Container reading in RMG crane operations

TERMINAL AUTOMATION THROUGH OCR AND OFR

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When it comes to Optical Character Recognition (OCR) technology and assessing OCR or Optical Feature Recognition (OFR) systems, there is often a lot of confusion. High OCR hit rates don't guarantee less exception rates.

ASSESSING OCR/OFR SOLUTIONS FOR CONTAINER TERMINALS

Operation efficiency in the capital-intensive container terminal industry is data driven. Data sources from different systems, vendors and stakeholders drive the terminal management system, or Terminal Operating System (TOS). Intelligent cameras capturing container information throughout the container handover processes provide critical data feeding the TOS.

Data accuracy is key for limiting exception handling and labour cost. Better safe than sorry: when taking into account Return on Investment of data capturing solution, total cost of ownership is determined by system reliability. A thorough understanding of camera system KPIs are fundamental in making the right choice.

CONTAINER TERMINAL AUTOMATION

Seaports and container terminals have invested heavily in infrastructure and automation during the past decade. Traditionally a labour-intensive industry, innovation in communication, connectivity and computing power has turned the industry upside down. Advanced terminals are almost fully automated and digital twins are the next real thing. The capital-intensive industry is embracing digitisation to improve operations efficiency, better customer satisfaction and a higher return. Data capturing and terminal intelligence have moved from the operations desk to the boardroom.

AUTOMATION STARTS WITH RELIABLE DATA

It is crucial to keep track of the continuous flow of in-and-outgoing containers. Missing one container and it might be lost for weeks. Accurate registration of container flow is essential for operations organisation. One of the main data sources for the TOS comes from the intelligent camera systems at the terminal gates, in the yard or at the STS cranes loading and unloading the vessels. The intelligent cameras register trucks and containers by reading container markings (OCR) as well as features (OFR). Typical OCR readings include the truck license plate, container number, ISO code and dangerous goods labels. Typical OFR readings include seal identification and automated damage inspection.

HIGH-END VERSUS LOW-END HARDWARE

Missing data by lacking or misreading information will dramatically affect the OCR system performance. Inaccuracy will lead to handling more instead of fewer manual exceptions and a system perceived as unreliable by gate clerks. On-camera image analysis software will perform better when picture quality is at its best. High-quality lenses and high-bright lighting are key for providing easy to read images for the

Truck OCR camera portals at Puerto Angamos - Chile

"TERMINALS WANT FAST PROCESSES; TOO MANY UNNECESSARY OPERATOR JOBS SLOW DOWN THE OPERATIONS."

AI-processor. If only a container number or license plate needs registration, a value for money solution might do the thing.

When high flows of trucks and container moves have to be processed 24/7 and in all weather conditions, or additional information is to be registered, the low-cost solution might eventually turn into replacement of the failing equipment. When information becomes critical, it is highly recommended to invest in a sustainable solution. Sometimes, one can't afford to buy cheap. Cameras with high quality lenses, global shutter technology and remote focus capability will save a lot of trouble.

AI AND DEEP LEARNING EXPERTISE

The Camco camera systems run AI engines for data capturing. The Camco expertise in deep learning and Convolutional Neural

Networks (CNN) has been integrated in OCR camera systems with the highest accuracy available today. Convolutional Neural Networks learn by experience, Camco feeds the network with large numbers of labeled images so the network learns the features that characterise objects. Defining the best suited network architecture and tweaking the algorithms requires time and expertise. A team of eight AI engineers develop new applications and improve system performance by tweaking algorithms pushing recognition rates to a maximum. It requires a lot of resources for every percent of OCR system improvement.

AI IMAGE RECOGNITION SOFTWARE

Accuracy and speed are the key drivers for any OCR/OFR system performance. Powerful CPUs use different algorithms for processing

different images at the same time. The processors are embedded, on-camera computing instead of relying on a remote AI-server makes the information faster. All Camco cameras are equipped with a 12th generation Intel processor.

EVALUATING AN OCR SYSTEM PERFORMANCE

In order to evaluate AI vision-based system accuracy, KPIs have to be defined. Multiple KPIs can be used to measure AI vision technology performance. The main question is which KPI should be used for what purpose: a KPI in a Maintenance & Service agreement may indeed be different from KPI related to the system acceptance.

Finally, when defining AI vision KPI, it is key to take into account only data generated by the AI vision system. Indeed, exceptions can also be created by missing
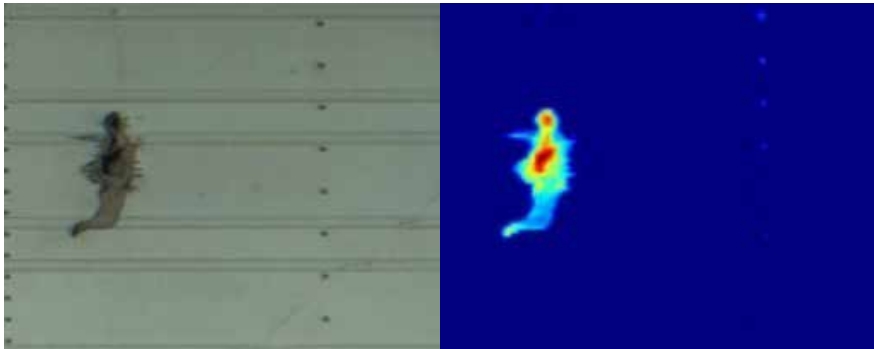
Automatic Damage Inspection heat maps. AI-based container and trailer damage recognition

High-end cameras with global shutter, remote focus and embedded AI engine

BoxCatcher STS crane OCR connected with crane PLC, travelling up and down crane mounted rails

"MISSING DATA BY LACKING OR MISREADING INFORMATION WILL DRAMATICALLY AFFECT THE OCR SYSTEM PERFORMANCE."

or incorrect data from the TOS. These TOS triggered jobs are not included in the AI vision based KPI definition. In this article, we focus only on the OCR/OFR exceptions created by the AI vision system.

CONFIDENCE LEVEL: ACCURACY IS KEY

The confidence level gives an estimated probability regarding the correctness of the reading result. Its value is calculated based on intermediate results of the algorithms. The confidence is a value between 0 and 100 per cent, and influenced by quality and wear of the container markings, light conditions and so on. In an industrial

process, the goal is reducing human intervention to the strict minimum and relying on only qualified data.

Note that TOS container vessel discharge or load data can be used by the OCR engine to increase the crane OCR hit rate. A missing digit can be recovered from the TOS system. Or truck appointment information can be used to correct missing data at the gates. At Camco, we are very careful and use this additional data only for confidence level calculation. It is key to discard the TOS autocorrection in assessing a vendor OCR result, the raw OCR result.
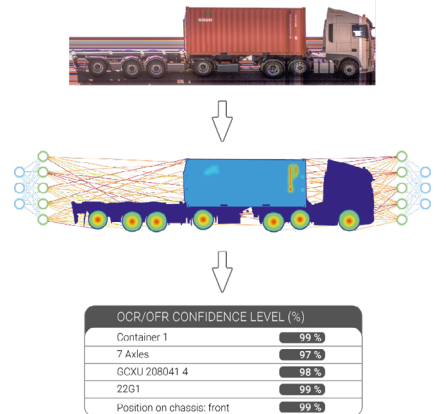
OCR/OFR HIT RATE KPI: SYSTEM PERFORMANCE

When measuring the performance of a stand-alone OCR/OFR system, the hit rate is the most relevant KPI. Whereas the confidence level for each reading is automatically computed by the system, the hit rate is determined through human verification, i.e. by visual check of each picture with the corresponding system read. A typical population size between 250 and 500 images is necessary for the hit rate to be statistically significant. All images in this population are used; no images are discarded, also missed pictures are taken

Optical Character Recognition (OCR): reading data strings and labels

Optical Feature Recognition (OFR): identifying seal presence and type

OCR/OFR CONFIDENCE LEVEL (%)	
Container 1	99 %
7 Axles	97 %
GCXU 208041 4	98 %
22G1	99 %
Position on chassis: front	99 %

CNN based OCR/OFR determination and confidence level

into account. Based on this verification, the number of correct verifications, or hit rate is expressed as a percentage of the total population size. Ideally, the OCR/OFR hit rate should be near 100 per cent.

Note that the confidence level is not taken into account in computing the hit rate. The hit rate is a useful KPI to measure the performance of a stand-alone OCR/OFR system, i.e. not integrated with any industrial process such as a truck gate process or crane process.

OCR/OFR JOB RATE KPI: PROCESS PERFORMANCE
An AI vision technology system is always integrated into an industrial process such as a truck gate or crane process. Since OCR/OFR output is used as one of the inputs for a specific industrial process, accuracy is key. Wrong data leads to wrong decisions, needing human intervention for corrective action.

Since each process step requires accurate data, the registered data confidence level is used to score the accuracy of the reading result and to trigger operator verification if below a pre-set threshold. For each attribute (for example LPR, container ID, or seal), a confidence level threshold is configured. The value of this threshold depends on the specific terminal process. The higher threshold, the higher the accuracy of the read information, but at the same time it

will increase the number of operator jobs for which no correction is needed. If the threshold value is set too low, then the risk to continue to work with an incorrect read result increases.

This confidence level threshold is a trade-off between a calculated risk for errors against the cost of interventions and is determined between Camco and the terminal project team.

The OCR/OFR job rate KPI can be calculated automatically by counting the number of generated operator jobs for a population of passages (after deduction of the TOS generated jobs). A passage can be a truck, spreader or train. The typical population size is between 250 and 500 passages to be statistically significant. All passages in this population are used; none are discarded, also missed pictures are taken into account. Based on this counting process, the job rate KPI equals to the number of OCR/OFR operator jobs, expressed as a percentage of the total population size.

COMBINING ATTRIBUTES LEADING TO HIGHER JOB RATE
If the OCR/OFR process output contains many (independent) attributes (LPR, container ID, IMDG, seal presence and so on), then the job rate will be higher due to the combination effect. Therefore, it is useful to only use the minimal set of OCR/OFR attributes needed for process execution. Although the job rate KPI is

not an indicator for the correctness of the OCR/OFR result as such, it is a very useful operator intervention KPI measuring the performance of a business process integrated AI vision-based system.

THE RIGHT KPI FOR EVERY PROCESS
In a project context, the OCR/OFR hit rate KPI is a useful performance measure as it can be specified during project contract negotiations. It is a raw performance measurement of a standalone OCR/OFR system, independent of any customer specific industrial process. However, from an operational point of view, a terminal is more interested in the amount of generated operator work. This work determines the operator workload and the total process duration.

Terminals want fast processes; too many unnecessary operator jobs slow down the operations. In an operations context after a project is accepted, the OCR/OFR job rate KPI is a more useful performance measure as it requires no human work to generate the KPI, and is a good indicator for operator workload. Which AI Vision performance KPI? Both KPIs can co-exist. Each KPI measures the output of a different process. The advice is to use the OCR/OFR hit rate KPI in a project context. During the lifetime of the solution, it is more useful to switch to the OCR/OFR job rate KPI. As mentioned before, TOS generated jobs are to be excluded in the AI vision performance KPI.

FACTBOX:

DEFINITIONS SUMMARY
- Confidence level: system accuracy measure: probability of reading correctness as computed by the AI vision-based system.
- OCR/OFR hit rate: raw performance measure, independent of the business process: total of correct readings related to correct data from manually inspected and corresponding images in statistic significant population.
- OCR/OFR job rate: performance measure of process integrated OCR/OFR system: total required human interventions related to all data readings, interventions being triggered by threshold confidence level and determined for a specific process step. No direct relation to OCR/OFR hit rate.

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ABOUT THE AUTHOR
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Anton Bernaerd is Head of Sales and for almost 20 years has been part of the Camco Technologies team. Anton has been sharing insights on process optimisation and terminal automation in more than 250 terminals across the globe. His unique expertise in gate and crane automation makes him an authority speaker in industry events.

ABOUT THE ORGANISATION
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Camco Technologies is the global leader in container terminal automation with innovative solutions for AI-based image recognition, gate automation, GNSS-based container tracking and terminal automation software. More than 250 terminals rely on Camco for container data registration and operations organisation.