



Survey of Image Fusion Techniques Applied to Microbiological Specimens

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Introduction

When analyzing microbiological specimens it is often difficult to see multiple layers of the specimen simultaneously. This hindrance can make it harder to determine the identity of the specimen under examination. Image fusion presents an option to overcoming this problem. With a good image fusion algorithm it is possible to take two pictures with different focal points and have those images combined to show both focal points with clarity. This is an excellent way to see different layers of a microbiological specimen simultaneously and make it easier to identify the specimen. Three different image fusion algorithms were surveyed to determine which would provide the greatest fidelity for the fusion of pictures of microbiological specimen. The importance of this research is to determine if these commonly used image fusion techniques can provide the same benefit on a micro scale as they do on a macro scale.

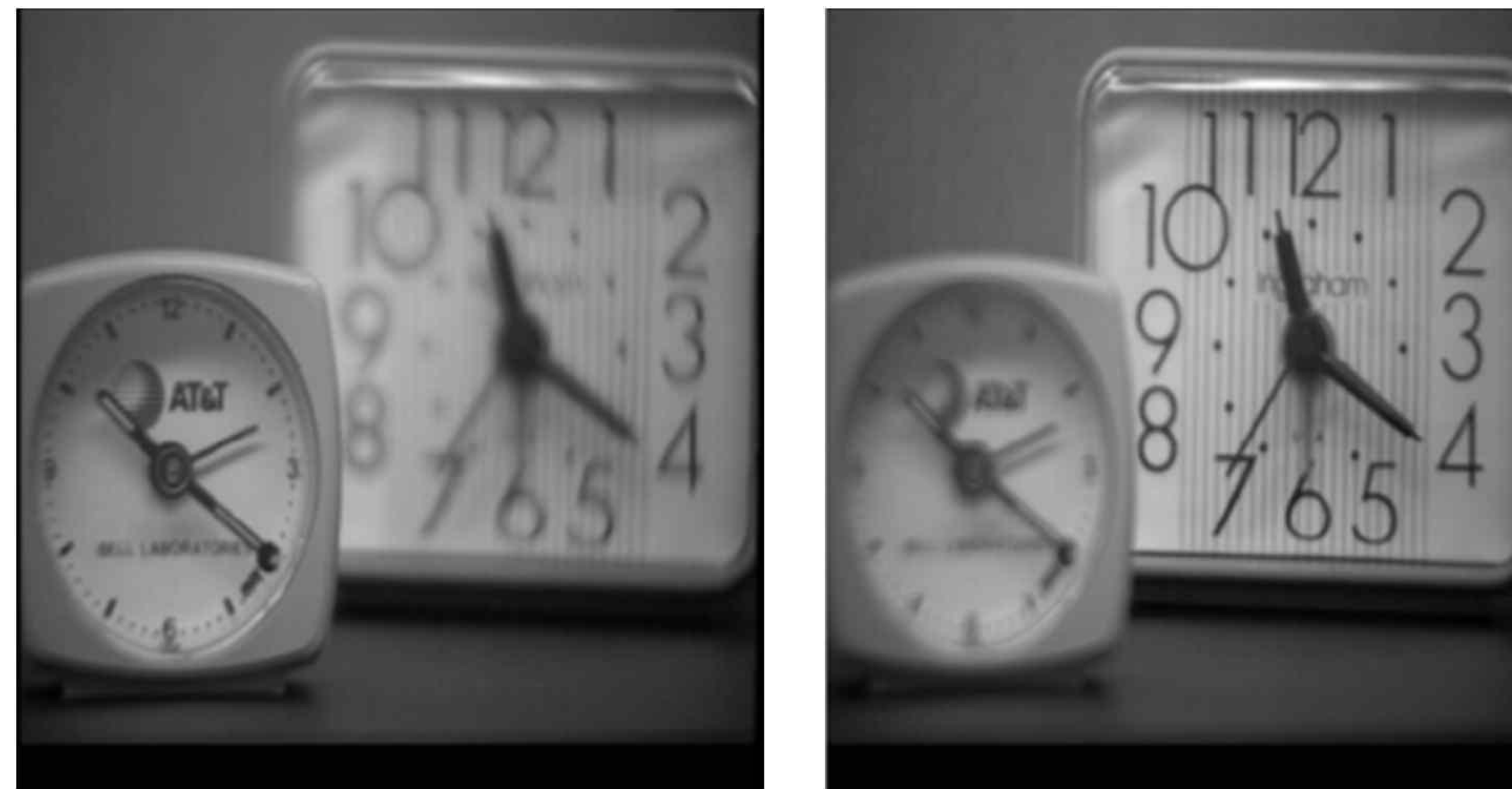


Image Source: Karen Stiles, Nebraska Public Health Laboratory

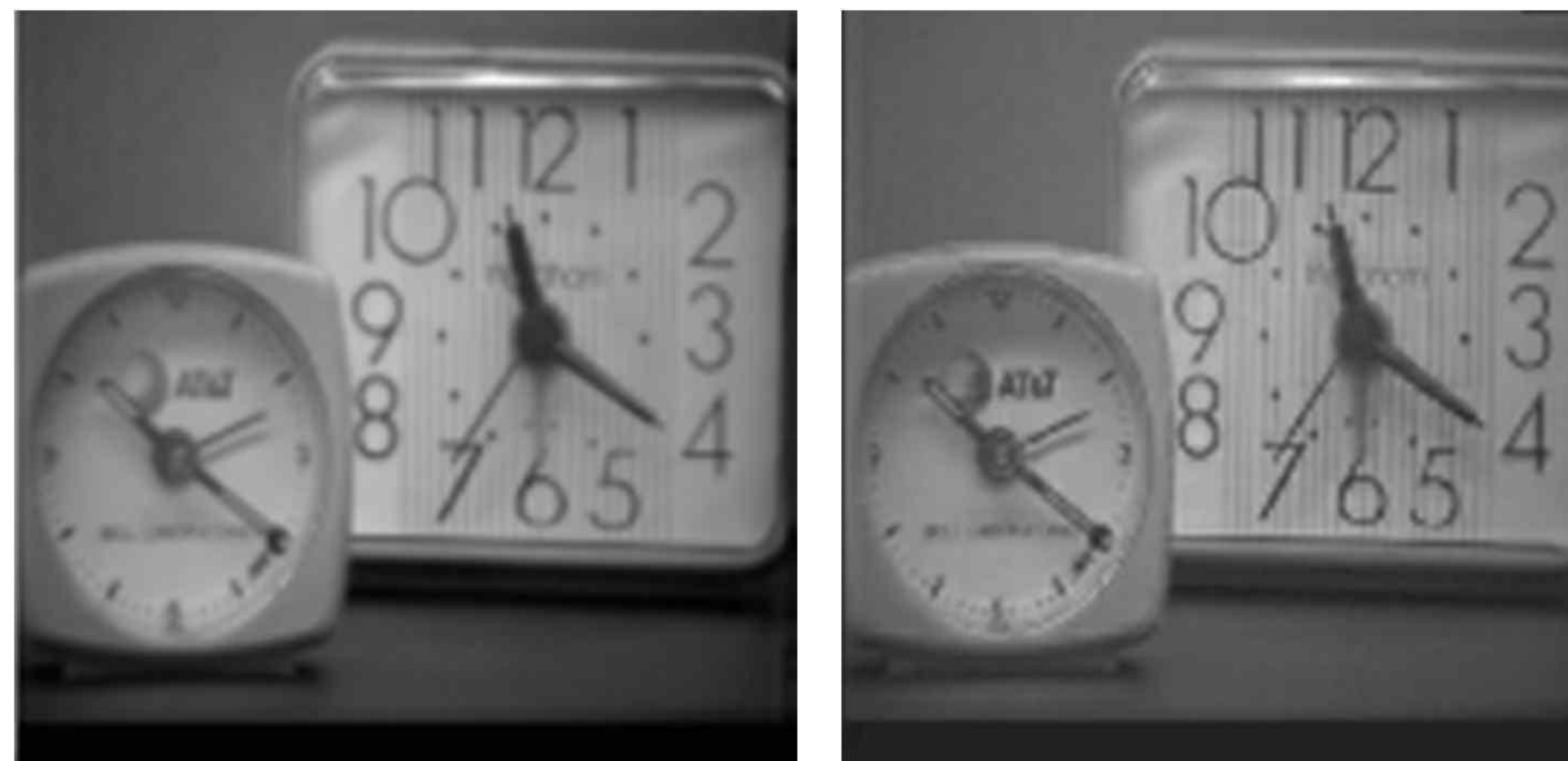
Further Research

- An empirical test to rate the quality of the image fusion technique based on features a microbiologist would need best preserved needs to be developed.
- Then the techniques would need to be analyzed using the test mentioned above.
- Once the most effective technique is discovered it can then be applied to microbiology purposes to aid microbiologists.

Sample Images



Original Pre-fused Images



Laplacian Pyramid Transform

Discrete Wavelet Transform



Nonnegative Matrix Factorization

Images Source:
ADu, JianHua, and MingHui Wang.
"Multi-Focus Image Fusion Based on
WNMF and Focal Point Analysis."
*Journal of Convergence Information
Technology* 6.7 (2011): 109-17.

Nonnegative Matrix Factorization (NMF)

- NMF works by taking an original set of data as a matrix and approximating it to two separate matrices based on a parameter; this can be applied to image fusion by setting the parameter to equal one and the original data matrix as the images being fused.
- When the parameter equals one the result of NMF is a single basis vector that represents both original images .
- This vector then constructs the fused image of the two original images.

Source: Junying Zhang; Le Wei; Qiguang Miao; Wang, Y.; , "Image fusion based on nonnegative matrix factorization," *Image Processing, 2004. ICIP '04. 2004 International Conference on* , vol.2, no., pp. 973- 976 Vol.2, 24-27 Oct. 2004

Discrete Wavelet Transform (DWT)

- A spatial-frequency decomposition that yields a multi-resolution analysis of an image.
- After the images are decomposed an image fusion rule is applied to determine what portion of the picture is "in focus" for both of the images based on the coefficient maps.
- The coefficient maps are then combined and the inverse discrete wavelet transform yields the combination of the images with the focal areas of the separate images both in focus.

Source: Nikolov, Stavri, Paul Hill, David Bull, and Nishan Canagarajah. "The Discrete Wavelet Transform." *Wavelets for Image Fusion*.

Laplacian Pyramid Transform

- Coarse approximations of the images are formed using low-pass filtering and down-sampling to form a Gaussian pyramid.
- The Laplacian Pyramid is then formed from the D-values, which represent the different local brightness, of two adjacent layers in the Gaussian pyramid.
- The decomposed layers are then integrated with respect to different image fusion rules so that the details and features in each layer of the Laplacian pyramid are highlighted.
- The images are then fused by using the Laplacian pyramid inverse transform.

Source: Zhao Ming; Changqing Lin; , "Improved pyramid image fusion based on pseudo inverse," *Information, Computing and Telecommunication, 2009. YC-ICT '09. IEEE Youth Conference on* , vol., no., pp.90-93, 20-21 Sept. 2009