Image blur analysis for the subpixel-level measurement of in-plane vibration parameters of MEMS resonators

Le H.V., Gouiffes M., Parrain F., Bosseboeuf A., Zavidovique B.

College of Technology, Vietnam National University, Hanoi, 144 Xuan Thuy, G2-206, Cau Giay, Hanoi, Viet Nam; Institute d'Electronique Fondamentale, Bat. 220, Centre Scientifique d'Orsay, F91405 Orsay Cedex, France

Abstract: The objective of this work is to develop a reliable image processing technique to measure the vibration parameters on every part of MEMS resonators using microscopic images of the vibrating devices. Images of resonators vibrating in high frequencies are characterized by the blurs whose point spread functions (PSFs) are expressed in a parametric form with two parameters - vibration orientation and magnitude. We find it necessary to use the reference image (image of the still object) when analyzing the blur image, to achieve a subpixel-level accuracy. The orientation of the vibration is identified by applying the Radon transform on the difference between the reference image and the blur image. A blur image is usually modeled as a convolution of the PSF of the vibration with the reference image and added noise terms, assuming uniform vibration across the view. The vibration magnitude could then be recovered by using a minimum mean-squared error (MMSE) estimator to find the optimal PSF with the identified orientation. However, in real images only parts of the image belong to the vibrating object and the vibration may not be uniform over all parts of it. To overcome that problem, we use local optimization with a mean of weighted squared errors (MWSE) as the cost function instead of MSE. Indeed, it is capable of suppressing non-vibrating high-frequency components of the image. Sensitivity analysis and experiments on real images have been performed.

Author Keywords: Blur; MEMS resonators; Point spread function; Radon transform; Subpixel; Vibration

Index Keywords: Image analysis; Mean square error; MEMS; Pixels; Image blur analysis; MEMS resonators; Point spread functions (PSF); Resonators

Year: 2007

Source title: Proceedings of SPIE - The International Society for Optical Engineering

Volume: 6696

Art. No.: 66962D

Link: Scorpus Link

Correspondence Address: Le, H. V.; College of Technology, Vietnam National University, Hanoi, 144 Xuan Thuy, G2-206, Cau Giay, Hanoi, Viet Nam; email: halv_kcn@vnu.edu.vn

Sponsors: The International Society for Optical Engineering (SPIE)

Conference name: Applications of Digital Image Processing XXX

Conference date: 28 August 2007 through 30 August 2007

Conference location: San Diego, CA

Conference code: 71837

ISSN: 0277786X
ISBN: 9.78E+12
CODEN: PSISD
DOI: 10.1117/12.733533
Language of Original Document: English
Abbreviated Source Title: Proceedings of SPIE - The International Society for Optical Engineering
Document Type: Conference Paper
Source: Scopus
Authors with affiliations:
1. Le, H.V., College of Technology, Vietnam National University, Hanoi, 144 Xuan Thuy, G2-206, Cau Giay, Hanoi, Viet Nam
2. Gouiffes, M., Institute d'Electronique Fondamentale, Bat. 220, Centre Scientifique d'Orsay, F91405 Orsay Cedex, France
3. Parrain, F., Institute d'Electronique Fondamentale, Bat. 220, Centre Scientifique d'Orsay, F91405 Orsay Cedex, France
4. Bosseboeuf, A., Institute d'Electronique Fondamentale, Bat. 220, Centre Scientifique d'Orsay, F91405 Orsay Cedex, France
5. Zavidovique, B., Institute d'Electronique Fondamentale, Bat. 220, Centre Scientifique d'Orsay, F91405 Orsay Cedex, France
References:
1. Horn, B., Schunck, B., Determining optical flow (1981) Artificial Intelligence, 17, pp. 185-203
2. Lucas, B., Kanade, T., An iterative image registration technique with an application to stereo vision (1981) Proceedings of the DARPA Image Understanding Workshop, pp. 121-130
3. Anadan, P., Computational framework and an algorithm for the measurement of visual motion (1989) International Journal of Computer Vision, 3, pp. 283-310
4. Rekleitis, I., Steerable filters and cepstral analysis for optical flow calculation from a single blurred image (1996) Vision Interface, pp. 159-166. , May
5. Yitzhaky, Y., Kopeika, N., Identification of blur parameters from motion blurred images (1997) Graphical Models and Image Processing, 59, pp. 310-320. , September
6. Burns, D., Helbig, H., A system for automatic electrical and optical characterization of microelectromechanical devices (1999) Journal of Microelectromechanical Systems, 8, pp. 473-482. , December
7. Hadar, O., Dror, I., Kopeika, N., Image resolution limits resulting from mechanical vibrations. part iv: Real-time numerical calculation of optical transfer functions and experimental verification (1994) Optical Engineering, 33, pp. 566-578. , February
8. Bracewell, R., (1995) Two-Dimensional Imaging, , Prentice Hall, Englewood Cliffs, NJ
9. Yitzhaky, Y., Boshusha, G., Levy, Y., Kopeika, N., Restoration of an image degraded by vibrations using only a single frame (2000) Optical Engineering, 39, pp. 2083-2091. , August
10. de Boor, C., (1978) A Practical Guide to Splines, , Springer-Verlag
11. Kundur, D., Hatzinakos, D., Blind image deconvolution (1996) IEEE Signal Processing Magazine, pp. 43-64. , May