DEVELOPMENT OF A USEFUL IMAGE PROCESSING SOFTWARE UTILITY FOR EFFICIENT DIAGNOSTIC MONITORING OF CIRCULAR MANUFACTURES

KOLIOPOULOS T. C.[1], AXINTE C. [2], KOLIOPOULOU G. [3]

[1]*Technological Educational Institute of Athens, Faculty of Applied Sciences and Engineering, Athens, Greece,*
[2]*University of Bacau, Faculty of Engineering, Romania*
[3]*Department of Experimental Physiology, Faculty of Medicine, University of Athens, Greece.*

Abstract: This paper presents a quick and accurate image processing monitoring method, which confronts the most common met problems in the quality assurance and safety certification of circular manufactures. An analysis is presented for mapping out life cycle diagnosis of manufactures within the field of circular geometries. Proper solutions are presented for the examining problem in order to develop effective image evaluation and mapping out methods of circular geometric manufactures. In the end, useful conclusions are made for the mapping out, risk assessment, safety certification and lining maintenance works within the management of manufactures' technical projects.

Keywords: manufactures' diagnostic surveying methods, manufactures' quality assurance, informatics and software tools for mapping out circular geometries, image processing, spatial analysis, environmental impact assessment, risk assessment, topometry, safety certification of manufactures, land uses, public health.

1. INTRODUCTION

Nowadays, problems like the continuously increasing energy consumption, environmental pollution, climatic change, forest fires, ecoterrorism, industrial accidents, toxic emissions, bioterrorism and others are becoming common and frequent met due to the quick industrialization of our life without taking the right measures in time. Therefore, several efficient informatics computer applications are necessary so as to provide proper solutions to particular environmental management problems as they are increasing in time [1,2,4,7,11,16,17,19,23,21,28,32]. A confrontation to the latter hazards could be given by the right monitoring and quality assurance of manufactures, environmental works and structures through the application of quick and accurate useful lining projects for mapping out the life cycle of manufactures and for several management cases, like civil rescue in emergencies; system' analysis control and biosafety; public health protection; life cycle analysis of eco-designs and other associated ones.

Efficient eco-design sustainable projects and environmental management I.S.O. standards have to be realized so as to confront the environmental crisis of our planet [8,31]. It is obvious that without taking the right measures in time, there will be an environmental collapse with unexpected consequences. In these circumstances, it is imperative necessary to find efficient ways in terms of timing and accuracy for the monitoring, project management and maintenance of manufactures using proper lining methods and image processing software utilities. Below is analyzed an efficient mapping out method for safety certification and quality assurance of manufactures which follow circular geometrical characteristics. It can have application on several water flow stream controllers on several agronomic hydraulic infrastructure works on quality assurance and safety certification of kit irrigation and drainage manufactures.

Technical works and their manufactures are becoming more complex as the necessities of our life are getting increased in time. Quick and accurate monitoring methods, manufactures' safety certification and ISO investigations are needed for any probable maintenance works of manufactures. It is obvious that without taking any right measures in time, there will be a disaster with unexpected consequences. In these circumstances, it is imperative necessary to find efficient mapping out monitoring methods so as to set up the right maintenance works. In such cases, a good timing of the project management and spatial monitoring is demanded in order to save civic populations, protect economic geographic resources and to minimize any associate risks and environmental impacts to any receptors. The investigation of circular segments could have application not only for monitoring life cycle of manufactures but also on image processing of orthophotomaps for identifying vegetation encroachments or investigation of change of land uses' boundaries on circular segments due to several reasons, making useful conclusions [1,5,6,10,13,14,16,17,19,22,28].

2. THE NECESSITY OF STRATEGIC ENVIRONMENTAL MANAGEMENT AND THE UTILIZATION OF GEOMETRICAL ANALYSIS OF CIRCULAR MANUFACTURES - APPARATUS FOR MONITORING METALLIC CIRCULAR SEGMENTS OF MANUFACTURES COVERED BY GLASS OR PLASTIC PROTECTION MATERIALS

A product designer can influence each of the product life cycle phases through careful design (fig. 1). It has been estimated that 70 to 80% of the cost of product development and manufacture is determined by the decisions made in the initial design stages [32]. Except the saving of cost of product another important issue is the monitoring of environmental impacts of such product. A proper investigation of any manufactures associated with environmental management systems should be applied according to ISO 14001 standards [8]. During the investigation of an environmental system should be considered the right environmental aspects and associated things, which are related to an eco-design product (fig. 2).

Fig. 1 Flow chart of green product design and eco-design steps, ISO 14001 appliance.

Requirements	*Technical*	*Environmental*	*Level*
customers	process	air	site/plant
legislation	storage	water	department
permits	transfer	waste	installation/ equipment
banks/insurance	transport	soil and groundwater	subcontractor/ supplier
complaints	utilities	energy consumption	
corporate, and Policy guidelines	product	nuisance	
		external safety	
		product	

Fig. 2 Environmental aspects and associated things to consider in an environmental system.

However, in this paper is analyzed the circular geometrical monitoring and safety certification of metallic manufactures within a plastic or glass cover based on x ray radiographic images. The digital x-ray radiographer Explor-X 65.was used for the image which is evaluated in this paper, where a view of it is presented in fig.3 [33].

Fig. 3 View of a digital x-ray radiographer Explor-X 65.

Fig. 4 An x ray radiography taken by Explor-X 65 presenting technical characteristics of a metallic manufacture consisted by a metallic circular ball on the edge of a metallic spring.

In fig.4 is presented a zoom of a one-centimeter length typical kit manufacture consisted by a small metallic ball located on the edge of a thin metallic spring, which is covered by a thin glass and it has been recorded by the x ray radiographic equipment Explor-X 65, with 0.4 level of radiation. The examining manufacture has a common use in several technological applications i.e. spraying devices, water canal flow controllers in irrigations-drainage agronomic infrastructure works, flood controllers, environmental investigations of circular land uses' plans and others.

3. AN IMAGE PROCESSING MONITORING METHOD OF CIRCULAR SEGMENTS OF MANUFACTURES

Firstly for a taken radiographic image several filters could be used for the improvement of its clarity depending on its particular image characteristics of circular geometries within complex curves [9,12,15,18,20,21,22,24,25,26,27,30]. The next step on which is focused on this paper is to identify the level of deformation of manufactures based on radiographic images or in bigger scale change of land uses' boundaries on plans based on aerial photographs. For monitoring the level of deformation of the edge of a circular segment a useful computational geometrical analysis is presented below based on s and h elements (fig. 5, 6, 7).

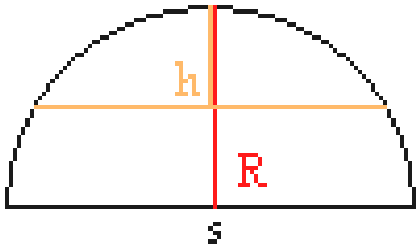

Fig. 5 Geometrical characteristics of a circular segment for $h \leq R$ and $s \leq 2R$, when h=R then s = 2R.

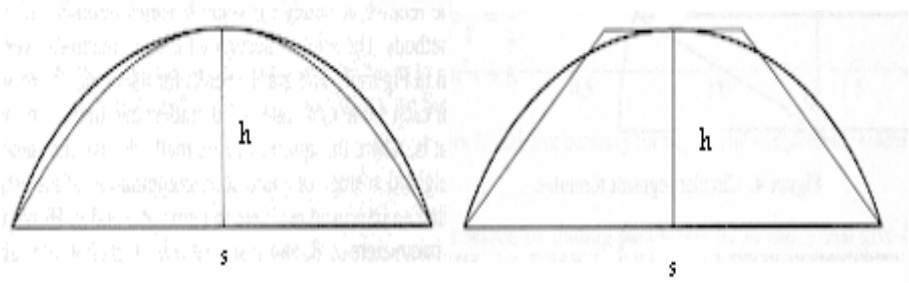

Fig. 6 Geometrical characteristics between a parabolic and
a trapezoidal approximation respectively of a circular segment.

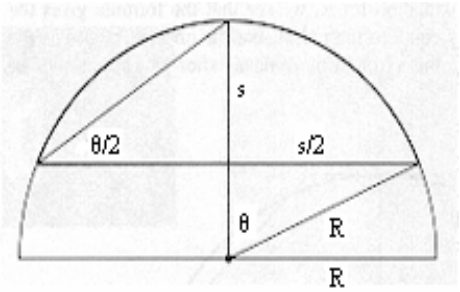

Fig. 7 Investigation of drawing geometrical relations for the development of circular segment formulas.

According to figures 5 a circular segment could be approximated by a parabolic or a trapezoidal approximation respectively. Archimedes, Greek ancient geometer, proved that the area A of a segment of a parabola is the 4/3 the area of the triangle with base s and height h, where h and s are the same quantities as for a circular segment but applied to a parabola instead, which means that A = h * s * 2 / 3 [3]. The latter particular formula is quite accurate when the height of the segment is much smaller than the radius, but the error increases as the height approaches the radius of the circle. However, for the trapezoidal approximation the area of the examining segment is A = 0.5 * (s + h) * h. As both trapezoidal and parabolic approximations include an error in approximated estimation of the area of a circular segment another accurate monitoring method for circular segments within manufactures and land uses is demanded. Therefore, the mathematical and respective technical problem is transferred mainly on how could be increased the accuracy based on image processing of a

radiographic image for the determination of a probable deformation of a circular segment within manufactures. The same problem could be investigated for aerial digital photographs of land uses' boundaries on given topographical plans, applying properly ISO standards for particular environmental problems. A useful solution of the latter problem is analyzed below based on a filtered image, analyzing its s, h geometrical elements.

Based on fig. 7 and according to geometry for $0 \le \theta \le \pi / 2$, since we are considering segments that are at most a semicircle with radius R, we have valid the next formulas:

$$s = 2 * R * \sin \theta \text{ , } h / s = 0.5 * \tan (\theta / 2), \; h = R * (1 - \cos \theta), \; A = (\theta - \sin \theta * \cos \theta) * R^2 \qquad (1)$$

However, based on fig. 5 and on trigonometry we find below the exact formula for the area of the circular segment in terms of s and h.

Therefore, based on fig. 5 we have valid the next formulas:

$$h / s = 0.5 * \tan (\theta / 2), \; A = (\theta - \sin \theta * \cos \theta) * R^2, \text{ and } R^2 = (R - h)^2 + (s / 2)^2 \qquad (2)$$

From the latter above formulas it follows the following formulas:

$$\tan\left(\frac{\theta}{2}\right) = \frac{2*h}{s}, \; \sin\left(\frac{\theta}{2}\right) = \frac{2*h}{\sqrt{s^2 + 4*h^2}}, \; \cos\left(\frac{\theta}{2}\right) = \frac{s}{\sqrt{4*h^2 + s^2}} \text{ and } R = \frac{s^2 + 4*h^2}{8*h} \qquad (3)$$

Substituting the above latter expressions for θ and R into the area formula and based on trigonometry, it yields the next useful computational formula for the area A of a circular segment approximation which can be calculated based on identified properly s, h elements of a filtered digital processed image.

$$A = \frac{\left(s^2 + 4*h^2\right)^2}{32*h^2} * \arctan\left(\frac{2*h}{s}\right) - \frac{s*\left(s^2 - 4*h^2\right)}{16*h} \qquad (4)$$

The above calculated area A of a probable deformed manufacture or a downgraded land use within circular segment geometry could be compared with other archived past images of the examining investigated manufacture or other land uses which follow similar geometrical characteristics in order to identify the magnitude of change of the examining image characteristics. Therefore, the above useful presented image processing method of circular segments based on s, h geometrical elements could be applied on any respective applied technical projects for the monitoring and maintenance of several manufactures and associated technical projects with circular segments geometries [16,17,18].

4. CONCLUSIONS

The presented image processing diagnostic monitoring method should be combined with relative ISO 14001 standards for the environmental quality assurance and proper management of environmental systems. The presented monitoring method is easy applicable not only on several circular manufactures of manufactures but also on monitoring the boundaries of circular segments of land uses based on orthophotomaps, taking any necessary relative safety and maintenance measures in time.

Hence, it can be used as an efficient risk assessment tool for both latter cases. Its results should be taken into account in the cases that maintenance of manufactures in several technical projects is demanded. However, circular segment computations should be learned to students during their drawing courses as well as during their computer ones so as to have a better experience in several spatial analysis applications for the development of image processing tools within computer multimedia applications; eco-design manufactures' quality assurance and environmental investigation surveying software.

Acknowledgements
The authors would like to thank the support of the Erasmus Project "Eco-design: An Innovative Path towards Sustainable Development", 51388-IC-1-2005-1-RO-ERASMUS-MOD-4, funded by E.U. The conclusions expressed herein represent the findings of the authors and do not necessarily represent the views of E.U., or of the participants in the relative Project.

REFERENCES

[1] Aldrich, T., Griffith, J. (1993). Environmental Epidemiology and Risk Assessment, (Ed. Cooke, C.), Van Nostrand Reinhold, New York, U.S.A.
[2] Atmatzidi, A., Glampedaki, M. (1993) Computer PC/PS in Education, Laboratory and Profession, ION Pubs, Athens, Greece.
[3] Britannica Encyclopaedia (2000), Britannica Pubs, U.K.
[4] Dangermond, J. (1990) A Classification of Software Components commonly Used in Geographic Information Systems, Introductory Readings in GIS, Taylor and Francis Pubs.
[5] Dickison, G.C. (1970) Maps and Air Photographs, Edward Arnold Publishers Ltd., London, U.K.
[6] Frank, A.U. (1995) GIS Materials for a Post-Graduate Course: Vol. 2 – G.I.S Technology, Technical University of Vienna, Department of Geoinformation.
[7] Informatics and Computer Technology Encyclopaedia (1986) New Technologies Pubs, Athens, Greece.
[8] I.S.O. 14001:2004, Standards and Regulations for Investigation, Monitoring, Management, Certification and Improvement of Environmental Systems, I.S.O. Pubs.
[9] Jain, A.K. (1989) Fundamentals of digital image processing, Prentice Hall Pubs.
[10] Jones, C.B. (1997) Geographical Information Systems and Computer Cartography, Longman Press.
[11] Jerke, N. (1999) Visual Basic 6: The Complete Reference, Osborne. McGraw Hill Pubs.
[12] John, C. (2008) Manual of Digital Photography, National Geographic Pubs.
[13] Kaparis, S. (1993) Special Subjects of Topography, Ministry of Education Pubs, Athens, Greece.
[14] Kaparis, S. (1997) Lining Methods of Technical Works, Educational Notes, Technological Educational Institute of Athens, Athens, Greece.
[15] Kavouras, D. (2007) Image and Signal Processing of Radiographic Medical Images, Educational Notes, Technological Educational Institute of Athens, Athens, Greece.
[16] Koliopoulos T. C., Koliopoulou, G., Axinte C. (2007) The use of efficient lining methods combined with numerical models for optimum project management of manufactures, M.O.C.M Journal, Number 13, Volume II, pp. 379-384.
[17] Koliopoulos T. C., Koliopoulou, G., Axinte C. (2007) An efficient Iterative Angle Trisection lining method for the management of curved manufactures in technical designs, M.O.C.M Journal, Number 13, Volume II, pp. 391-396.
[18] Lawrence, J.D. (1972). A Catalog of Special Plane Curves, Dover Pubs, New York.
[19] Lintz, J., Simone, H.D. (1976) Remote Sensing of Environment, Addison – Wesley Pubs Co, London, U.K.
[20] Lynn, P.A., Fuerst, W. (1990) Digital signal processing with computer applications, John Wiley & Sons Pubs.
[21] Matlab (2008) Matlab Reference Guide, MathWorks.
[22] Mertikas, S. (2006) Remote Sensing and Digital Image Processing Analysis, ION Pubs, Athens, Greece.
[23] Mousas, V. (2006) Programming for Engineers with Fortran 95/2003, ION Pubs, Athens, Greece.
[24] Oppenheim, A.V., Schafer, R.W. (1975) Digital Signal Processing, Prentice Hall Pubs.
[25] Papamarkos, N. (2005) Digital Image Processing and Image Analysis, Gkiourdas Pubs, Athens.
[26] Robert, M. (1987) Digital Signal Processing, Addison Wiley Pubs.
[27] Rosenfeld, A., Kak, A.C. (1982) Digital picture processing, Academic Press Pubs.
[28] Shamsi, U.M. (2002) G.I.S Tools for Water, Wastewater, and Stormwater Systems, A.S.C.E. Press, U.S.A.
[29] Stearns, S.D., David R.A. (1988) Signal processing algorithms, Prentice Hall Pubs.
[30] Stanley, W.D., Doughtery, G.R. Doughtery, R. (1984) Digital signal processing, Prentice Hall Pubs.
[31] The Monography Ecodesign for sustainable development, vol. I – IV, edited in the frame of Erasmus Project "Eco-design: An Innovative Path towards Sustainable Development", Brasov 2007.
[32] Tsouroplis, A., Klimopoulos, S. (1991) Introduction to Informatics, Pelekanos Pubs, Athens, Greece.
[33] Villa Sistemi Medicali (1996) EXPLOR-X 65 and 70 with timer mod. CCD User's Manual, Villa Sistemi Medicali Publication, Italy.