



Implementation of Gate and Crane OCR Systems for Container Terminal Automation and Security

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1. Introduction

Container terminal operators worldwide have expressed the need for accurate real-time accounting of the incoming, outgoing and existing inventory. The accelerated growth in container traffic is driving terminals to employ systems that increase productivity and throughput, enhance their capability to accurately track inventory, and relieve present and future bottlenecks in terminal activity.

New port and container security initiatives and regulations will also heavily rely on automated identification and tracking of containers as they enter and exit the port via ship, truck or rail. Manually intensive identification and tracking processes, typically employed today, are inherently inefficient, insufficient and potentially, in itself, could pose a threat to the terminal security.

This paper follows the successful commissioning of the world's largest container OCR (optical character recognition) installation, encompassing gate systems, crane systems and yard inventory tracking, installed in 2002 in the Port of Los Angeles. These OCR systems automatically identify containers, truck plates and chassis numbers with accuracy approaching 100%. This paper presents a background on the state-of-the-art of container OCR technology and focuses on the application of this technology for security applications and for the automation of the container handling process.

2. Background

Shipping container terminals are currently undergoing an unprecedented growth rate worldwide, with annual growth rates in Asia of 10-35% expected to continue for at least the next 5 years. Automation has a major part to play in supporting the efficient handling and capacity required for meeting the growth in container trade. Whereas most terminals today already employ various levels of automation, including sophisticated TOS systems for container movement and inventory management, container OCR systems provide a necessary link in the terminal's automation chain.

Hi-Tech Solutions has recently commercialized its container code recognition (CCR) systems for portal and pedestal gate applications and crane applications. Since the container markings follow an ISO international standard, the CCR systems can be installed in any location worldwide.

A CCR system can generally be divided into 3 general modules:

1. Image-capturing units (including illumination devices)
2. A software recognition engine and application programs
3. System infrastructure, (mounting and support structure and communication network).

The image-capturing units must include an optical and illumination solution to produce images of the container ID number with sufficient quality, (focus, resolution, contrast, and uniformity), under all operating and ambient conditions, (sunlight, sun glare, night time, adverse weather conditions). The software recognition engine and application programs must be able to process these images and convert them into data for real-time processing. The hardware and software must operate in unison to accurately read the container and vehicle numbers while the container is passing through a gate lane, being lifted or lowered by a crane, sitting on a chassis slot or being handled by other container handling equipment.

The design and selection of the image-capturing and software systems has a great impact on the system infrastructure requirements, determining mounting position and constraints for the cameras and illuminators as well as triggering requirements and solutions. The support structure system and design also plays a critical role in the installation cost and the reliability and maintainability of the system.

3. OCR Applications for Security Enhancement

Following the events of September 11, 2001, container terminals and ports worldwide have assumed new responsibility and accountability for the tracking and handling of containers. The major impetus of the new container security procedures will be to ensure that containers are properly identified and, for those specially designated, inspected and checked prior to entry to and exit from container terminals.

The core elements of the recently established Container Security Initiative (CSI) are as follows:

- Identify high-risk containers
- Pre-screen those containers identified as high risk before they are shipped to foreign ports
- Use of Non-Intrusive Inspection (NII) technology to quickly pre-screen high-risk containers and random checks
- Utilize secure containers
- Employ effective real-time risk management

Furthermore, in accordance with the C-TPAT (Container Trade Partnership Treaty), participating companies will receive “fast lane” treatment through shipping ports and border crossings.

Regardless of the security inspection process designated for the specific containers, direct identification and tracking of containers will be necessary to ensure proper implementation of inspection and utilization of risk management.

System applications implementing OCR together with other screening and security technologies, such as Gamma/X-Ray/Neutron Detection/Inspection, Smart seals and RF tags, explosives detection and others can provide accurate real-time accounting of incoming and outgoing containers and carrier inventories in container ports. It can also be used in profiling containers to be inspected for their contents.

Using newly available Non-Intrusive Inspection (NII) systems, the contents of the containers can be examined. Mobile gamma and x-ray detection devices provide radiographic images of the containers’ contents. Neutron-based inspection modules can automatically detect threat materials based on material specific signals

stimulated by the neutron probe. Since, in most terminals, the volume of containers entering and leaving the terminals is much too high for 100% inspection, profiling together with random selection are required to choose the most-likely candidates for inspection. Strategic deployment of these NII systems can give a high level of security without the need for 100% inspection

The video imaging of the containers intended for damage inspection can also provide data for profiling since these images can detect tampering as well as damage. Also, one of the major inputs to the profiling algorithm is from C-TPAT, the US Customs Service program for Worldwide tracking of containers and their contents.

Whatever the security process designated for any specific container, OCR tracking will be necessary to ensure that containers do not bypass pre-defined check-points in the terminal process. This is due to the fact that OCR provides real-time direct identification of the container and can thus acknowledge release of a container through a given point (crane, rail portal, or gate, after checking that the container has been authorized for release at that point) or alert the system if a container attempts to slip through the process prior to completion of any supplementary security check.

It should also be noted that NII systems could be easily integrated with OCR at gates, on cranes and at rail stations.

The benefits of OCR for port security can be summarized as follows:

- OCR-based tracking provides direct identification of the object without a secondary device
- OCR eliminates false-identification resulting from manipulation of other tracking device such as RF tags
- Automated tracking and screening system eliminates manual intervention of traffic at gates, cranes and rail yard
- Real-time identification provides for automated operations and improved security response
- Facilitates “fast-lane” treatment with high level of efficiency and operational integrity
- OCR, implemented at gate and crane loading points, can be utilized to ensure that containers do not bypass security check points
- Archives digital images that may be used for security verification and post-processing

4. OCR Applications for Enhanced Productivity and Automation

Shipping terminal operations differ greatly among the terminals, and employ different container handling systems in terminals of different types and sizes: common-users or dedicated; hub center (transshipment and/or relay) or import/export; gateway or feeder port; intermodal rail or truck distribution inland; just to name a few. The level of automation greatly depends on the handling and processing operations themselves. Nevertheless, most terminals today can markedly benefit from OCR by further automating inefficient gate, yard, rail and marine operations while simultaneously reducing the operating costs.

Common OCR applications for terminal automation include the following systems:

- Gate OCR system (for portal and pedestal gates)
- Crane-mounted OCR systems (Quay crane, RTG, MTG and other CHE’s)
- Rail Operations (rail portal gates)
- Yard Operations (Moving Inventory Vehicles, utilizing integrated OCR and GPS systems)

All of the above OCR systems offer multi-level benefits to this market. The shipping container terminals utilizing OCR will enjoy more efficient use of labor, yard space and handling equipment to result in improved productivity and profitability. In order to meet fast turn times for containers, tighter control over the movement

of terminal assets such as containers, cranes, chassis and trucks will be necessary, and is enabled by OCR. Furthermore, most container terminals today implement terminal operating systems (TOS) database programs that automate the handling of all assets in the terminal based on manual entry of container and truck numbers. OCR will complete the automation cycle for these terminals. Some terminals have already been automated to some extent. These would benefit even more from OCR since no other visual verification is utilized.

Major benefits for the implementation of these systems include:

- Enables complete automation of the container handling processes in terminals
- Enables real-time inventory and container tracking management in terminals
- Increase terminal capacity at a fraction of the cost of terminal expansion.
- Increases reliability and accuracy of the container tracking
- Reduces terminal staffing requirements
- Images captured can also be archived for damage inspection evidence
- Provides a major data input for container profiling

The following table summarizes some of the common applications of OCR in container terminals:

No.	Description	OCR Elements	Benefits
1	Portal Gate	Container, LPR (truck Plate) and Chassis (optional)	Increased throughput and productivity, as well as accuracy in data entry; reduced operating costs. Container number can be identified at downstream pedestal gate by LPR or chassis alone
2	Pedestal Gate	Container, LPR and Chassis optional	Increased throughput and productivity, as well as accuracy in data entry. Reduced operating costs
3	Gate with Damage Inspection	Container, Chassis and LPR (optional)	Archiving of container images for evidence of container condition at terminal entry and exit gates
4	Quay Crane	Container	Increased throughput and productivity, as well as accuracy in data entry; reduced operating costs
5	Quay Crane with Damage Inspection	Container	Archiving of container images for evidence of container condition at shore entry and exit cranes
6	RTG	Container	Tracking of container position as it is handled and stacked in yard
7	Container Handling Equipment	Container	Tracking of container position as it is moved from one vehicle to another
8	Crane Loading	Truck - LPR	Can automatically identify incorrect containers before handling by crane
7	MIV	Container	Automatically updates yard inventory; reduced operating costs
8	Rail Portal	Container	Automatically reads and records container inventory at rail station points; reduced operating costs and trackside personnel

5. Gate OCR Installations in the Port of Los Angeles

Some 68 Gate OCR systems and have already been installed and commissioned within the Port of Los Angeles at the TraPac (Trans Pacific Container Service Corp.) Terminal and at the new APM Pier 400 Facility. The systems were supplied by Hi-Tech Solutions and integrated and installed by APS Technology of San Diego, California.

The following figure shows one of the Gate OCR plaza systems.

Figure 1: 24-lane Inbound Plaza Gate OCR Installation at Pier 400



A Gate OCR system is a fully integrated gate system that can read container numbers, chassis numbers and the truck license plate numbers for each truck as it passes through a lane. The system scans the ID numbers while the truck is in motion, triggered by a set of sensors. Each unit simultaneously controls multiple cameras for multi-view recognition of the container and chassis. The application program controls and sets the illumination levels, captures and processes images from a number of cameras, extracts the ID numbers, classifies the type of containers, verifies the results and finally outputs (and optionally displays) the final results.

The Gate OCR systems supplied to TraPac and Pier 400 are characterized by the following attributes:

- The system provides an integrated hardware and software solution consisting of proprietary hardware and highly accurate software programs
- Ambient lighting is augmented with triggered, synchronized, solid-state illuminators that are activated for a split second during each read event.
- Each lane is handled by a single processor which captures and process all of the images for container, chassis, and truck numbers
- The system is installed and supported on a single truss per lane, providing simple, reliable, low cost support structures



Figure 2: Gate OCR System at Pier 400 Terminal

The gate systems can be supplied in various configurations and accommodate variable site geometry. The integration of truck plate and chassis number recognition is available based on terminal requirements.

6. Crane OCR Installations in the Port of L.A.

A quay-crane OCR system was installed on a Paceco ship-to-shore crane at TraPac for pilot testing during the second half of 2002. The system automatically reads and records the container code number each time a container is handled by the crane. This sophisticated image-capture and recognition system is installed directly on the crane and interfaces with the crane control system.

The crane OCR system includes an array of rugged video high-performance camera units mounted on the crane sill beams, designed and positioned to handle all standard size containers. The cameras are equipped with auto-zoom lenses to capture images at variable distances from the sill beams. The container code information is processed by the host computer that is also installed on the crane. The updated container status is then transmitted to the crane control station using a wireless interface.

The Crane OCR system, which interfaces directly with the crane PLC, waits for a spreader twist-lock change to occur. When the twist-locks are reported to change from open to closed, the CCR will start monitoring the hoist and trolley positions. When these positions indicate that the container is within the defined trigger zone, the camera and grabber subsystem is initiated. As soon as the container leaves the trigger zone, the system will analyze the image data with the hoist position log, to find the correct images of the container. When the pictures have been selected, the OCR function is activated and the ID code is read from the images.

The following figures show the camera mounting on the sill beam. Figure 3 shows the cameras at their initial test-installation, and Figure 4 shows the final mounting of the cameras in their protective housings.



Figure 3: Initial Camera Installation on Pilot system at Trapac



Figure 4: Final mounting of cameras in protective housings

Additional crane-mounted OCR systems have been designed for other container handling equipment, such as RTG and RMG cranes. For these cases, the OCR stations will enable identification of the containers as they are moved throughout the yard.

7. Summary

The implementation of OCR systems for feasible identification and tracking of containers offers important benefits. Container terminals utilizing this technology will enjoy more efficient use of labor, yard space, and handling equipment while realizing improved productivity and profitability. In order to meet fast turn times for containers at all shipping ports worldwide, tighter control over the movement of terminal assets is becoming increasingly vital. An OCR system will significantly advance the automation cycle for these container terminals that are presently using manual entry methods for container, chassis, and truck numbers.

The growing security needs of container-handling terminals worldwide also necessitate automated identification and tracking of containers at various points of the supply chain. Today, more than ever, the need to overhaul terminal security systems and procedures is immediate and often government-mandated. OCR will well serve as one of the integral technologies providing real-time identification and tracking of containers as they pass through the terminal borders.

The current OCR systems running at both the APM Pier 400 and TraPac terminals in the Port of Los Angeles have achieved high performance levels, robustness, and operability. With over 70 full OCR systems now in operation, they have demonstrated accuracy for container recognition of nearly 100%. The systems have been successfully integrated into the two different terminal operations; one employing a Navis TOS and the second utilizing its own proprietary TOS. But most importantly, these systems have succeeded in automating the terminals' gate and crane processes while significantly reducing operating costs associated with each of these operations.

Gate, Crane, Rail and Yard OCR systems may be now be considered a viable and feasible means for enhancing terminal automation, management and security.