding strategy. By customizing colors, heights, and designs, brands can create a memorable identity that resonates with consumers.

#### 2. Challenges Encountered

While the project demonstrated promising results, several challenges were encountered during the implementation process:

* **Scanning Reliability**: Although the scanning success rate was high, certain conditions—such as poor lighting or unusual angles—affected the reliability of scanning. Future iterations of 3D QR codes may need to optimize design elements to enhance performance in varying environments.
* **Complexity of Creation**: The process of creating 3D QR codes requires familiarity with both programming and 3D modelling software, which could be a barrier for some users. Simplifying the conversion process or providing user-friendly tools could broaden accessibility.
* **Cost of Production**: For businesses, the production of 3D QR codes may entail additional costs, particularly if unique designs or customizations are involved. Evaluating the cost-effectiveness of such codes compared to traditional 2D codes will be essential for widespread adoption.

#### 3. Future Directions

The project opens up several avenues for future research and development:

* **Improved Scanning Algorithms**: Developing algorithms specifically tailored for 3D QR codes could enhance their readability across different devices and conditions. Incorporating machine learning techniques might help in this endeavor.
* **User-Centric Design Tools**: Creating intuitive design tools that allow users to easily generate and customize 3D QR codes could encourage wider adoption. Features could include drag-and-drop interfaces and real-time previews.
* **Integration with Augmented Reality (AR)**: Future work could explore the integration of 3D QR codes with AR technology. This combination could create immersive experiences, where scanning a 3D QR code unlocks additional digital content, enhancing user interaction.
* **Market Studies**: Conducting market research to assess consumer response to 3D QR codes in various contexts will provide valuable insights. Understanding user preferences and behaviours can guide further enhancements and marketing strategies.

#### 4. Summary of Key Points

In summary, the conversion of 2D QR codes to 3D formats presents significant potential for enhancing user engagement and branding opportunities. While challenges exist, the positive results indicate that 3D QR codes could become a valuable tool in the evolving landscape of digital interaction. By addressing the challenges identified and exploring future directions, this innovation could redefine how QR codes are utilized across industries.

**CHAPTER-08**

**CONCLUSION**

1. **CONCLUSION:**

This project successfully explored the conversion of traditional 2D QR codes into engaging 3D formats, demonstrating both the technical feasibility and the enhanced user experience associated with this transformation. By leveraging image processing techniques and 3D modelling software, we created visually appealing QR codes that retain the essential functionality of their 2D counterparts.

The implementation results indicated a high scanning success rate for the 3D QR codes, along with positive user feedback regarding their aesthetic appeal and engagement potential. The study highlighted several advantages of 3D QR codes, including increased visibility, brand differentiation, and versatile applications across various industries.

However, the project also identified challenges that need to be addressed for wider adoption. These include ensuring consistent scanning reliability in diverse conditions, simplifying the creation process for end-users, and evaluating the cost-effectiveness of producing 3D QR codes compared to traditional 2D versions.

Looking ahead, the findings of this project pave the way for further research and development in the realm of QR codes. Potential future enhancements could include improved scanning algorithms, user-centric design tools, and the integration of augmented reality features. By addressing the identified challenges and capitalizing on the opportunities presented, 3D QR codes have the potential to redefine digital interaction, offering a compelling alternative to standard QR codes.

In conclusion, this project not only contributes to the existing knowledge surrounding QR code technology but also opens up exciting possibilities for innovation in user engagement and branding strategies. As the digital landscape continues to evolve, 3D QR codes may play a pivotal role in how information is conveyed and experienced.

**CHAPTER-09**

**FUTURE WORKS**

1. **FUTURE WORK:**

While this project successfully demonstrated the conversion of 2D QR codes to 3D formats, several avenues for future research and development remain to be explored. The following areas present opportunities to enhance the functionality, usability, and adoption of 3D QR codes:

#### 1. Enhanced Scanning Technology

* **Algorithm Development**: Future work could focus on developing advanced scanning algorithms tailored specifically for 3D QR codes. These algorithms could improve decoding accuracy under varying conditions, such as different lighting environments, angles, and distances.
* **Machine Learning Integration**: Implementing machine learning techniques to analyze scanning patterns and optimize the recognition process could lead to significant improvements in usability. Training models on a diverse set of 3D QR codes may enhance scanning performance across devices.

#### 2. User-Centric Design Tools

* **Creation Software**: Developing user-friendly software or web applications that allow users to easily create and customize 3D QR codes could facilitate wider adoption. Features could include drag-and-drop interfaces, templates, and real-time previews of designs.
* **Guidelines and Best Practices**: Establishing guidelines for designing effective 3D QR codes will help users understand how to balance aesthetic appeal with functionality, ensuring that codes remain easily scannable.

#### 3. Integration with Augmented and Virtual Reality

* **AR Experiences**: Exploring the integration of 3D QR codes with augmented reality (AR) technology could create immersive experiences. Scanning a 3D QR code could trigger AR content, allowing users to interact with digital elements overlaid in the physical world.
* **Virtual Reality Applications**: Investigating the use of 3D QR codes in virtual reality environments could provide innovative ways to access information or trigger events within VR applications, enhancing user interaction.

#### 4. Market Research and User Studies

* **User Behaviour Analysis**: Conducting comprehensive studies to understand consumer preferences and behaviours regarding 3D QR codes will provide valuable insights. This research could inform design choices and marketing strategies to maximize engagement.
* **Industry-Specific Applications**: Exploring how different industries (e.g., retail, healthcare, entertainment) can leverage 3D QR codes to enhance customer experiences or streamline operations will provide practical case studies and best practices.

#### 5. Cost Analysis and Scalability

* **Production Cost Evaluation**: Investigating the production costs associated with 3D QR codes compared to traditional 2D codes will help businesses assess the economic viability of adopting this technology.
* **Scalability Solutions**: Developing methods to scale the production of customized 3D QR codes for mass distribution could facilitate their adoption in marketing campaigns, product packaging, and event promotions.

**CHAPTER-10**

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