COMPUTER VISION BASED TECHNIQUE FOR ONLINE MONITORING OF BLANK GEOMETRY IN SHEET METAL FORMING PROCESSES

PhD. eng.Marin Florin Bogdan,PhD.eng. Epureanu Alexandru,
PhD.end. Maier Catalina, PhD.eng. Marinescu Vasile
"Dunărea de Jos" University of Galați

Abstract

The objective of this research is to develop a computer vision technique for online monitoring of blank geometry in sheet metal forming processes. An on-line machine vision system is presented. The acquisition system includes a camera and a diffuse illumination system. Camera and illumination have been mounted in the metal forming device to monitor de displacement of tracking elements. The acquired images are processed in order to assess the current position of the tracking elements.

KEYWORDS: sheet metal forming, computer vision

1. Introduction

Sheet metal forming is a widely used and costly manufacturing process. A limiting factor in design process is the necessity of producing the desired shape with no wrinkles in the sheet metal. As manufacturing industries are growing rapidly, the demand for precise and accurate information concerning parts design and formability of sheet metal becomes essential.

The objective of this research is to develop a computer vision technique for online monitoring of blank geometry in sheet metal forming processes.

Computer Vision offers consistency, accuracy and repeatability, in contrast to the subjectivity, fatigue, slowness, and cost associated with human inspection. The advantages of using a machine vision system include a decrease in the time required for measurement as well as greater accuracy of measurements and better flexibility than conventional methods. Adopting this methodology, the user's skill has no influence on the final measurement and a faster measurement process has been possible. An on-line machine vision system is presented. The acquisition system includes a camera and a diffuse illumination system. Camera and illumination have been mounted in the metal forming device to monitor de displacement of tracking elements. The acquired images are processed in order to asses the current position of the tracking elements.

The challenge of the current research is to develop a powerful technique to assess the current position of mechanical elements with high precision, dealing with issues such as light interference and profile recognition. Image segmentation is one issue to be solved considering the light interference.

Image segmentation has been extensively investigated in the past decades with the development of a large number of image-segmentation methods [1, 2, 3, 4, 5].

The aim of image segmentation is the identification of partition of the image into a set of regions which are visually distinct. Image segmentation is a fundamental step in many computer vision applications. Generally, the choice of a segmentation algorithm, or parameterization of a given algorithm, is selected at the application level and is fixed for all images within that application. Our goal is to create a stand-alone method to evaluate segmentation quality.

The simplest segmentation process is to find the border between regions with different luminosity or color. In this case, the gray level of an object is useful in separating it form other objects and from the background for the purposes of the analysis. The simplest segmentation process consists in object/background discrimination by transforming the gray-level object into a black object and the gray-level background. The use of binary image is very common in many Computer Vision applications because of its dimensionality reduction. To have a good segmentation result it is necessary that object and background have sufficient contrast level.

Several authors study computer vision techniques in deep drawing processes [6], [7], [8], [9], [10].

2. Applying the method

The sensing device is a camera mounted in the deep-drawing device [Fig. 1]. The camera acquires the scene and transfers the acquired images to a computer for processing, analyzing the images and assessing the tracking elements current position. With this hardware structure, as shown in Fig. 1, the goal of the developed technique is to asses sheet metal wrinkles.

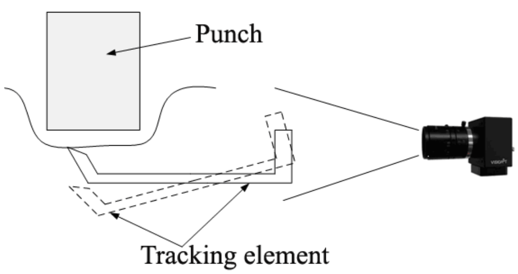

Fig. 1. *Measuring system architecture*

The monitoring systems of metal forming processes presume a series of tracking elements whose position is continuously modified. The camera assesses the current position of tracking elements and measures the relative displacement of the elements. In Fig. 2 shows the scene to be analyzed by the camera. The software aims to identify tracking elements relative displacement. Problems arising in implementation of such a system are camera calibration and image segmentation. Camera calibration aims at detecting errors due to imperfections of intrinsic camera lens. Segmentation problem is particularly important because the system should have a high precision (Fig.5).

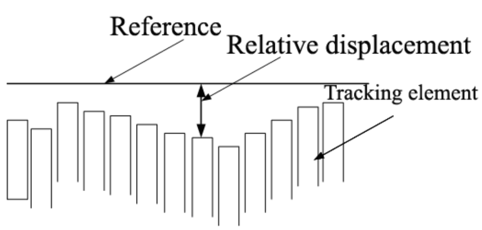

Fig. 2. *Scene to be identified*

In order to assess 2D position in image with high precision we need to handle two important preparatory phases, camera calibration and segmentation.

Accurate calibration of a camera is of most importance in computer vision systems with high precision. Camera calibration is needed in various applications which involve measurements, such as stereo vision, robot navigation, inspection and automated assembly, robot vision. One important aspect of calibration is estimating the internal or intrinsic parameters of the camera. These parameters determine how the image coordinates of any point may be computed, given the three-dimensional (3-D) position of the point with respect to the camera.

Cameras are not perfect and show a variety of distortions and aberrations. For precise measurements, the most important issue is the distortion that the camera exhibits. Most cameras have lenses that exhibit a substantial amount of distortion. The camera assembly is often misaligned internally, and the CCD sensing array may not be orthogonal to the optical axis of the lens as shown at the bottom of Fig. 3.

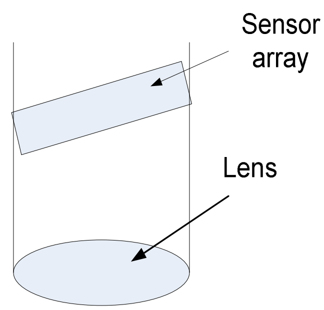

Fig. 3. *Misalignment of the lens with the sensor array*

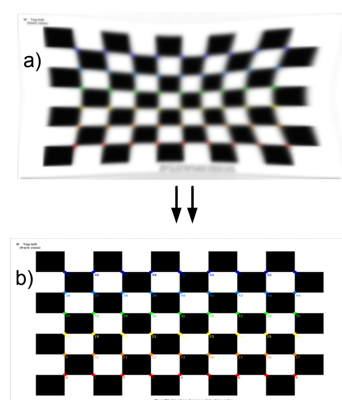

Fig. 4. *Pattern use for camera calibration: a) exaggerated distortion produced by camera lens; b) compensated distortion*

In Fig. 4 is shown the lens error that produces the distortion of the image. The image shown in Fig. b) is the calibration pattern used for calibration. The aim of calibration is the identification of parameters to assess correctly the current scene.

The camera intrinsic parameters are:

(1) effective focal lengths,

(2 optical center,

(3) distortion coefficient

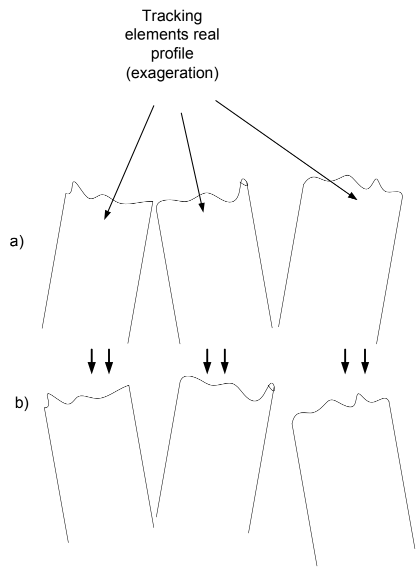

Fig. 5. *The issue of finding the tracking elements profiles*

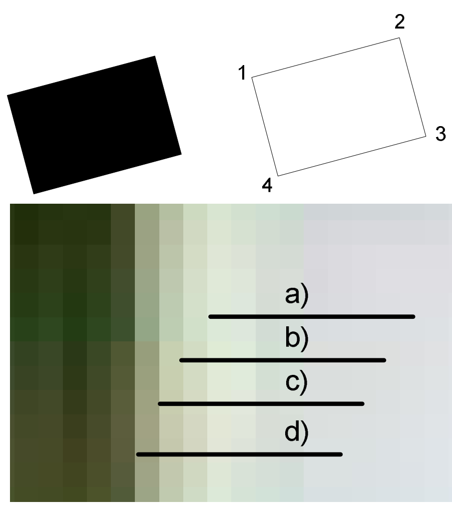

Fig. 6. *Segmentation problem with different levels of gray*

After these procedures, it is possible to compute all measurements, based on the methodologies presented previously. The measurements are in pixel unity and must be converted to millimeters. To get the conversion factor, a standard object was photographed using the camera in different heights (Tab. 1). Observing these results we note that the conversion factor (λ) increases as the height diminishes. Seeing that λ expresses the amount of pixels that corresponds to 1 mm, we realize that in order to get more accurate measurements, the camera must be next to the analyzed part.

Table 1. *Determined value per pixel*

Pixel	Value (mm)
Width	0.017
Height	0.013

One of the problems consists in the determination of the tracking elements profiles.

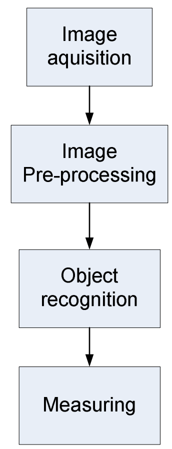

Fig. 7. *Steps in artificial vision measuring systems*

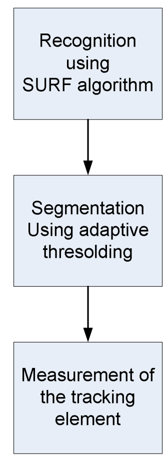

Fig. 8. *Measuring algorithm*

The algorithm to measure tracking elements position is described in Fig. 8.

The first step is to recognize the tracking element position considering its profile [Fig.5].

The second step is the segmentation where the regions are separated to precisely recognize the border between background and the tracking element.

The third step is to assess the position of the region previously identifying the tracking element.

3. Conclusion

The essential problem of using computer vision techniques consists of image quality, because image analysis requires that features of interest be well defined, either by edges, brightness or color. The preprocessing step is essential in this context. The choice of the most appropriate method to pre-processing and threshold the image, in its two main components (the object and the background), must be sufficiently robust in order to generate images without quality loss.

Each algorithm should be tested considering accuracy and repeatability. For that reason, we should compare the best relationship between the spent time in the measurement process and its acquired accuracy.

This research has successfully developed a computer vision based technique for online monitoring of blank geometry in sheet metal forming processes integrated system in PC-based platform. Based on a single CMOS camera mounted on the deep-drawing device, the system can assess occurring of wrinkles in sheet metal. Future development will include 3D reconstruction of the scene in order to assess sheet metal forming errors.

Acknowledgements.

The authors gratefully acknowledge the financial support of the Romanian Ministry of Education and Research through grant IDEI-1759.

REFERENCES

[1] Gern, A., Moebus, R., Franke, *Vision-based lane recognition under adverse weather conditions using optical flow*, Proceedings of IEEE Intelligent Vehicles Symposium, pp. 652–657 (2002).

[2] E. Borenstein, S. Ullman. *Learning to segment,* Conference on Computer Vision, 315–328, 2004.

[3] C. Carson, S. Belongie, H. Greenspan, J. Malik. Blobworld, *Color- and texture-based image segmentation using EM and its application to image querying and classification.*, IEEE Transactions on Pattern Analysis and Machine Intelligence, 2010.

[4] Y. Gdalyahu, D. Weinshall, and M. Werman. *Stochastic image segmentation by typical cuts*, IEEE Conference on Computer Vision and Pattern Recognition, 596–601, 1999.

[5] R. M. Haralick and L. G. Shapiro. *Survey: Image segmentation techniques*. Computer Vision Graphics Image Process, 29:100–132, 1985 24(8):1026–1038, 2002.

[6] J.Duflou, J. Váncza, R. Aeren, *Computer aided process planning for sheet metal bending: A state of the art,* Computers in Industry, Volume 56, Issue 7, 747-771, 2005

[7] J.R. Duflou, T.H.M. Nguyen, J.-P. Kruth, D. Cattrysse, *Automated Tool Selection for Computer-Aided Process Planning in Sheet Metal Bending*, Manufacturing Technology, 54 (1), 451-454, 2005.

[8] G. L. Damoulis, E. Gomes, G. F. Batalha, *New trends in sheet metal forming analysis and optimization trough the use of optical measurement technology to control springback*, International Journal of Material Forming, 3 (1), 29-39, DOI: 10.1007/s12289-009-0413-0, 2010.

[9] Z. X. Gan, H. Zhang and J. J. Wang, *Behavior-Based Intelligent Robotic Technologies in Industrial Applications Robotic Welding*, Intelligence and Automation, Control and Information Sciences, 362, DOI: 10.1007/978-3-540-73374-4_1, 2007.

[10] *Understanding and Applying Machihe Vision* Second Edition, Revised and Expanded Nello Zuech Vision Systems International Yardley, Pennsylvania, ISBN 0-8247-8929-6, 1998.

[11] F. Gayub, J. L. González, E. Fuente, F. Miguel, J. R. Perán, *On-line machine vision system for detect split defects in sheet-metal forming processes*, 0-7695-2521-0/06, IEEE, 2006.

[**12] D .Barrientos, E. Fuente, E. Barrentos, F.J. Trespaderne**, *Machine Vision System for defect detection in metal shhet forming process,* International Conference of Visualization, Imagining And Image Processing, 289-294, 2001.

Tehnică bazată pe vederea computerizată pentru monitorizarea on-line a geometriei semifabricatului în timpul proceselor de formare a foilor metalice

—Rezumat—

Scopul acestei cercetări este de a dezvolta o tehnică bazată pe vederea computerizată pentru a monitoriza on-line geometria semifabricatului in timpul proceselor de formare a foilor metalice. Este prezentat un sistem de urmărire on-line. Sistemul de achiziție include o cameră şi un sistem de iluminare cu lumină difuză. Camera şi sistemul de iluminare au fost montate pe dispozitivul de formare pentru a monitoriza deplasarea elementelor de urmărire. Imaginile achiziționate sunt procesate în scopul de a determina poziția curentă a elementelor de urmărire.