AUTOMATION SYSTEM FOR ROCKET MOTORS ANOMALIES DETECTION THROUGH TOMOGRAPHIC IMAGES – AN INITIAL PROPOSAL

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Abstract. *The software use for analysis and study of images is nowadays a great progress in many areas of knowledge, from medicine to engineering. This work presents a initial proposal for Automation Tools Integration for Implementation of Device for Detection and Analysis of Anomalies in Rocket Motors through Tomographic Images. It presents possible resources for inspection in aerospace vehicles propellents, through the computerized tomography system, and the fundamental importance in acquiring and analyzing these images that could avoid for in risk the perfect motor operation and consequently the perfect rocket operation.*

Keywords*: image analysis, industrial tomography, automation, image manipulation*

1. Introduction

Through resources of associated computer science the other devices are possible to automate countless procedures. The software use for analysis and study of images is nowadays a great progress in many areas of knowledge, from medicine to engineering.

This work tries to become complete two areas of knowledge: it would engineer mechanics and computer science. In the first, more precisely, concepts and automation tools, and in computer science the image processing and analysis. The main goal is to present an initial proposal of an automated device implementation for inspection in aerospace vehicles propellents, through the computerized tomography system. Since it is an initial proposal, there are some items that are not defined, for instance, about which tomographic algorithm will be used.

The computed tomography integrated in automated process, aims the inspection through information contained in images, making possible in a first phase, the flaws area verification, and so in a second phase, the flaw analysis. The obtained images will be analyzed each one, through specific software with resources for image processing and manipulation, and in agreement with predefined criteria, the system will signal the occurrence of some image with problems, making possible the interruption of the process at any moment.

At first, this proposal of project consists of three items: controlling table (specified and developed by another work group), computed tomography and supervisory system. These items must be interlinked, and to present a communication system among themselves.

2. Digital Image Processing

The application of image processing techniques is extending more and more, causing crescent interests in several areas of knowledge. Through these techniques it is possible to improve images obtained for human interpretation and the automatic analysis by computer of scene extracted information.

According to (Marques and Vieira 1999) the image processing has growing up since the appearance of digital computers. The use of computational techniques to improve images had beginning in Jet Propulsion Laboratory (Pasadena, California–USA) in 1964. These techniques served as base for enhances and images restoration perfect methods for other subsequent space programs, as the Apollo series manned expeditions, for instance.

An image is a physical properties distribution. While a white and black image has an intensity value to each point, a colored image has three associated values, Red, Green, Blue - RGB. The radiological images are analogical. These analogical images cannot be directly treated for computer, because the computers operate with numbers. If converted for a digital form, the image can be modified in several ways, and, if necessary, stored in a computer, before being presented in a monitor or printed.

To analyze an image, it is necessary therefore, that it is in digital format. The image processing includes transformations, enhance, restoration, compression, registration and reconstruction.

3. Inspection and Analysis Techniques

The radiological techniques were applied initially to medical diagnosis. From X-Ray appearance to nowadays, many methods and techniques arose, and evolution is constant. These resources have begun to also be used in industry, adapting the equipments and techniques for the analysis of other components different from the human body.

In the industrial x-ray the same beginning of the clinical x-ray is used. The material to be analyzed is placed between an issuing source of radiation and a film.

Some of the emitted rays are absorbed by the material and some will cross it, sensitizing the film and producing in it an image of the tested material. The test final product, the radiological foil, is analyzed to detect material discontinuities. This is an inspection technique and analysis used in several areas, besides the aerospace.

The industrial x-ray works with radiation doses about ten larger times than the usual ones in clinical x-ray tests. Thus, the requirement safety is of fundamental importance in test accomplishment. The radiation types used are: the X and gamma rays. (Cozaciuc, Silva, Togni 2000)

Another inspection technique that has been applied makes use of the Computerized Tomography.

According to (Bio-Imaging Research, Inc., 1999) "the Computerized Tomography creates cross section images by projecting a thin-beam X-ray through one plane of an object from many different angles. As the X-ray pass through the object, some radiation is absorbed, part is scattered, and some is transmitted. In some scanners a cone-beam covers an area detector so that many slices, or a volume, they can be scanned at once". Figure 1.

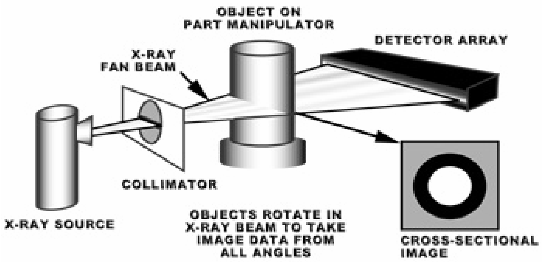

Figure 1– Outline of a Tomography System.

Although using several methods for obtaining a density image of some object physical property, all the tomography techniques share of the same mathematical problem, that is to reconstruct the original distribution starting from projections obtained with the measures accomplished externally starting from several angles.

According to (ICPE S.A., 1998), the industrial tomography is analogous to medical tomography but, because of the high attenuation of the X and gamma rays in metals, the energy range used is higher and the collimators and detection system, in some applications, different.

The Industrial Tomography is capable to show the examined object interior in two (2D) or three (3D) dimensions. The obtained information, respectively the tomograms, is usually a pixels map of the attenuation coefficient (or density) values of the scanned slices or a projection of the viewed voxels of the 3D matrix of the object.

Computerized Tomography Images are much easier of interpreting than conventional X-ray images, because the characteristics are not put upon in the image. The exact positioning of the internal characteristics can also be identified. Besides, density differences inside of the object are easily identified in the same way that quantified, and they can be associated desirable or undesirable object or material characteristics. Finally, scanned parameters such as the thickness of the slice in the cross section or data collection time can be altered to be reached the best combination of image quality and inspection time.

4. Proposal for Automation Aerospace Application

The reliability of sounding rockets or satellite launching vehicles results from the growing number of flights happened and with some dispositive that guarantee how they were developed and manufactured. There are procedures for the warranty of the vehicles quality, and one of the used procedures is the accomplishment of Non Destructive Test. They are tests accomplished in materials, pieces and components, without destroying them and not interfering in the future use of the same ones. A type of non destructive test used in motors inspection is using X-Ray. It bases on the differentiated absorption of the penetrating radiation for the piece that is being tested. This absorption can be detected through a film or image tube, and it indicates the existence of a discontinuity. The advantage in presenting the radiographic foil, is a permanent registration test, and as disadvantage the high involved cost. Special cares with safety are a fundamental point in the accomplishment of the test.

With the objective to modernize this inspection system and to still turn it more efficient, it is proposed to implement an automated system to execute this task. It would be used a Computed Tomography then, coupled to a computational system that would control the acquisition and manipulation of these images, indicating the existence or not of possible anomalies.

Through the computed tomography, it is obtained fine traverse layers of the analyzed object, while in the x-ray an only image is supplied. In the computed tomography it doesn't happen the overlap of images as in the industrial x-ray, it would be then possible to define with larger precision the anomaly region.

4.1. Proposal of Automated System

As mentioned previously, the project will be composed of three items: controlling table, computed tomography and supervisory system.

The controlling table will be the dispositive where it will be placed the motor and that will control its movement (angular and longitudinal). To each movement an image will be obtained through the computed tomography, and controlling this synchronism will be a supervisory system. The functional specification is exposed in Fig. 2.

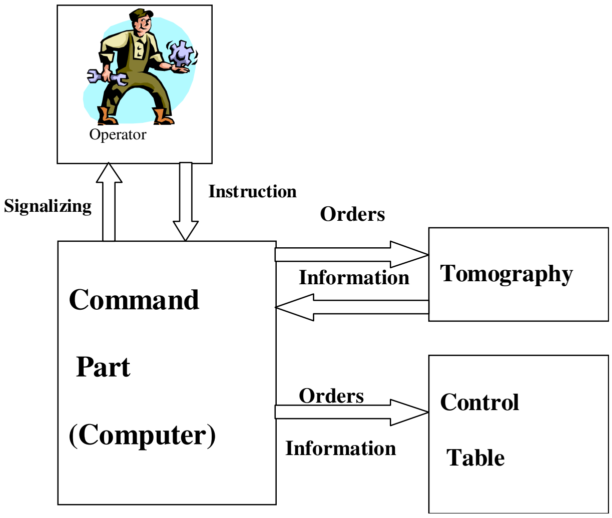

Figure 2 – Functional Specification

At first moment, in hardware terms, the vision system will be composed by a microcomputer, a computed tomography coupled in the controlling table. A Prototype of a System of Vision Generic is described in Fig. 3, according to (National Instruments, 2000a).

According to accomplished research, some tomography systems supply the image in the digital format, so in the accomplishment of this present work this situation was considered.

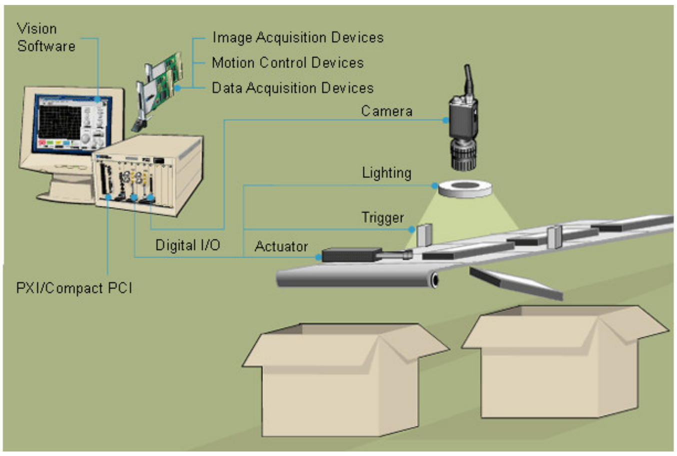

Figure 3 - Prototype of a System of Vision Generic.

Through this device, images will be acquired and transferred for a microcomputer in order to make possible their analysis. At first the system will have an automated phase, where the motor will be analyzed entirely. The images will be analyzed and the existence of flaws area verified. Detected the existence of flaws, the system signals and in case the user requests, the process is interrupted and it passes for a second phase. In this phase the system will become off-line, the controlling table will position the device exactly in the suitable place for the flaws area, and new tomographc images will be acquired, this time being used a larger refinement, or be diminishing the values of the intervals used by the controlling table among the acquisition of an image and other, so that it is made the analysis and classification of the found flaw.

This whole manipulation process and images analysis will be made through specific software, which will receive as entrance the images generated by the computerized tomography in file format (extension .gif, .jpg, .bmp). Starting from these images it will be possible to obtain related information for instance, to the incidence of flaws in areas of the motor considered critics and to obtain statistical data, that they will graphically be able to be represented, facilitating like this the interpretation of the results for the final user.

5. Implementation

To implement this system, it took place a research and study of open software to allow implementation and that could integrate control tools and analysis tools and manipulation of images. It gets to Lab VIEW - Virtual Laboratory Instrument Engineering Workbench (National Instruments ™), which is a supervisory system with resources that assist to the mentioned requirements.

According to (National Instruments, 2000b), Lab VIEW is a graphical programming language that uses icons instead of lines of text to create applications.

As the components of the system were not still acquired, it was opted initially to create a prototype. An application is being developed, simulating all the procedures graphically. The instructions are showed on computer display and the user could inform the necessary data to operate the specified system components, or be the control of the longitudinal and angular displacement. At each movement the image acquisition is exhibited for soon after its analysis, Fig. 4.

Figure 4 – Application Initial Screen.

Starting from the image acquisition, software resources are used for its analysis. The images used in this application, for demonstration, are typical images of the traverse cut of a sample of solid propellent destined to the vision tests.

As it is known the problem types that may occur, some rules were established, in order to detect occurrences that could really mean problems of the motor. Example in Fig. 5.

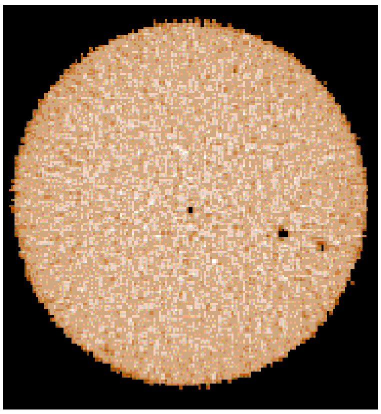

Figure 5 – Example of flaw area (holes).

It was considered that by definition all the images will have the same size in pixels (N x M), in order to use the same criteria for their manipulation. As one of the used resources is the creation of a mask, the image size is fundamental so that there are not analysis mistakes. The images used in this simulation are 629 x 697 pixels.

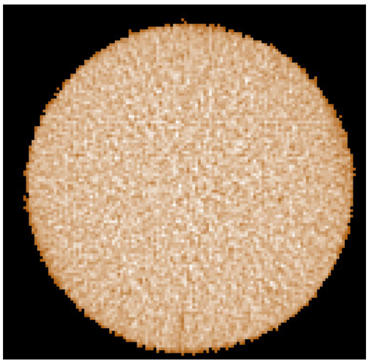

Figure 6 – Example of Pattern Image.

A technique tested to analyze the images was to define an image pattern and to compare it with the others, Fig. 6. After some tests, it was verified that the processing time for this comparison and analysis of images was relatively long, and it could become unviable the test of a motor of great dimensions. Sees that, other alternatives are being researched to accomplish this analysis, so that after properly tested and compared, be defined the procedure that better it is applied to the problem.

6. Final Comments

This work is an initial proposal, so its development is not concluded. The computed tomography system is not specified, and researches and tests of different procedures for analysis of the images continue being accomplished until being determined the most efficient and viable for the system. Some of these proposal goals are that the automated system is of easy manipulation, the interface is *user friendly* and that provides won in time and consequently efficiency in the inspection process.

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