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New Gen QR Scan for Container Documents in Seconds

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ABSTRACT:

In the shipping and logistics industry, container documentation is a Critical process that is often slowed down by manual data entry, leading to inefficiencies, delays, and human errors. This project focuses on Developing a QR code-based documentation system to streamline Container handling, improve accuracy, and reduce manual effort. The Proposed system assigns unique QR code to each container, enabling Automated identification, verification, and tracking through scanning Devices at key checkpoints. The project adopts a structured Methodology consisting of requirement analysis through field Observations and stakeholder interviews, system design involving QR code generation, scanning workflows, and database storage, Implementation by integrating QR code scanners in containers, and pilot testing in a logistics environment to enhance the performance. The study emphasizes the potential of QR code technology to enhance documentation efficiency in container Freight stations and logistics parks managing high container volumes.

Keywords: Automation, QR code, Digitalization, Efficiency, Scanning

1. INTRODUCTION

QR codes are increasingly used in container and supply chain management for **efficient tracking, verification of documents, and reducing manual intervention**. Research articles focus on implementing systems that link physical containers and documentation to digital information via QR codes.

The shipping and logistics industry relies heavily on documentation such as bills of lading, invoices, customs forms, and inspection records. Traditionally, these documents are handled manually, resulting in inefficiencies, delays, data duplication, and frequent human errors. As container volumes increase globally, the limitations of paper-based documentation systems become more critical.This project introduces a QR code–based documentation system that digitally links physical containers with their corresponding electronic records. Each container is assigned a unique QR code that provides direct access to its documents through a simple scan using a smartphone or scanner. The system enables real-time updates, centralized access, and improved coordination among stakeholders such as shipping companies, port authorities, warehouse operators, and customs officials.

"New gen" technologies for scanning container documents generally fall into two distinct categories based on current research: **Next-Generation Document Intelligence** for physical documents and **Advanced Container Security Scanning** for software containers used in application development.

The objective of this project is to design, demonstrate, and evaluate a practical solution that improves container documentation efficiency while remaining cost-effective, scalable, and easy to deploy in real-world logistics environments.

2. SYSTEM OVERVIEW

The proposed system integrates QR code technology with digital document storage and scanning mechanisms. A QR code acts as a bridge between the physical container and its digital records. When scanned, it redirects the user to a secure platform where container-related documents are stored and managed.

Significant scheme components include:

- Digitized container documents stored in a centralized database
- Dynamic QR codes assigned to individual containers
- Scanning devices such as smartphones or USB cameras
- Image processing and QR decoding software
- Secure access control and logging mechanisms

Together, these components form an integrated system that automates document access and minimizes manual intervention.

3. DIGITIZATION OF CONTAINER DOCUMENTS

The first stage of the system involves digitizing all relevant container documents, including bills of lading, packing lists, invoices, and customs forms. These documents are uploaded to a secure digital platform, ensuring centralized storage and controlled access.

Digitization eliminates dependence on physical paperwork and allows documents to be updated, shared, and retrieved in real time. By maintaining a single source of truth, the system prevents inconsistencies and reduces the risk of outdated or incorrect information being used during container handling.

4. DYNAMIC QR CODE GENERATION

Each container is assigned a dynamic QR code rather than a static one. Dynamic QR codes allow the linked content to be updated without changing the physical code printed on the container. The QR code links to a secure web portal containing container-specific documentation. This approach ensures flexibility, as document updates or status changes are immediately reflected when the code is scanned. Dynamic QR codes also support tracking features such as scan history, time, and location.

5. QR CODE MOUNTING ON CONTAINERS

The generated QR code is printed on durable, weather-resistant labels and affixed to the container exterior at visible and accessible locations. Multiple placements may be used to ensure redundancy and easy scanning from different angles.

Proper mounting ensures that QR codes remain readable despite exposure to harsh environmental conditions common in ports and container yards. This physical-digital integration is essential for reliable system performance.

6. QR CODE SCANNING PROCESS

Authorized personnel scan the QR code using smartphones, handheld scanners, or fixed USB cameras. Upon scanning, the system automatically redirects the user to the container's digital document portal.The scanning process is fast, contactless, and requires minimal training. Built-in error correction features in QR codes ensure accurate decoding even if the code is partially damaged or misaligned.

7. ACCESS AND DOCUMENT MANAGEMENT

Once scanned, users gain immediate access to all documents associated with the container. Access rights are controlled through user permissions, ensuring that sensitive information is only available to authorized stakeholders.The system supports document viewing, downloading, updating, and verification. All access events are logged, creating a transparent audit trail that enhances accountability and security.

8. SECURE DOCUMENT STORAGE

All digital documents are stored in a secure, centralized platform. Access is role-based, and security mechanisms ensure data confidentiality, integrity, and availability. QR codes serve as secure gateways to the storage system rather than storing sensitive data directly. This approach minimizes security risks while ensuring fast access.

9. SYSTEM METHODOLOGY

The system methodology follows a structured approach:

- ✓ QR code placement and alignment
- ✓ Image acquisition using USB cameras
- ✓ Image preprocessing and enhancement
- ✓ QR code detection and decoding
- ✓ Data validation and retrieval
- ✓ System response and logging

This methodology ensures reliable QR code recognition and efficient document access under varying operational conditions.

Efficiency and Cost Reduction

- **Customs Inspection Systems:** Research at the Port of Keelung proposed a cloud cargo image system using QR codes. Customs officers scan a container's QR code to access interior photos and a voucher, allowing verification against X-ray images. This method showed a 32% increase in examination performance by reducing the need for costly manual unpacking.
- **Logistics and Inventory Management:** Studies explore how QR codes on pallets, storage boxes, and specific items can link to product databases, shipping instructions, and inventory lists, offering real-time visibility and improving operational efficiency.

- **Document Management:** Research has demonstrated that QR-based access can lead to 40% faster document distribution and 30% efficiency gains by simplifying information sharing for stakeholders across the supply chain.

IMAGE ACQUISITION AND PROCESSING: USB cameras are used to capture real-time images of QR codes. The captured images undergo preprocessing steps such as grayscale conversion, noise reduction, and thresholding to improve clarity.These techniques enhance decoding accuracy and allow the system to function effectively without specialized or expensive hardware.

QR CODE DETECTION AND DECODING: The decoding process identifies QR code finder patterns, determines orientation, and extracts encoded data. Error correction mechanisms ensure reliable decoding even when the QR code is partially damaged.Decoded data is validated before being used to retrieve container documents, ensuring system reliability and data integrity.

SYSTEM DEMONSTRATION AND PROTOTYPE: A prototype setup using foam boards, USB cameras, and QR codes was developed to demonstrate system functionality. This setup allowed controlled testing and visualization of scanning, decoding, and document retrieval processes.The prototype validated the feasibility of the system for real-world applications.

HARDWARE COMPONENTS

Important hardware components include:

- USB camera for image capture
- QR codes as data carriers
- Foam boards for stable mounting
- Scanners and computing systems

These components were selected for their affordability, availability, and ease of integration.

Reduction of Manual Errors

By automating document access, the system significantly reduces manual data entry and associated errors. All stakeholders access the same verified digital records, minimizing discrepancies and delays. This improves coordination across logistics operations and enhances overall data accuracy.

Traceability and Transparency: Each QR code scan can be logged with time and location data, providing a digital trail of document access. This improves traceability, accountability, and compliance with regulatory requirements.
Real-time visibility supports better decision-making and operational planning.

Reduction of Paperwork and Costs: The digital system minimizes the need for printed documents, reducing printing, storage, and handling costs. It also reduces the risk of document loss or damage. Lower paper usage supports sustainability goals and environmentally responsible logistics practices.

Scalability and Deployment: The system is designed to scale for high-volume operations such as ports and logistics parks. Its modular architecture allows easy expansion and integration with existing logistics platforms. Minimal training requirements and compatibility with common devices support smooth adoption.

Results and Performance Evaluation

Testing demonstrated high QR decoding accuracy, fast response times, and reliable document access. The system performed well under varying lighting and alignment conditions.

Overall, the results confirmed improvements in efficiency, accuracy, and accessibility compared to traditional systems.

Future Enhancements

Potential future improvements include:

- Mobile application integration
- Cloud-based storage
- Enhanced security features
- IoT and GPS integration
- Offline access and synchronization
- AI-based analytics

These enhancements would further strengthen system performance and applicability.

10. CONCLUSION

The QR code–based container documentation system offers an effective, efficient, and scalable alternative to traditional paper-based logistics documentation. By linking physical containers to secure digital records, the system improves speed, accuracy, transparency, and sustainability. The successful prototype demonstration confirms its feasibility for real-world deployment. With further enhancements, the system has strong potential to support the digital transformation of modern logistics and supply chain management.

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