M2 Internhip Position (April 2021-September 2021)

Title: Characterization of the algal colonization of mortar surfaces using image analysis

Host institution: Ecole Nationale Supérieure des Mines de Saint-Étienne (MINES Saint-Etienne), FRANCE
SPIN / LGF, UMR CNRS 5307
Bonus: ~600 euros/month
Candidate profile: M2 student in image analysis
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Duration: 5-6 months

Description

- **General context**

The building facades are progressively and inevitably subjected to biological colonization inducing physical and aesthetical degradations of the construction. The involved microorganisms are bacteria, algae, cyanobacteria, fungi, lichens and even higher plants if no prevention is applied. The implantation of microorganisms depends on many factors such as climate, environment, light, relative humidity, roughness, porosity, chemical composition, surface pH. . . [1]. Several studies were devoted to the investigation of the influence of these parameters on biofouling, at laboratory scale as well as at real scale.

In the literature, some authors have attempted to model this phenomenon [2]. They showed that the Avrami's germination growth model was quite a good tool to express the temporal evolution of the colonization rates. Avrami's model is based on two processes: the nucleation, corresponding to the appearance of nuclei of a new phase and the growth representing the increase in the size of these nuclei with time. In this work, the colonization rate follows a sigmoid type curve as a function of time and the biofouling is initiated by the attachment of algae on the surface of samples creating many spots and considered as nuclei. As a consequence, the colonization can be modeled by the Avrami's model.

- **Objectives**

In this general context, the objective of this internship is to characterize the colonization mechanism of materials by algae using image analysis. Indeed, some specific experiments [5] have been done in the laboratory to acquire several sequences of images of a mortar colonized by algae at different time (see Figure 1). Some image processing and analysis tasks [6] will then needed for the characterization:

  - Image segmentation in order to quantify the attachment of algae. In order to take into account images of various mortars colonized by the algae in different conditions, a segmentation method based on pixel supervised classification [3], [4] will be investigated
  - Examination of the nucleation process. At each time step *t*, new algal spots fixed on the surface will be identified by image analysis using tree structure.
  - Examination of the growth process. All along the time, the aim will be to locate and track changes of each algal spot that can be found on the surface of the sample.
  - In this way, the Avrami's germination-growth model parameters will be identified and used to model the algal colonization phenomenon. The results of the final colonization rate (obtained by image analysis) will be compared with the analytical one.

(a) day 0 *(b) day 12* *(c) day 19* *(d) day 23*

Figure 1: Examples of image of a mortar colonized by algae at different time.

References

[1] J.J. Ortega-Calvo, X. Arino, M. Hernandez-Marine, and C. Saiz-Jimenez. Factors affecting the weathering and colonization of monuments by phototrophic microorganisms. Science of The Total Environment, 167:329–341, 1995.

[2] T.H. Tran, A. Govin, R. Guyonnet, P. Grosseau, C. Lors, D. Damidot, O. Deves, and B. Ruot. Avrami's law based kinetic modeling of colonization of mortar surface by alga klebsormidium flaccidum. International Biodeterioration and Biodegradation, 79:73–80, 2013.

[3] C.M. Bishop. Neural Networks for Pattern Recognition. Oxford University Press, 1995.

[4] V. Gonzalez-Castro, J. Debayle, and V. Curic. Pixel classification using general adaptive neighborhood-based features. In Proceedings of the 22nd International Conference on Pattern Recognition (ICPR), Stockholm, Sweden, 2014.

[5] T.H. Tran, A. Govin, R. Guyonnet, P. Grosseau, C; Lors, E. Garcia-Diaz, D. Damidot, O. Deves, and B. Ruot. Influence of the intrinsic characteristics of mortars on biofouling by klebsormidium flaccidum. International Biodeterioration and Biodegradation, 70:31–39, 2012.

[6] R.C. Gonzalez and R.E. Woods. Digital Image Processing. Prentice Hall, 2008.