Optical inspection methods as an alternative for the improvement of industrial processes

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ABSTRACT

A means of facilitating the transfer of Optical inspection methods knowledge and skills from academic institutions and their research partners into Panama optics and optical research groups is described. The process involves the creation of an Integrated Knowledge Group Research (IKGR), a partnership led by Polytechnic University of Panama with the support of the SENACYT and Optics and Optometry Department, Polytechnic University of Catalonia. The project is designed to address the shortage of key skills in the field of precision engineering for optical applications. The main issues encountered during the development of the knowledge transfer teaching and learning are discussed, and the outcomes from the first year of knowledge transfer activities are described. In overall summary, the results demonstrate how the Integrated Knowledge Group Research and new approach to knowledge transfer has been effective in addressing the engineering skills gap in precision optics for manufactured industrial sector.

Keywords: Knowledge Transfer, optical inspection, speckle, texture, industrial sectors, surface quality.

1. Introduction

Processes experienced changes in the world economy in the last 20 years have affected the developing countries, with negative effects on their economies due to low scientific and technological level they possess. Panama, as a member country of the sector, does not escape this great reality, with great limitations on high technology, confront serious difficulties to undertake projects and programs within the activities for the development of industrial sector. One of the most important aspects to watch in the industry in Panama, is the lack of funds for investment in research and development projects. The experience of the industrial sectors of developed countries around new or improved products is that their production, are supported by high investments in research projects that aim, bring to market these new or improved products. That is, creating new knowledge from which new applications arise in the industry.

When compared to other countries, the manufacturing firms of Panama share common characteristics with those of developing countries, reduced efforts for innovation. Strictly at the regional level, although Panamanian firms show a better compromise with innovation, this is strongly linked to the incorporation of technology through the form of knowledge embedded in capital goods. In effect, it is possible to find a direct relationship between innovation intensity, productivity and quality of employment, the larger being the expenditure in innovation, the higher the productivity level and the higher the number of qualified human resources [8], [9], [10].

Of the total number of firms to whom questionnaires were mailed and visited, 506 valid responses were received (71.2%). Table 1 shows the distribution of economic activities of these firms and Table 3 their size distribution.

Sector	Number of firms	Distribution (%)
Extraction of stone, sands and salt	10	1,98
Manufacture	273	53,95
Generation, transmission and distribution of electric energy	9	1,78
Construction	23	4,55
Wholesale	66	13,04
Retailers	44	8,70
Hotels and restaurants	32	6,32
Air, water and Land transport	28	5,53
Real State	16	3,16
Rest (Education, waste, residual water disposal, cultural, sports and entertainment activities	5	0,99
Total	506	100

Table 1 Distribution of the Economic Activities of the Firms in the Sample
Courtesy from Research, Technology and Innovation in the Private Sector of Panama

As shown in Table 2, firms employ a small number of personnel with the highest academic degree, only 0.41% of the total, while 4.5% correspond to foreign employees [8], [9], and [10]. In spite of this distribution, 91.8% of persons employed with this high academic degree are nationals of Panama, as shown also in the same Table. The bulk of employees concentrate in the group of people having finished secondary education (61.1%), almost all of national origin (99.4%).

	PhD	Master	Postgraduate.	Bachelor	High School	Other	Total
Employment Panama	0,41	1,74	1,03	17,44	61,11	18,28	100
Employment Foreign	4,55	10,62	3,20	36,76	38,11	6,75	100
Total	0,45	1,81	1,05	17,61	60,91	18,18	100

Table 2 Distribution of employment according to academic level in 2008
Courtesy from Research, Technology and Innovation in the Private Sector of Panama

	PhD	Master	Postgraduate.	Bachelor	High School	Other	Total
Employment Panama	91,18	94,84	97,34	98,19	99,46	99,68	99,13
Employment Foreign	8,82	5,08	2,66	1,81	0,54	0,32	0,87
Total	100	100	100	100	100	100	100

Table 3 Distribution of employment according to nationality of employees in 2008
Courtesy from Research, Technology and Innovation in the Private Sector of Panama

Research, development in Panama: Of the total number of firms in the sample 17% undertook in 2008 activities to generate new knowledge or new applications of existing knowledge [8], [9], and [10]. Of the firms that conduct R&D activities areas of application were: 57% in engineering, 43% in the natural sciences (mainly chemistry, environment and mathematics and informatics). Only 0.41% of people employed are engaged with R&D activities, of which 40.8% are researchers and 38.7% technicians, while 20.4% are administrative and support personnel.

Firms engaged in	% of the total sample	% of innovative firms
R & D Activities	17	37
Firms that count on	% of the total sample	% of innovative firms
R & D Laboratories	8	18
Human Resources		
Employment in R & D (% of the total employment in the firms)	0,41	
Employment in R & D (% of the average per laboratories)	6,6	

Table 4 Distribution of employment according to nationality of employees in 2008
Courtesy from Research, Technology and Innovation in the Private Sector of Panama

Innovation in the Panamanian Private Sector: The distribution of expenditure shows a strong bias towards the incorporation of external knowledge, 73% explained by the import of capital goods and 9.45% by expenditures in technology transfer, as shown in Table 5.

	Distribution of Expenditures in Innovation Activities (%)			Accumulated 2006-2008	Expenditure Innovation Activities as % of sales 2008	% of Imports 2006-2008
	2006	2007	2008			
Internal R&D	5.12	1,88	4,18	3,86	0.07	17,98
External R&D	0.21	0,20	4,47	3,32	0.05	80,43
Capital Goods	69.59	79,17	71,94	73,00	1,08	79,64
Hardware	7.65	4,66	1,95	2,95	0,05	26,68
Software	8.19	5,21	1,76	2,96	0,05	26,42
Technology transfer	0.26	0,13	12,86	9,45	0,17	0,73
Industrial design and engineering	0.66	3,11	0,95	1,31	0,02	24,49
Management	0,11	0,79	0,25	0,33	0,01	3,10
Training	2,17	1,31	0,59	0,87	0,02	16,32
Consulting	6,03	3,55	1,05	1,95	0,04	3,89
Total	100	100	100	100	1,54	

Table 5. Effort in innovation activities 2006-2008
Courtesy from Research, Technology and Innovation in the Private Sector of Panama

These results show the degree of deficiency we have in the area of innovation and technology transfer, which is why our project "Optical inspection methods and their applications in the manufactured industry: Knowledge transfer to Panamanian industry", will contribute greatly to improving this identified problem. Therefore, this proposal is to undertake basic and applied research in a topic of border handling the international scientific community, such as the optical inspection methods area, in addition to digital image processing [1], [2], and [10]. Furthermore, the project will allow the formation of human resources in topic where the whole world is betting, mainly by large profits, at all levels, this implies and Panama cannot be the exception.

2. Description of project and results

This project is part two strategic lines of the National Strategic Plan for Science and Technology in relation to the generation of knowledge, in this case in basic sciences, can be used as a tool to contribute to national development through research groups formally established and concrete results for surface characterization and evaluation of materials using optical metrology and digital image processing [3], [4], [5], [6], [7]. The project also has an impact on the issue of the quality of industrial production, where the "National Strategic Plan for Science and Technology 2015-2019" [8], [9], [10] notes that Panama has traditionally been a technological structure that allow amendments and innovation in equipment and techniques used, which allow the investment recovers in less time, i.e. can improve our industrial weaknesses.

Conduct basic and applied research in the field of inspection of materials will bring significant benefits to the near future. Since replacing equipment and methods that are currently used in industry [10], for other non-invasive, and whose speed of processing of information obtained faster, is a new challenge facing the Panamanian business sector for success in improving the product quality in this sense is to develop a "prototype" for the real time inspection in production lines. The main beneficiaries of this project will be the national and international scientific community, the country's productive sectors, Panamanian university students, where these issues can be included in the curricula of some careers, graduate level thesis. In the medium and long term, all that is developed in this project and others in the future, we predict that they will have a significant impact on the birth of some kind of technology company that is able to incubate in some of the business incubation systems that already exist in the country, with one of them at the Technological University of Panama.

2.1 Setup system configuration

The setup is built with a CCD camera Pike F-032B with 640 x 480 effective pixels, with 8 bits per pixel, a 5mW He-Ne laser with a wavelength of 632, 8 nm, and a beam expander, the power of which can be adjusted to avoid the digital camera signal saturation (Fig 4). The camera is in the sample normal direction. The format of the images was 640×480 pixels. The angle between the incident laser light beam and the normal direction was fixed to be as small as practical to reduce the effect of the direction of surface microstructure in the surface roughness evaluation. In the setup, the angle is 25°. By means of the simple setup, different speckle pattern images from paper surface roughness samples were obtained [28], [29].

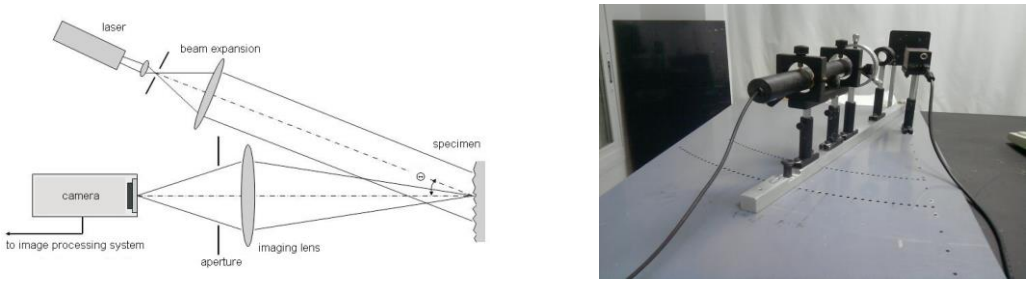


Figure 4. Experimental system

2.2 The properties of the speckle contrast

When we project a monochromatic plane wave over a surface that is assumed to be rough and its correlation function depends only on the differences of measurement coordinates, then the relationship between the height variations of the surface and the amplitude variations of the scattered wave is, in general, an extremely complex one, influenced by variations of surface slope and their effect on reflection, multiple scattering, and shadowing [9].

If, $I=(x,y)$ is the image that has "N" pixels, we define the mean "$\bar{I}$" of the image and the standard deviation "σ" as:

$$\bar{I}=\frac{\sum_{1}^{N} I(x,y)}{N} \tag{3}$$

$$\sigma=\sqrt{\frac{\sum_{1}^{N}(I(x,y)-\bar{I})^{2}}{N}} \tag{4}$$

Then the contrast is defined as [9]:

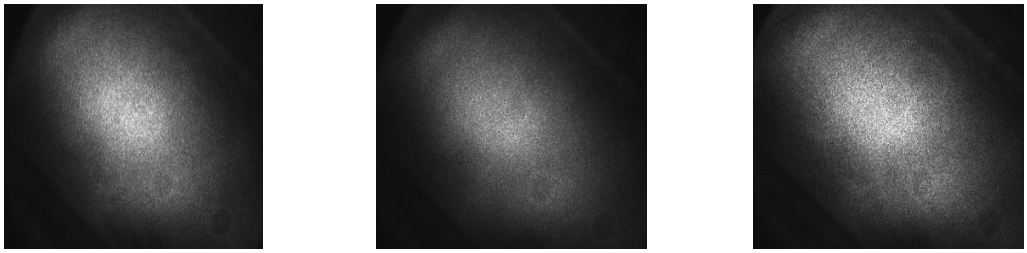
$$C=\frac{\sigma}{\bar{I}} \tag{5}$$

Contrast is a measure of how the fluctuations of intensity are in a speckle pattern compared with the average intensity.

3. Results

We have characterized the roughness of 8 papers of different types, with Roughness, an air leak method Bendtsen and calculating the contrast using speckle.

Figure 5, shows three images of the speckle pattern variations for different rugosities. This implies that the speckle pattern texture properties change with the surface roughness, and it is possible to extract the surface roughness from the speckle pattern texture images using the speckle contrast.



B-1 B-3 B-4

Figure 5. Speckle pattern variations against the special papers surface roughness.

Table I. Results of the measurement of the roughness obtained with the method Bendtsen and using the inverse of the contrast of the image of speckle for 8 special papers.

Samples	Bendtsen (ml/s)	1/Contrast
B-1	19	0.9970
B-2	66	1.0801
B-3	52	0.9905
B-4	72	1.1119
B-5	57	0.9791
B-6	72	1.0006
B-7	242	2.4654
B-8	189	2.4430

In figure 6, we compare the results obtained calculating the inverse of the contrast with the results obtained with the Bendtsen method.

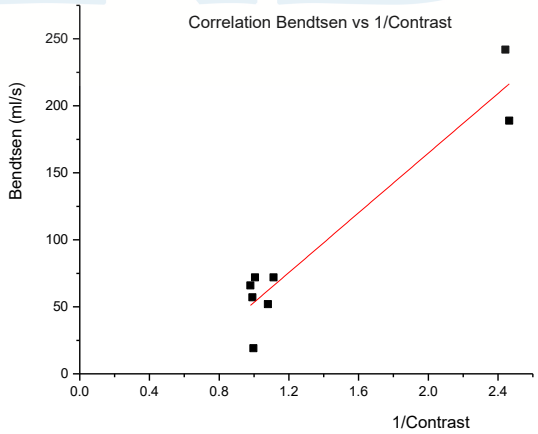


Figure 6. Bendtsen method versus Inverse of contrast (R^2 = 0.90396)

4. Conclusions

Perform a motivation campaign manager of the industrial establishments in order to achieve greater collaboration and more reliable information on this type of research. In which we mention, meetings with the most important groups such as Union of Industrialists of Panama, Panamanian Chamber of Commerce,

Association of Small and Medium Enterprises, among others. They have been shown to industries in Panama that processes optical inspection and methods of digital image processing provide innovative solutions in the field of industrial automation processes which dramatically improves productivity and management the quality of manufactured products, thus increasing their competitiveness in the market. A large number of industrial activities have benefited from the use of these technologies, such as in the areas the production of paper, textiles, metal, glass, industrial machinery components, electronics manufacturing, pharmaceutical and medical among others.

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