Thesis for the degree of Licentiate, Örnsköldsvik 2014

# IMAGE ANALYSIS APPROACH FOR MODELING COLOR PREDICTIONS IN PRINTING

**G M Atiqur Rahaman**

Supervisors:
Prof. Per Edström
Dr. Ole Norberg
Dr. Magnus Neuman

Digital Printing Center
Department of Natural Sciences
Mid Sweden University, SE-891 18, Örnsköldsvik, Sweden

ISSN 1652-8948
Mid Sweden University Licentiate Thesis 108
ISBN 978-91-87557-32-3

Department of Natural Sciences
Mid Sweden University
SE-851 70 Sundsvall
SWEDEN

ISBN 978-91-87557-32-3
ISSN 1652-8948

Academic dissertation courtesy of Mid Sweden University submitted to public scrutiny for the Degree of Licentiate at 10:00 a.m. on Friday, 28 February, 2014 in the Mediacenter DPC, Mid Sweden University, Järnvägsgatan 3, Örnsköldsvik.
The seminar will be held in English.



Printed by Mid Sweden University, Sundsvall, Sweden, 2014

## ABSTRACT

The colorimetric approach to color printing and reproduction can only be used for a specific viewing situation. To remove that limitation, recent technological developments have allowed for an alternative approach called spectral printing. Existing color prediction models used for colorimetric reproduction can be applied to spectral reproduction, but in practice that becomes very cumbersome and time consuming. This work proposes an extension of *Murray-Davies (MD)* tone reproduction model with the aim to develop a color prediction model suitable for making spectral printing successful. The extension is based on analysis of microscale halftone images that has also resulted in a novel approach to estimate physical and optical effects in the print.

A general light microscope modified with an RGB camera is used for capturing microscale images of printed halftone dots both in transmittance and reflectance mode. In the first phase, the same sets of parameters are obtained both by experimental image analysis and MD optimization technique to evaluate a set of successful color prediction models as *spectral Neugebauer* and Yule-*Nielsen (YN)* modified *spectral Neugebauer* model. Effective colorant coverage and *YN n-factors* are the determinants of the prediction accuracy for a particular print set up. However, the measured properties such as light scattering, absorption and ink density show correlation with dot gain.

In the second phase, a new concept is introduced to divide the effective dot area into solid ink and ink-paper mixed (mainly dot edge) area. A segmentation method using the *k-means* clustering technique is proposed and applied to various samples printed by impact and non-impact printing processes. The segmentation results are used to study the dot gain characteristics and evaluate the performance of base MD model. The concept is also used to expand the base MD equation to properly account the light reflected off solid ink, unprinted paper and mixed areas. The expanded model considerably improves the accuracy both in terms of spectral and colorimetric errors while preserving the law of conservation of energy. Another advantage is that the model requires only three measurements of reflectance.

The goal of the thesis work is to increase knowledge of how print media interactions affect the performance of color prediction models. The proposed model can be used as a component in the spectral color management workflow. Furthermore, the developed image analysis methods can be used as a tool to characterize paper, ink or halftone prints in the paper and graphic arts industry.