



HAL
open science

Retinex Filtering for Fabric Fault Detection

Amelia Carolina Sparavigna, Roberto Marazzato

► **To cite this version:**

Amelia Carolina Sparavigna, Roberto Marazzato. Retinex Filtering for Fabric Fault Detection. 2016.
hal-01347958

HAL Id: hal-01347958

<https://hal.science/hal-01347958>

Preprint submitted on 22 Jul 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Retinex Filtering for Fabric Fault Detection

A. C. Sparavigna¹ and R. Marazzato²

¹ Department of Applied Science and Technology, Politecnico di Torino, Torino, Italy

² Visiting Staff at Department of Mathematical Sciences, Politecnico di Torino, Torino, Italy

The paper is proposing the use of a Retinex filter (GIMP Retinex) for improving those methods of fabric fault detection, which are based on image processing. Since the Retinex filtering is simulating the human vision, it seems possible that it could act in processing the images as the trained staff of textile industry is acting in the visual inspection of the fabric on off-line stations. Here some preliminary examples are proposed, which seem quite interesting for a preprocessing of the images, on which a further analysis can be applied to determine the presence of defects.

Keywords: image processing, Retinex filtering, GIMP Retinex, texture analysis, fabric fault detection

The visual inspection of woven fabrics is fundamental for textile producers to guarantee the quality of their products as being free from defects. Traditionally, trained staff is performing a visual inspection on off-line stations for finding any fault present in the fabric. Sometimes the human inspection is supported by some automatic inspection methods for detecting defects, which are working during the production processes, that is directly on the looms.

As discussed in [1], the automation of such visual inspection process [2] “is a multifaceted problem” which is requiring “complex interaction among various system components”, and then an investment for the development of a final inspection system which could be commercialized. About twenty years ago, such an investment was considered as economically attractive [3], so that some industrial inspection systems had been developed (I-TEX from Elbit Vision Systems, Barco Vision's Cyclops, Zellweger Uster's Fabriscan) [4]. In spite of the presence of commercial systems, the research for further improvements of the textile fault detection continues as evidenced by the recent publications on this subject, such as [5-10].

The studies for the development of automatic systems based on artificial vision for the textile fault detection started several years ago. The researches immediately evidenced the difficulties of such task, difficulties that are intrinsic to the fact that fabric faults are often very small and hardly detectable, having a visibility strongly dependent on illumination (front or back lighting) and reduced by the vibrations of the mounting devices [11-15]. For the analysis of fabric textures, several statistical approaches had been used and developed [16-17], such as some methods based on the Fourier analysis of the grey levels of images [18], on Gabor filtering [19,20] and wavelets with adaptive bases [21]. In addition, an approach based on an image processing, developed for the study of liquid crystals [22], had been proposed by one of the authors in [23-25].

To authors best knowledge, there is a possibility not yet experimented, and this possibility is here proposed: it is the use of a Retinex filtering of the images of fabrics, to enhance the visibility of defects.

Of the Retinex filtering, we have discussed in some recent papers, applying it to microscopy, radiography and detection of vehicles in foggy images [26-30].

Of this filtering, let us shortly remember the following. Retinex filtering methods had been developed to solve some experimental observations. These experiments concerned the fact that it is easy to find discrepancies between an image we have recorded by a camera and the real scene we have observed. The reason is that humans are able to see details both in the shadows and in the nearby illuminated areas, whereas a photograph of the same scene is showing either the shadows as too dark or the bright areas as overexposed [31].

Modelled on the peculiar features of the human vision, which are quite different from those of the recording devices [32,33], several algorithms of image processing had been developed to simulate the human ability of adapting to adverse conditions. These algorithms are known as Retinex algorithms. The first of them was conceived by Edwin H. Land, an American scientist and inventor, best known as co-founder of Polaroid Corporation [34-35]. As explained in Ref.31, through the years, Land evolved several models, until his last one proposed in 1986. The term “Retinex” was coined by Land himself, combining the words “retina” and “cortex”, to indicate the results of his researches, that human colour perception is involving all levels of vision processes, from the retina to the cerebral cortex.

Several Retinex approaches exist [33,39]: the single-scale Retinex (SSR), the multiscale Retinex (MSR), and, for colour images, the MultiScale Retinex with Colour Restoration (MSRCR). Among MSRCR we find the GIMP Retinex, a freely available tool developed by Fabien Pelisson [40] (GIMP is the GNU image processing software). The resulting image of this filter can be adjusted selecting different levels, scales and dynamics. There are three “levels”: uniform, which tends to treat both low and high intensity areas fairly, low, that “flares up” the lower intensity areas on the image, and high that tends to “bury” the lower intensity areas in favor of a better rendering of the clearer areas of the image. The “scale” determines the depth of the Retinex scale. Minimum value is 16, a value providing gross, unrefined filtering. Maximum value is 250. Optimal and default value is 240. A “scale division” determines the number of iterations in the multiscale Retinex filter. The minimum required, and the recommended value is three. The “dynamic” slider allows adjusting colour saturation contamination around the new average colour (default value is 1,2).

Let us processing some images of faults in fabrics by using the GIMP Retinex. This does not mean that it is enough the use of a Retinex filter for an automatic detection, but that is could improve the score of successful detections, by increasing the visibility of the defects.

Faults in the structure of woven fabrics are deviations from the recurrence of a fundamental unit, and usually appear as subtle lines, dark or bright, in the image frame. The more frequently encountered defects are broken or missing picks. Dust, extraneous staples or oil spots can also be observed. Let us start from the defect in the Figure 1. The image is showing a mispick, a rather common defect, produced when a yarn is lacking or broken on the loom, and it is a defect expanding on the surface fabric and involving several neighbor yarns. Mispicks are easy to find by eye inspection, such as dust and little oil spots. These defects are eye-inspected with back lighting. The same illumination system was used to record image in the Figure 1.

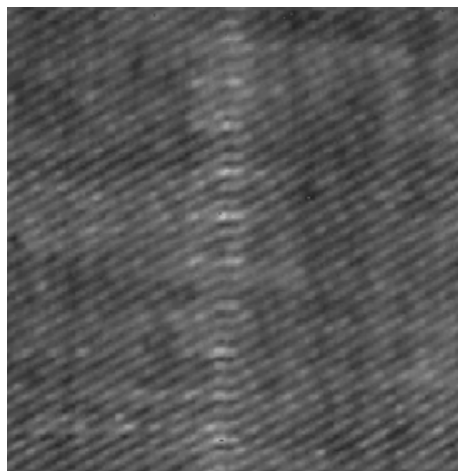


Figure 1: A mispick in a textile woven fabric. Image size is 40 mm.

We use the GIMP Retinex filter with the following parameters. Scale=150, Scale division=4 and Dynamic slider=0. The result for the image in the Figure 1 is given in the Figure 2 for the three levels: uniform, low and high.

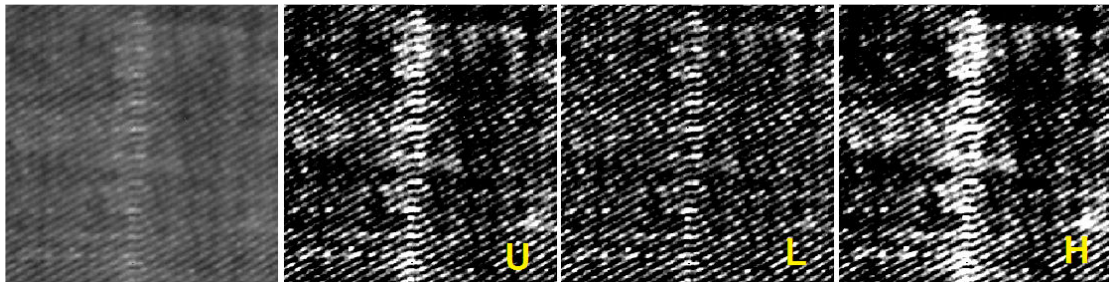


Figure 2: On the left the original image. The other images are those obtained using GIMP Retinex, for Uniform, Low and High levels.

It is evident the selective action of the filtering, so the three outputs are enhancing different features of the fabric. In particular, the low level (L) filtering seems suppressing the fault, whereas the high level (H) filtering enhances its visibility. In fact, we have two images to compare, L and H. L could represent the fabric as it would be “without defect”, and H the “defect”. Using these images, we can try a further analysis comparing them. Let us consider image L in the Figure 2 and invert its colour tones with GIMP, having the panel L-I in the Figure 3. We can add this image to image H. The result is an almost homogenous grey image, having the position of the defect evidenced by the bright region. Reducing the grey tones to three or five, we have the results in the Figure 4.

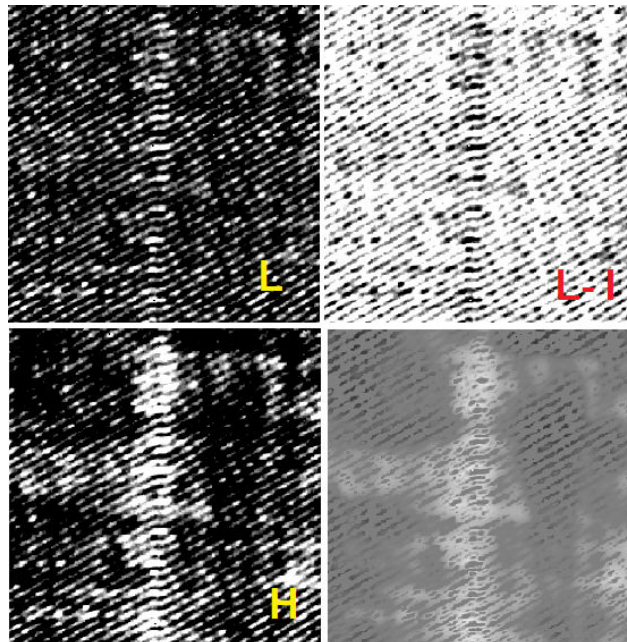


Figure 3: Let us use image L in the Figure 2; we can invert the colour tones with GIMP, having the panel L-I. We can add this image to image H. The result is the almost homogenous grey image, having the position of the defect evidenced by the bright region (low-right panel). The grey areas are those where the two images are coincident.

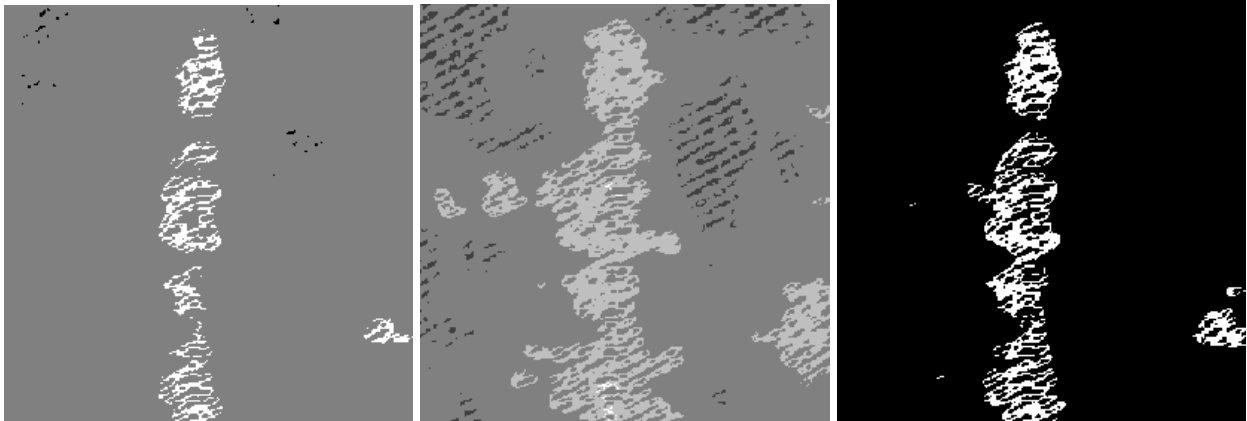


Figure 4: The result obtained in the Figure 3 can be shown by a reduced number of grey tones, three on the left and five in the middle. On the right, we can see the effect of a suitable threshold.

It is easy to imagine a segmentation of this image which is able evidencing the position of the defect for an automatic inspection.

Let us consider another example. It is the same fabric of the Figure 1, but here we see some dust on it, which is altering the light transmitted by the fabric. Here again we can do the same as in the Figure 2. The result is given in the Figure 5. Adding the High level filtered image to the inverse of the Low level filtered image we obtain the image in the left panel of Figure 6. In the right panel we can see the result given with a reduced number of grey tones.

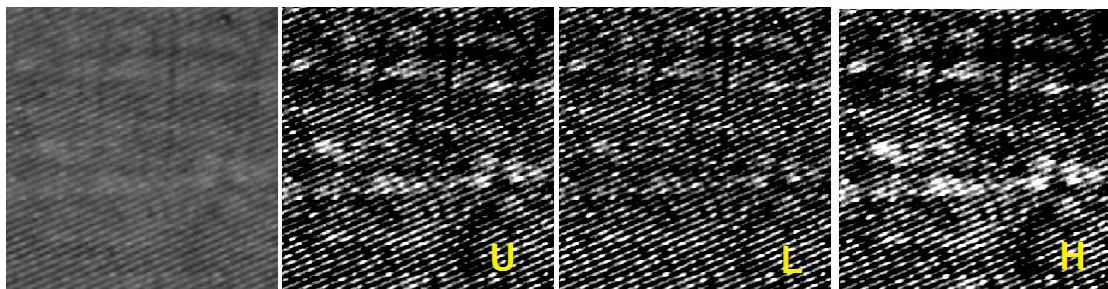


Figure 5: On the left the original image. The other images are those obtained using GIMP Retinex, for Uniform, Low and High levels.

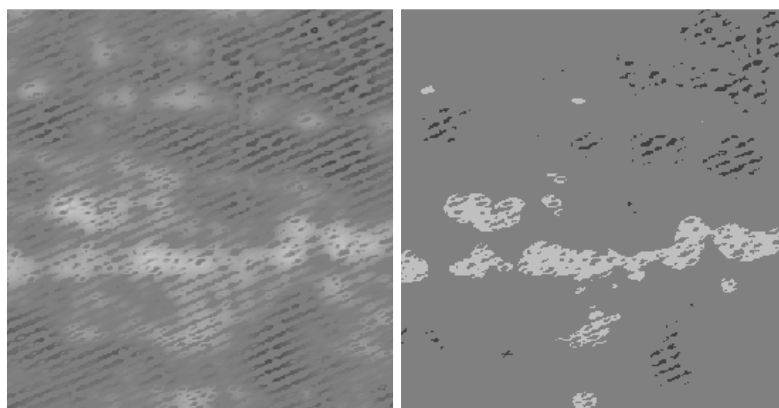


Figure 6: Adding the High level filtered image of the Figure 5 to the inverse of the Low level filtered image of Figure 5 we obtain the image in the left panel. In the right panel we can see the result given with a reduced number of grey tones.

In the Figure 7, we can see on the left, the image of a missing pick, another quite common defect in fabrics. In the same image, we can see the result of Retinex filtering. Again, using the same addition of images as in the Figures 3 and 6, we can obtain the results given in the Figure 8.

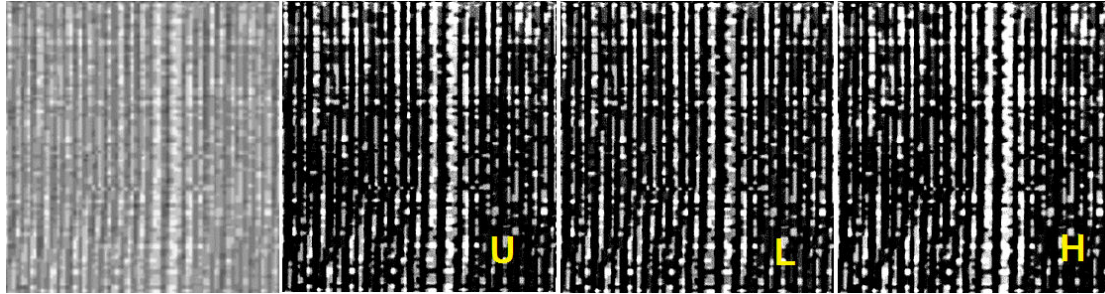


Figure 7: On the left an image showing a missing pick (image size is of 20mm). The other images are those obtained using GIMP Retinex, for Uniform, Low and High levels. Note that the low level filtering is reducing the effect of the double pick, whereas the high level filtering is enhancing it.

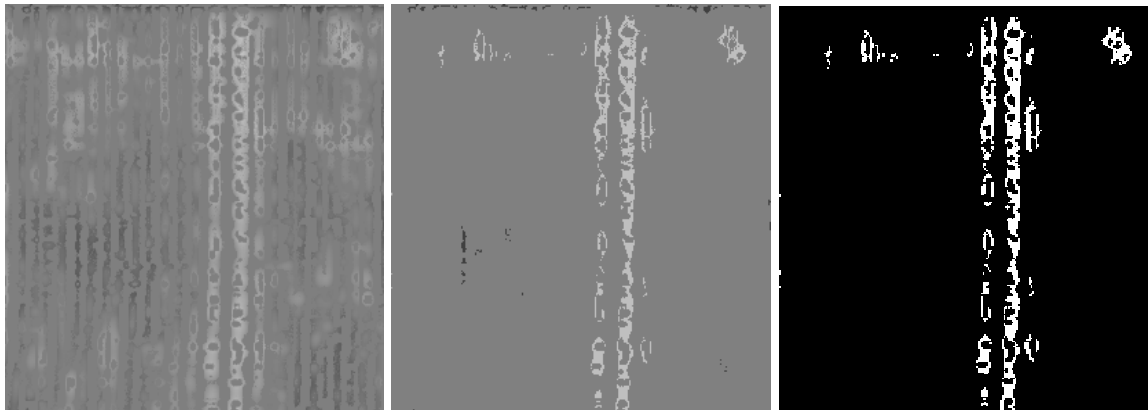


Figure 8: Adding the High level filtered image of the Figure 7 to the inverse of the Low level filtered image of Figure 7 we obtain the image in the left panel. In the middle panel we can see the result given with a reduced number of grey tones. On the right, the result after a suitable threshold.

In these examples, we have considered an image of a certain fabric and from it, using the Retinex filter, we have obtained two images. One (L), which is obtained after selecting the low level filtering, is that where the lower intensity areas are evidenced. The other image, obtained using the high level (H), has the clearer areas are favored. Let us note that, in the given examples, we have used a back lighting illumination system for inspecting the fabric. In them, we have seen a fault as a region which is transmitting more light. Therefore, L is close to the “good” fabric, H is close to the “bad” fabric. Therefore, from a single image of the fabric, we had two filtered images we can compare to determine the presence of a defect.

In the Figure 9, we can see another example of a defect observed using a back lighting. It is a weaving mismatch. This defect has an extension on 8-10 yarns and, sometimes, it is difficult to identify. On the left, we see the original image, in the middle the image we obtain after mixing L and H image as made for the Figure 3, and in the right panel the result after enhancing the contrast. In this case, the defect is stopping the light, but also in this case, the proposed approach based on L and H filtered images seems giving some interesting results.

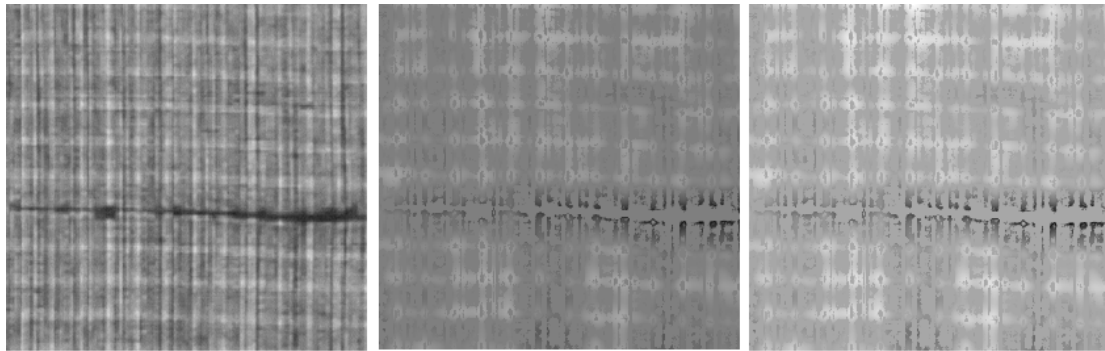


Figure 9: A weaving mismatch in a fabric. This defect has an extension on 8-10 yarns and, sometimes, it is difficult to identify. The size of the figure is 20 mm. On the left, we see the original image, in the middle the image we obtain after mixing L and H image as made for the Figure 3, and in the right panel the result after enhancing the contrast.

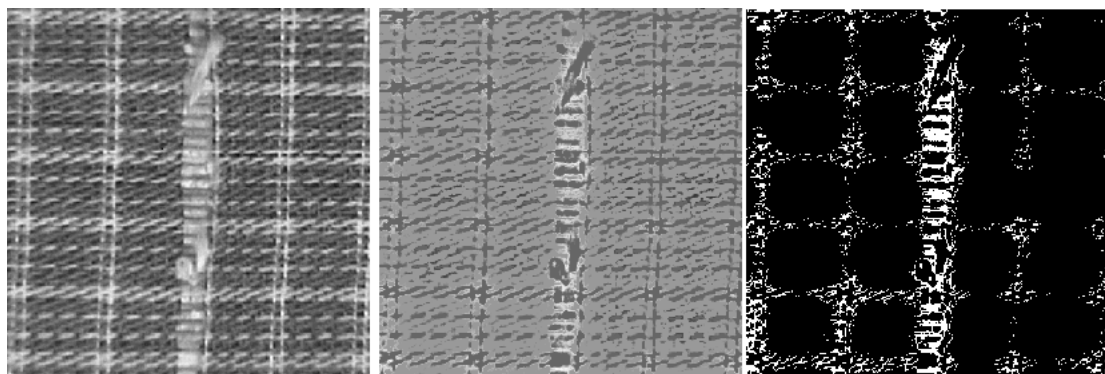


Figure 10: Defect in a complex fabrics with yarns of different colors (image size is 20 mm).

Another possible defect is that shown in the Figure 10, where we see a fabric observed in front lighting. On the left, we see the original image, in the middle the image we obtain after mixing L and H image as made for the Figure 3, and, in the right panel, the result after thresholding.

In fact, being the defect composed by bright yarns, for the Retinex filter it is the same as a region seen in back lighting which is transmitting more light.

As a conclusion, after the examples we have proposed in the previous images, we can tell that, from an image of a certain fabric, using the Retinex filter we can obtain at least two useful images. One can be that obtained after selecting the low level filtering (L), where we find the lower intensity areas of the image enhanced. The other image can be that obtained using the high level (H), where the clearer areas of the images are favored. If we suppose to work with a back lighting illumination system and that a fault is a part of the fabric which is transmitting more light, the proposed approach seems quite good. This happens because L is close to the “good” fabric and H is close to the “bad” fabric. In this manner, we have, from an image of the fabric, two filtered images we can compare to determine the presence of a defect

Some other studies are necessary to improve this approach based on Retinex filtering, when we have defects which are difficult to identify, such as the presence of tiny flaws or doublepicks. Unlike mispicks, the doublepicks which appear when two yarns are very close, produces very narrow lines in the fabric. Some preliminary analyses of Retinex filtering seem quite promising.

Let us end the paper, with a further example of a simple use of GIMP Retinex. In the previous examples we have proposed this filter for preprocessing the images to be used in an automatic vision

system. However, Retinex could be used just to help human vision, for instance, in detecting tiny flaws of the fabric. A simulation is given in the Figure 11. In the upper panel, we have the fabric as it could be seen, where defects are hardly visible. However a simple filtering with GIMP Retinex give us the presence of defects. Then, a device which is giving a filtered image could be used to improve the visual inspection on the off-line stations.

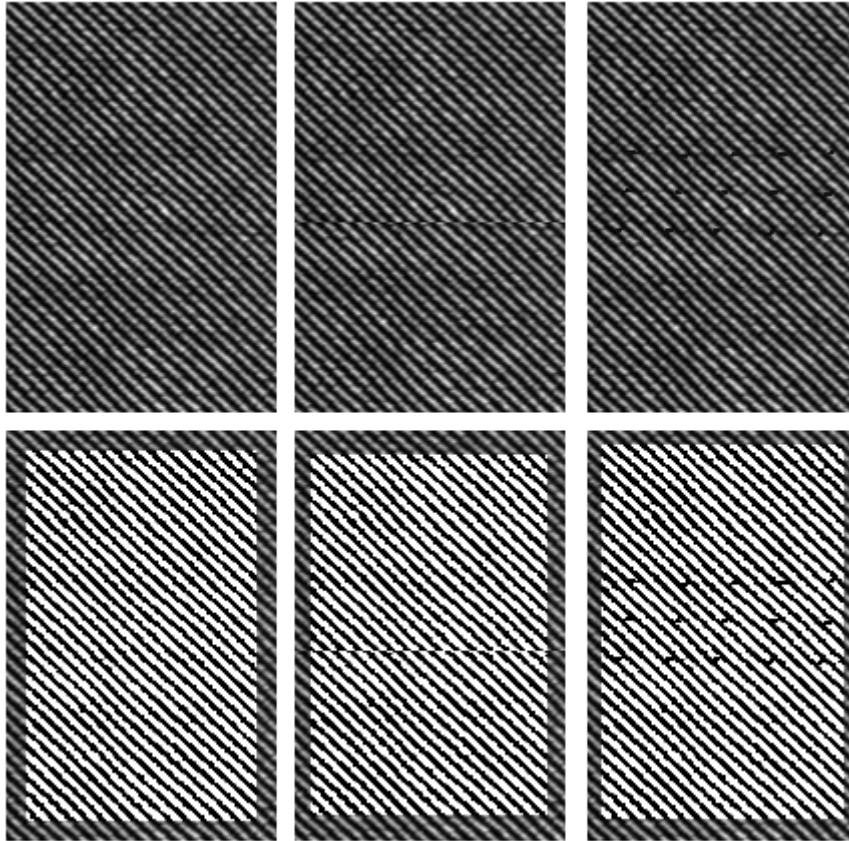


Figure 11: In the upper panels, the simulation of a good fabric (left) and the same with defects (middle, right). A simple Retinex filtering is evidencing them.

References

- [1] Kumar, A. (2008). Computer-Vision-Based Fabric Defect Detection: A Survey, *IEEE Transactions on Industrial Electronics*, 55(1), 348-363. DOI: 10.1109/TIE.1930.896476
- [2] Rosandich, R. G. (1997). *Intelligent Visual Inspection*. London, U.K.: Chapman & Hall.
- [3] Nickolay, B. N., & Schmalfuß, H. (1993). Automatic fabric inspection—Utopia or reality? *Melliand-Text.ber.*, 73, 33–37.
- [4] Dockery, A. (2001). *Automated fabric inspection: assessing the current state of the art*. Techexchange. com.
- [5] Jing, J., Zhang, H. , Wang, J., Li, P., & Jia, J. (2013). Fabric defect detection using Gabor filters and defect classification based on LBP and Tamura method. *Journal of the Textile Institute*, 104(1), 18-27.
- [6] Schneider, D., Holtermann, T., & Merhof, D. (2014). A traverse inspection system for high precision visual on-loom fabric defect detection. *Machine vision and applications*, 25(6), 1585-1599.
- [7] Bhangale, R. S., & Zope, C. D. (2014). *An Introduction to Textile Defect Identification and Classification Using Wavelet Transform and Neural Networks*. *International Journal of Advanced Electronics and Communication Systems*.

- [8] Li, P., Zhao, Z., Zhang, L., Zhang, H., & Jing, J. (2015). The Real-Time Vision System for Fabric Defect Detection with Combined Approach. In *International Conference on Image and Graphics* (pp. 460-473). Springer International Publishing.
- [9] Huang, C. P. (2014). A Study on the Algorithm of Fault Information Automatic Detection for High-Precision Intelligent Instruments. In *Advanced Materials Research*, 846, 167-171. Trans Tech Publications.
- [10] Jinlian Hu (2011). *Computer Technology for Textiles and Apparel*, Elsevier.
- [11] Sari-Sarraf, H., & Goddard, J. S. (1999). Vision systems for on-loom fabric inspection, *IEEE Trans. Industry applications*, 35, 1252-1259.
- [12] Campbell, J. G., & Murtagh, F. (1998). Automatic vision inspection of woven textiles using a two-stage defect detector, *Opt. Eng.* 37, 2536-2542.
- [13] Yau, H. F., Chen, P. W., Wang, N. C., & Lay, Y. L. (1998). Optimization of the illumination beam size of an optical textile defect inspection system, *Meas. Sci. Technol.* 9, 960-966.
- [14] Ribolzi, S., Merckle, J., & Gresser, J. (1993). Real time fault detection on textiles using optoelectronic processing, *Textile Res. J.* 63, 61-71.
- [15] Kasdan, H. L. (1979). Industrial application of diffraction pattern sampling, *Opt. Eng.* 18, 496-503.
- [16] Haralick, R. M., Shanmugam, K., & Dinstein, I. (1973). Textural features for image classification, *IEEE Trans. Syst., Man, Cybern., SMC-3*, 610-21.
- [17] Abouelela, A., Abbas, I., El Deeb, I., & Nassar, S. (2000). A statistical approach for textile fault detection, *IEEE International Conference on Systems, Man, and Cybernetics*, 8-11 Oct. 2000, 4, 2857-2862.
- [18] Chan, C. H., & Pang, G. (2002). Fabric defect detection by Fourier analysis, *IEEE Transactions on Industry Applications*, 36, 1267-1276 (2002).
- [19] Arivazhagan, S., Ganesan, L., & Bama, S. (2006). Fault segmentation in fabric images using Gabor wavelet transform. *Machine Vision and Applications*, 16(6), 356-363.
- [20] Kumar, A., & Pang, G. K. H. (2002). Defect detection in textured materials using Gabor filters, *Industry Applications, IEEE Transactions on Industry Applications*, 38, 425-440.
- [21] Jasper, J. W., Garnier, S. J. & Potlapalli, H. (1996). Texture characterization and defect detection using adaptive wavelets, *Opt. Eng.*, 35, 3140-3149.
- [22] Montrucchio, B., Sparavigna, A., & Strigazzi, A. (1998). A new image processing method for enhancing the detection sensitivity of smooth transitions in liquid crystals, *Liq. Cryst.*, 24, 841-852.
- [23] Sparavigna, A. C., & Montrucchio, B. (2006). Performing Textile Fault Detection by Means of Texture Analysis. *WSEAS TRANSACTIONS ON SIGNAL PROCESSING*, 2, 541-548.
- [24] Sparavigna, A., & Montrucchio, B. (2006, April). Texture analysis for textile fault detection. In *Proceedings of the 5th WSEAS international conference on Applied computer science* (pp. 861-866). World Scientific and Engineering Academy and Society (WSEAS).
- [25] Sparavigna A., Dorma, G. & Montrucchio, B. (2006). Diffractive optics for fabric fault detection, pp. 82-88, Vol. 5, *SCI2006 - X World Multi-Conference on Systemics, Cybernetics and Informatics*, Orlando, Florida, July 16-19.
- [26] Sparavigna, A. C. (2015). GIMP Retinex for enhancing images from microscopes. *International Journal of Sciences*, 4(6), 72-79.
- [27] Sparavigna, A. C., & Marazzato, R. (2015). Effects of GIMP Retinex Filtering Evaluated by the Image Entropy. *arXiv preprint arXiv:1512.05653*.
- [28] Marazzato, R., & Sparavigna, A. C. (2015). Retinex filtering of foggy images: generation of a bulk set with selection and ranking. *arXiv preprint arXiv:1509.08715*.
- [29] Sparavigna, A. C., & Marazzato, R. (2016). Evaluation of GIMP Retinex Filtering of Images by Means of the Shen++ Max Shannon Entropy Finder. <hal-01308434>

- [30] Sparavigna, A. C. (2015). An image processing approach based on Gnu Image Manipulation Program GIMP to the panoramic radiography. *International Journal of Sciences*, 4(5), 57-67.
- [31] Barnard, K., & Funt, B. (1999). Investigations into multi-scale Retinex, in *Colour Imaging: Vision and Technology*, L. MacDonald, Ed. and M. Ronnier Luo. Ed., John Wiley and Sons, pp. 9-17. ISBN: 978-0-471-98531-0
- [32] Zhixi Bian, & Yan Zhang (2002). Retinex image enhancement techniques: Algorithm, application and advantages, EE264 final project report for Image Processing and Reconstruction.
- [33] Jobson, D.J., Rahman, Z., & Woodell, G.A. (1997). A Multi-Scale Retinex for bridging the gap between colour images and the human observation of scenes, *IEEE Transactions on Image Processing* 6(7):965-976. DOI: 10.1109/83.597272
- [34] Land, E.H. (1986). An alternative technique for the computation of the designator in the Retinex theory of color vision, *Proc. Nat. Acad. Sci.* 83:3078-3080. PMID: PMC323455
- [35] Land, E.H. (1983). Recent advances in Retinex theory and some implications for cortical computations, *Proc. Nat. Acad. Sci.* 80:5163-5169. PMID: PMC384211
- [36] Land, E. H. (1986). Recent advances in Retinex theory, *Vis. Res.* 26:7-21. DOI: 10.1016/0042-6989(86)90067-2
- [37] Land, E. H. (1959). Experiments in color vision, *Scientific American*, May Issue, 285-298.
- [38] Land, E. H. (1959). Color vision and the natural image, *Proc. of the National Academy of Sciences* 45(1):115–129. PMID: PMC222521
- [39] Jobson, J., Rahman, Z., & Woodell, G.A. (1997). Properties and performance of a center/surround Retinex, *Image Processing IEEE Transactions on* 6(3):451-462. DOI: 10.1109/83.557356
- [40] Fabien Pelisson, GIMP Retinex, <http://www-prima.inrialpes.fr/pelisson/MSRCR.php>