Media & Public Relations: Jocelyne Rouis
Tel + 33 (0)4 76 82 69 44 - Fax: +33 (0)4 76 82 69 33
presse.pagora@grenoble-inp.fr

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PRESS RELEASE
18 July 2019

Microscopic modeling of printed dots to improve the fight against counterfeiting

June 21, 2019, Louis Vallat-Evrard defended his doctoral thesis of the University Grenoble Alpes, prepared under the supervision of Nadège Reverdy-Bruas, Associate Professor HDR, and of Lionel Chagas, Research Engineer (Grenoble INP-Pagora / LGP2). He presented the results of his research work entitled *Measurement, analysis and modeling at the microscale of printed dots to improve the printed anti-counterfeiting solutions*.

Applications in the field of product security and authentication to prevent counterfeiting rely on abilities of microscale measurements of printed dots. Thus, researches described in this manuscript have been directed toward the development of measurement methods and apparatus to characterize halftone dot at the microscale.

A polarized reflection optical microscope has been adapted with a commercial digital camera. The Bayer matrix was removed from the surface of the camera and raw images were retrieved. The microscope stage, the camera, the photometer and the thermometer were controlled directly in a Python graphic user interface specifically developed. A high dynamic range capture method was proposed and tuned specifically to obtain richer information on the ink and paper regions. The measurement apparatus and methods helped improve the accuracy and automate the measurements of the halftone dots at the microscale.

The physical and optical dot gains were then separated and analyzed. A Gaussian fitting of the ink and paper histogram peaks was proposed to measure automatically the ink and paper region reflectance as a function of the ink coverage. Thresholding algorithms were applied to separate optical and physical dot gain. An objective threshold evaluation method was developed in order to define the best threshold algorithms for halftone images. The method was based on a simulation of the optical dot gain effects and of the microscope distortions to obtain test images and ground truth images.

Thirty threshold algorithms from literature were evaluated and demonstrated dependency on the ink coverage of the halftones. Two novel threshold algorithms were then developed specifically to process halftones. The first threshold algorithm was based on the determination of the amount of ink peak shift. The second threshold algorithm proposed a pretreatment of the images by applying a pseudo-deconvolution strategy, removing the optical dot gain from the halftones. Characterizations of the optical and physical dot gains were then conducted analyzing 2708 different halftones.

Finally, a physical dot gain model and an optical dot gain model were proposed in order to predict the halftone reflectances from raster to print. The physical dot gain model was based on the generation of single ink particles placed according to a probability mask and on a fusion of the ink particles. The model was evaluated with 43269 dot morphologies that were captured automatically on the microscope. A novel halftone reflectance model was proposed based on a double convolution with two different paper point spread functions. It allowed an accurate reproduction of the main effects of the light diffusion with, at the same time, an accurate reproduction of the light entrapment near the edges of the dots.

Contacts
Nadege.Reverdy@pagora.grenoble-inp.fr
Lionel.Chagas@pagora.grenoble-inp.fr
Logo
logo-lgp2.eps