Proposal for a complete 3D surface reconstruction using images from a scanning electron microscope (SEM)

Mayra Yucely Beb[1*], Sounkalo Dembélé[1], Akkiz Bekel[2], Isabelle Jouffroy-Bapicot[3], Sébastien Thibaud[1], Nadine Piat[1], Olivier Lehmann[1], Jean-Yves Rauch[1], Patrick Rougeot[1], Louis-Marie Lebas[2], Cyril Langlois[2], Lucian Roiban[2], Clémentine Fellah[4], Gilles Cuny[5], and Karine Masenelli-Varlot[2]

[1] *FEMTO-ST Institute, Univ. Bourgogne Franche-Comté, CNRS, UFC, ENSMM, 25030 Besançon cedex, France.*
[2] *Univ Lyon, INSA Lyon, UCBL, CNRS, MATEIS, UMR5510, 69621 Villeurbanne, France.*
[3] *Laboratoire Chrono-environnement, UMR 6249 CNRS, Université Bourgogne Franche-Comté, 25000 Besançon Cedex, France.*
[4] *Univ Lyon, ENSL, Univ Lyon 1, UJM-Saint- Etienne, CNRS, LGL-TPE, F-69007 Lyon, France*
[5] *Univ Lyon, Université Claude Bernard Lyon 1, CNRS, ENTPE, UMR 5023 LEHNA, F-69622, Villeurbanne,*

[*] *mayra.bebcaal@femto-st.fr*

Abstract: A three-dimensional model enables the development of accurate solutions to have more information about the thickness, texture, and characteristics of small-size samples for education and metrology applications. This project proposes an idea to obtain a complete 3D surface reconstruction using the application of Pollen 3D for the scanning electron microscope (SEM) images with high magnification. The main objective is to have a set of images of the complete 360° rotation of the sample with a robot inside the chamber of the SEM. Simulation SEM images with Blender (open source application) are proposed for results validation.

1. Description of the propose

This proposal divides the project into four main modules, Robot calibration, automatic image acquisition, auto-calibration with SEM model, and reconstruction with 2-100 images, as shown in Figure 1.

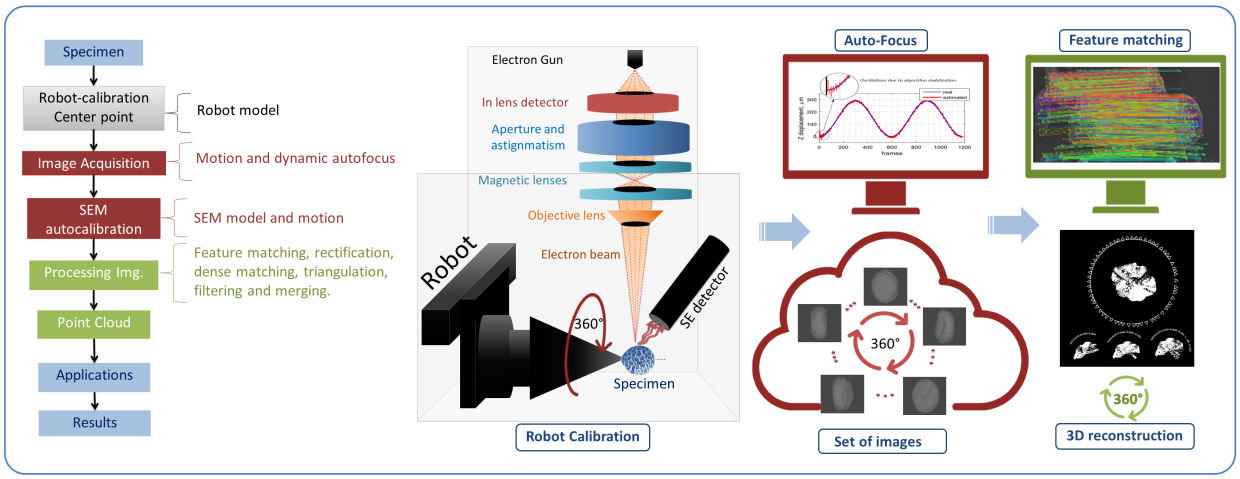

Fig. 1. Proposal for a complete 3D surface reconstruction using images from SEM; the main modules are robot calibration, automatic acquisition, auto calibration, and 3D reconstruction.

There are many applications for 3D surface reconstruction from SEM images (Mountains from Digital Surf, France; 3DSEM from Zeiss, Germany; MeX from Alicona, Austria; etc.). The current commercial ones are mainly geometry based, and they use the values of sample plataform rotation taken directly from the SEM interface [1, 2, 3, 4, 6]. Nonetheless, SEM experience indicates that these values accuracy is no longer guaranteed because

of errors in sample positioning concerning the sample eucentric point with mechanical platforms on a micro-scale. To overcome this problem, this proposed is based on the auto-calibration achieved in the application Pollen 3D [5]; this platform will be used to reconstruct the 3D point clouds, and this project proposes a complete application from image acquisition.

2. Acknowledgements

This work has been supported by EIPHI Graduate school (contract "ANR-17-EURE-0002"), the Equipex ROBOTEX project (contract ANR-10-EQPX-44-01), the plateform MIFHySTO, the French National Network METSA (FR3207 CNRS-CEA).

References

[1] A. Baghaie, A. P. Tafti, H. A. Owen, R. M. D'Souza, and Z. Yu. SD-SEM: Sparse-dense correspondence for 3D reconstruction of microscopic samples. *Micron*, 97:41–55, June 2017.

[2] G. Barbieri and F. P. da Silva. Acquisition of 3D models with submillimeter-sized features from SEM images by use of photogrammetry: A dimensional comparison to microtomography. *Micron*, 121:26–32, June 2019.

[3] L. Dong, L. Zhang, B. E. Kratochvil, K. Shou, and B. J. Nelson. Dual-Chirality Helical Nanobelts: Linear-to-Rotary Motion Converters for Three-Dimensional Microscopy. *Journal of Microelectromechanical Systems*, 18(5):1047–1053, Oct. 2009.

[4] B. E. Kratochvil, L. X. Dong, L. Zhang, and B. J. Nelson. Image-based 3D reconstruction using helical nanobelts for localized rotations. *Journal of Microscopy*, 237(2):122–135, 2010.

[5] A. V. Kudryavtsev, V. Guelpa, P. Rougeot, O. Lehmann, S. Dembélé, P. Sturm, and N. Le Fort-Piat. Autocalibration method for scanning electron microscope using affine camera model. *Machine Vision and Applications*, 31(7):69, Sept. 2020.

[6] T. Vynnyk, T. Schultheis, and T. Fahlbusch. 3D-measurement with the stereo scanning electron microscope on sub-micrometer structures. *Journal of the European Optical Society - Rapid publications*, 5(0), Sept. 2010.