Use of Vision Systems for Weighing Control of Railway Cars in Port Areas: An Automatic Identification Proposal

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ABSTRACT

This work presents the operating architecture of the manual control system intended for cargo transported by railway trains from the Port of Santos, located at the city of Santos in Brazil.
This article presents also the proposal of an operating architecture and a software architecture for an automatic identification system of railways cars – identified as 'SIAV' or Automatic Car Identification System in this text.
The results of the developed segmentation software (called AWImaging) operating along with off-the-shelf software for vision systems and off-the-shelf cameras, in order to compose the Automatic Identification System of Railway Cars by means of optical character identification, are also presented in this article.

Keywords: Digital Image Processing, Image Segmentation, Optical Character Recognition, Port Automation.

1. INTRODUCTION

In a globalized world, the performance of a country's economy depends more and more on the operational and organizational efficiency of cargo transport control at the seaports.
The Port of Santos, located in the city of Santos in Brazil, is the largest Latin American seaport, where railway cars do part of the cargo transportation. Therefore, one of the critical processes in cargo transport control is the car weighing procedure, which can be divided into three
Macro-stages: car positioning on the weighing platform, car identification and data record. These three macrostages are classified as manual processes according to the automation theory, that is, they are processes executed by human operators. Port of Santos is administrated by CODESP ("Companhia das Docas do Estado de São Paulo").
CODESP uses two main computerized systems to manage the entire railway network operation in the Port of Santos, which includes railway car traffic and weighing:
- The Car Management System (SGV), which provides administrative and fiscal information on the railway cars;
- The Car Weighing Management System (SGPV), which monitors and controls the weighing platform; it is integrated to the SGV.

An operator at the weighing post executes car identification process for each train. This operator reports the car numbers by radio to another operator at the control center. The car number data are also sent to the control center operator through images taken by a digital camera, installed next to the car weighing post. The control center operator has the responsibility of comparing the images with the identification numbers reported by the weighing post operator. Figure 1 represents the operating architecture of the railway car identification system.
Comparisons with similar systems are not presented because the developed software was especially specified for this particular application.
The presented contribution has practical engineering character, fitted to ports located in developing countries.

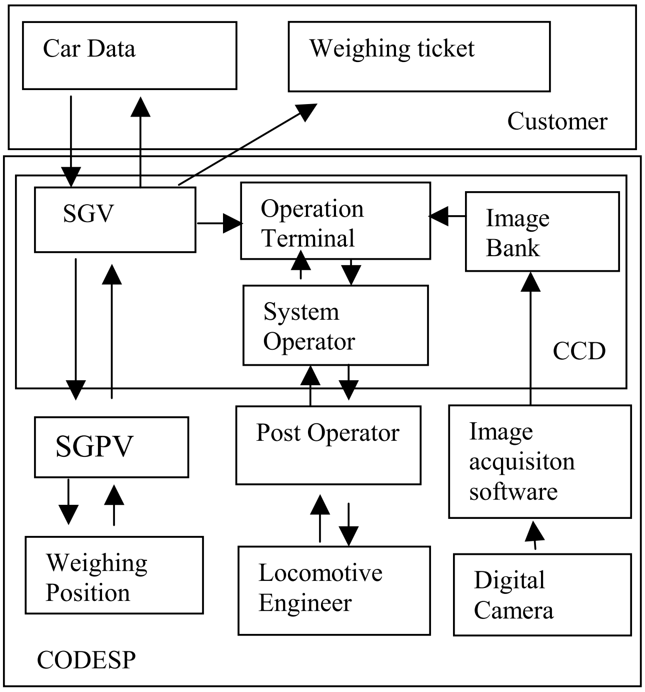

Fig. 1 Operating architecture of the Manual Railway Car Identification.

2. PROPOSED MODEL FOR AN AUTOMATIC RAILWAY CAR IDENTIFICATION

The operating architecture of the automatic car identification relies on integrating the Car Weighing Management System (SGPV) to the Car Management System (SGV), a computer-based administrative system located at the Operational Control Center (CCO).

The proposed operating model replaces the manual checking process (and the resulting manual data entry in the SGV) by a module called Automatic Car Identification System (SIAV), with the capability of integrating both systems and recognizing the characters automatically by optical means.

Figure 2 illustrates the operating architecture of the proposed system.

The car identification and weighing process, as described by [7], must be executed when the railway car is correctly positioned on the weighing platform.

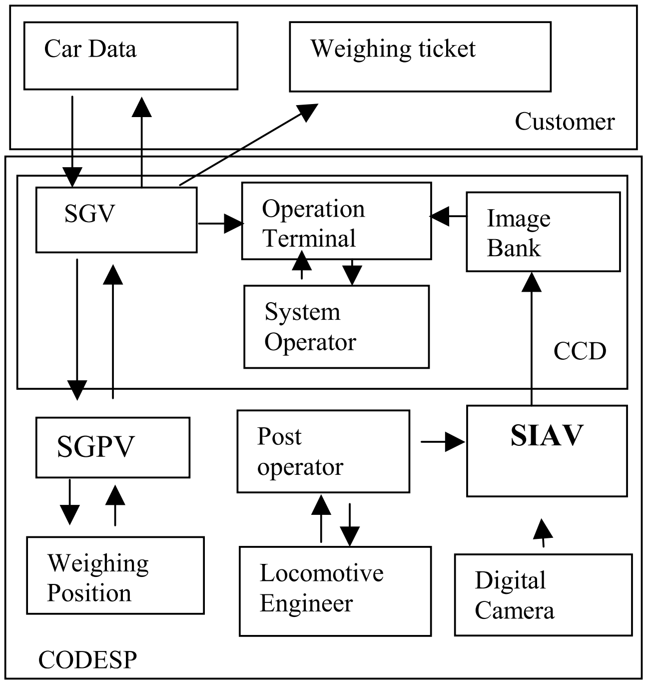

Fig. 2 Operating architecture of the Automatic Railway Car Identification.

Therefore, the proposed car weighing and automatic identification process is composed by two macrostages:

- Car positioning at the weighing platform.

With the help of the weighing post operator, the locomotive engineer positions the car on the weighing platform correctly. The car must be perfectly still and fully uncoupled from the train.

- A command from the operator to the SIAV, so this system can identify the car automatically.

The weighing post operator sends a command to the SIAV, in order to start the automatic car identification. The SIAV identifies the car automatically and transmits the resulting data to the operation terminal, so the weighing process can be completed and the weighing ticket can be issued.

When car identification is not successfully completed, an alarm is generated to the CCO operator, who must then check such occurrence at the SGV, using the reference images and contacting the weighing operator by radio. At the same time, the images of weighed or non-weighed cars are stored in the image repository, along with the date and time information of the recording process – which will enable performing audits in the system when needed.

3 SOFTWARE ARCHITECTURE OF THE PROPOSED SIAV MODEL

Several modules compose the Automatic Car Identification System:

- Interface Module to the Digital Input Output Device. This module works with the information provided by the weighing post operator, regarding the correct car positioning. It is integrated to the Image Acquisition Module, determining the exact moment each picture must be taken; it receives also the "completed weighing" data from the SGV Integration Module, in order to actuate the corresponding signaling flag.

- Image Acquisition Module. It collects the images by working with the digitizer card. It has the responsibility of delivering such images as bitmaps to the Automatic Car Identification Module; besides, it sends also the new images, containing the superposed date time collection data and properly compressed in a JPEG format, to the image repository at the SGV's server.

- Automatic Car identification Module. Using the bitmap images provided by the Image Acquisition Module, this module performs a new optical recognition of the railway car identification. Once concluded this process, it must confirm the data through the check digit and by searching the SGV's database. The Automatic Identification Module is also in charge of reporting any faults in the recognition process or in the checking of identified cars, by generating a proper alarm to the operator.

- SGV Integration Module. This module serves both the SIAV and the SGPV. It enables accessing the car management system's database and performing the system integration tasks.

- Weighing Post Interface Module. This is an existing module, which operates at the Weighing Position of Santos Port; it receives a weighing authorization through the SGV integration module and returns the measured weight to that module.

Figure 3 illustrates the proposed SIAV software model.

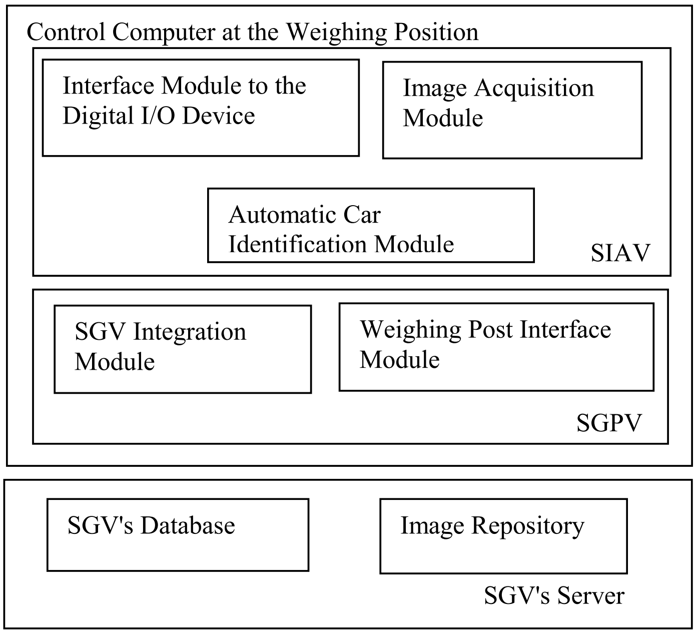

Fig. 3 Software architecture of the proposed SIAV model

3.1 DEVELOPED SOFTWARE – AWIMAGING

With the purpose of implementing digital image processing techniques to evaluate the proposed operating model, an image preprocessing software (*AWImaging*) was developed using the C++ language for Windows platforms. The *AW Imaging* utilization interface can be seen in Figure 4. As this software performs image segmentation, it can be integrated to any off-the-shelf software for viewing systems. Such modular architecture allows higher flexibility and a better SIAV performance, considering that many existing programs that had been analyzed require very favorable lighting conditions and close proximity of the object to be recognized.

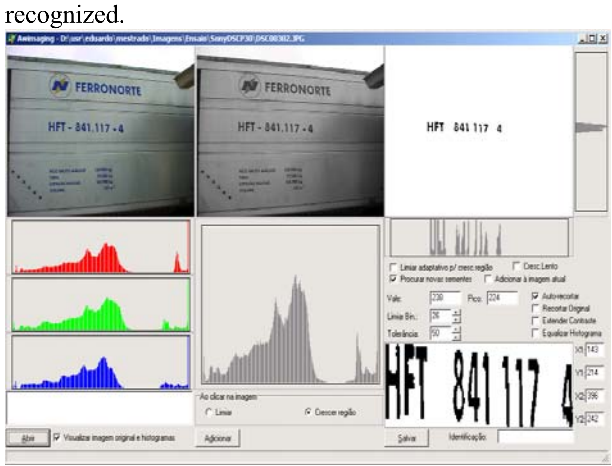

Fig. 4 Interface of the AWImaging software

The execution flow of this software includes the following tasks:

a. Loading the original image.
b. Generating individual histograms of each RGB component.
c. Converting the color image to gray tones.
d. Generating the image histogram in gray tones.
e. Binarizing the data.
f. Horizontal and vertical projections.
g. Segmenting the target area.
h. Saving the resulting image and data for future analysis.

Fig. 5 Original color image loaded in the AWImaging software

4. PERFORMED TESTS

A test was performed with the AWImaging software, involving the collection of 142 images of railway cars undergoing loading and unloading procedures at the Port of Santos. The images had been acquired by means of three digital cameras with distinct features and capabilities:

Camera 1 – This plain Webcam took 88 images with a resolution of 320x240 pixels.

Camera 2 – This pen type Webcam took 35 images with a resolution of 640x480 pixels.

Camera 3 – Good hand-held camera with built-in flash. It took 82 images with a resolution of 640x480 pixels.

Such pictures had been taken at several times during the day and night, thus enabling a variety of images with distinct lighting conditions. It is also worth emphasizing that several car types had been photographed.

The target area for segmentation purposes is the car ID number, which is painted on the sides of any railway car that operates in the Brazilian territory.

The context in which the car pictures are taken, especially when comes to the lighting variations, involves complex scenes that are not easily segmented. To make things worse, the different railway companies and car models adopt distinct identifications in terms of colors and letter types (fonts), as there is no standardization for such identification in Brazil. Examples of collected images for each one of the cameras can be seen in Figures 5, 6, 7 and 8.

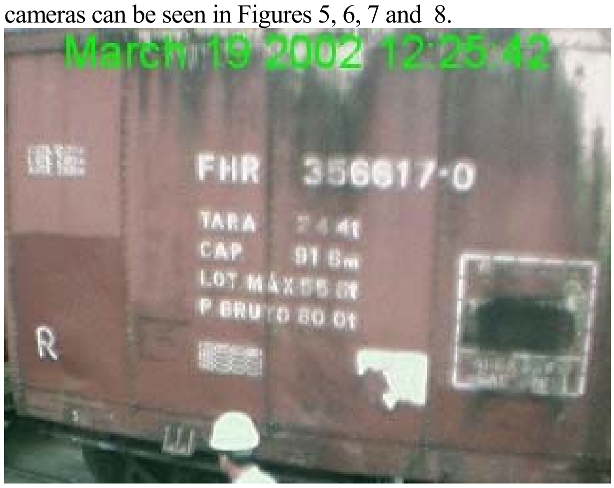

Fig 6 Daytime image, camera 1

Fig. 7 Daytime image, camera 2

Fig 8 Nighttime image, camera 3

Once segmented by the AWImaging software, the images had been submitted to an optical recognition by two standard, off-the-shelf programs: EASYOCR from Elvitec and CUNEIFORM`99 from Cognitive Technologies. Each one of these programs exhibits specific features and is intended for particular purposes that reflect the main available commercial products.
The EASYOCR software (Software 1) has the purpose of recognizing texts in those documents digitized by scanners.
The CUNEIFORM` 99 software (Software 2) is intended for the recognition of small-sized texts; it can be integrated to industrial viewing systems.
The recognition results of such programs can be used to validate the efficiency of the applied segmentation methods, considering that the goal of this segmentation test is optical recognition after all. The individual results of each camera and software can be seen in Table 1 – which contains only the usable images that had been correctly recognized.

Table 1 Percentage of successfully recognition procedures executed by SIAV with the AW Imaging software, regarding the different programs and cameras

	Camera 1	Camera 2	Camera 3	Total
Overall No. of images	79	23	40	142
Hit percentage with Software 1	17%	46%	9%	35%
Hit percentage with Software 2	20%	86%	79%	55%

4. CONCLUSIONS

The achieved results confirmed the feasibility of segmenting target objects for optical recognition purposes, regarding the identification of railway cars at port areas, even with the use of relatively plain techniques.
The success of these techniques depends on some factors, such as image quality and lighting conditions – situations that can be handled or significantly improved with the use of sophisticated equipment and lighting solutions.
In the specific case of those photographed cars, the conservation state and the vandalism to which they are subject are factors that can prevent, in many cases, a proper segmentation and consequently the optical recognition of any ID number. Still in the analyzed cases, the absence of an ID standardization can impair a successful segmentation, which would then render the recognition process more difficult.
As other conclusion of this article, the development and implementation of automatic recognition systems based on vision´s systems for cargo transport control in port areas are essential to increase the efficiency of this sector.

6. REFERENCES

[1] E. Mantovani, **Identificação Automática de Vagões na Área Portuária: Uma Solução com Análise de Imagens** (Automatic Car Identification at Port Areas: An Image Analysis Solution), Dissertation (Master's Degree Course) – Polytechnic School, São Paulo University – São Paulo, Brazil, 2002.

[2] H. A. Hegt, "A High Performance License Plate Recognition System", **IEEE International Conference on Systems, Man and Cybernetics**, Vol. 5, 1998, pp. 4357-4362.

[3] T. Sirithinaphong, K. Chamnongthai, "Extracting of Car License Plate Using Motor Vehicle Regulation and Character Pattern Recognition", **IEEE Asia-Pacific Conference on Circuits and Systems**, 1998, pp. 559-562.

[4] R. C. Gonzalez, R. E. Woods, **Digital Image Processing**, Boston, Addison-Wesley, 1992.

[5] R. Crane, **A Simplified Approach to Image Processing: Classical and Modern Techniques in C.** New Jerse – Prentice Hall, 1997.

[6] D. Shen, H. H. S. Ip, "Markov Random Field Regularization Models for Adaptive Binarization on Nonuniform Images", **IEEE Proceedings on Vision, Image and Signal Processing**, Vol.5, 1998, pp. 322-332.

[7] S. L. Pereira, **Aspectos sobre processos automatizados de pesagem rodo-ferroviária: uma proposta de modernização de postos em operação.** (Aspects on automated processes for highway/railway weighing: an update proposal for existing units), 1995. 120p. Doctorate Thesis – Polytechnic School, São Paulo University–São Paulo