Design and optimization of fiber-optic colorimetric probe based on ANN for estimating spectrum of color samples

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ABSTRACT: A new, optimized colorimetric probe based on ANN used for color estimation of printed samples obtained by digital printing is presented in this paper. Color measurement is based on the change in the intensity of light that is transmitted from LEDs to a measuring point and is reflected from the measuring point to a photodetector. The probe consists of seven optical fibers, six of which are mounted on LED sources and serve to transmit light from the source to the color sample, and the seventh fiber is mounted on the photodetector and serves to transmit reflected light from the color patch to the detector. Color patches were printed on gloss coated white paper, according to the ISO Fogra Coated 39 profile.

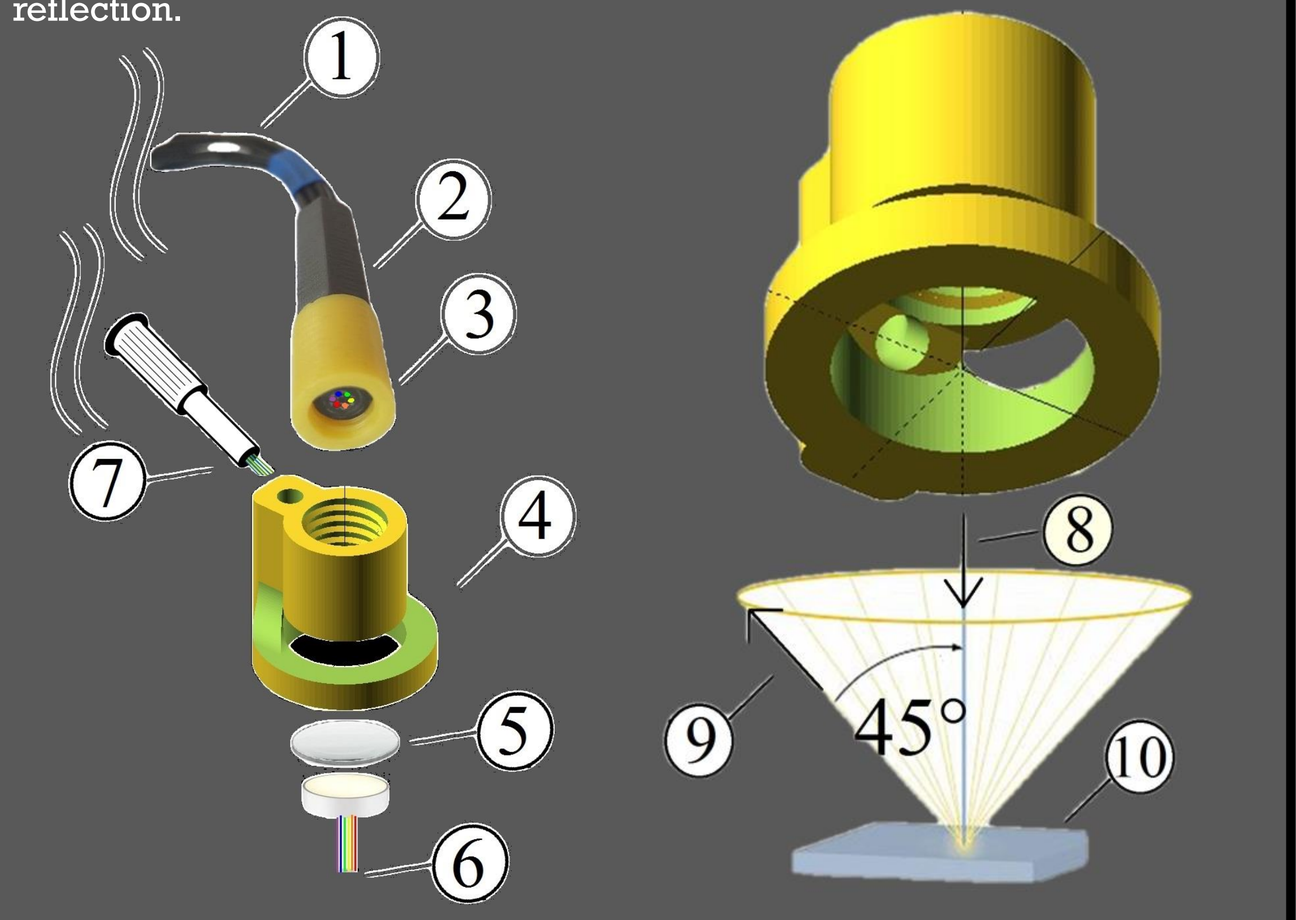
Spectrum estimation:
Cubic Hermite interpolation method was used for the purpose of the reflectance spectrum estimation, and the obtained spectral curves mostly corresponds well to those obtained by a commercial spectrophotometer (Fig. 1).

ANN based solution:
The input data of ANN consists of six measured values which represent the intensities of reflected light at specific wavelengths, while the output is formed of thirty-six points which are used to predict the shape of the spectral curve in the range of 380-730 nm (to obtain a resolution of 10 nm). The algorithm used for the training purposes is Nesterov Adam Optimizer, and the cost function is the mean squared error function.

Table 1. Measurement error compared to referent spectrophotometer EyeOnePro

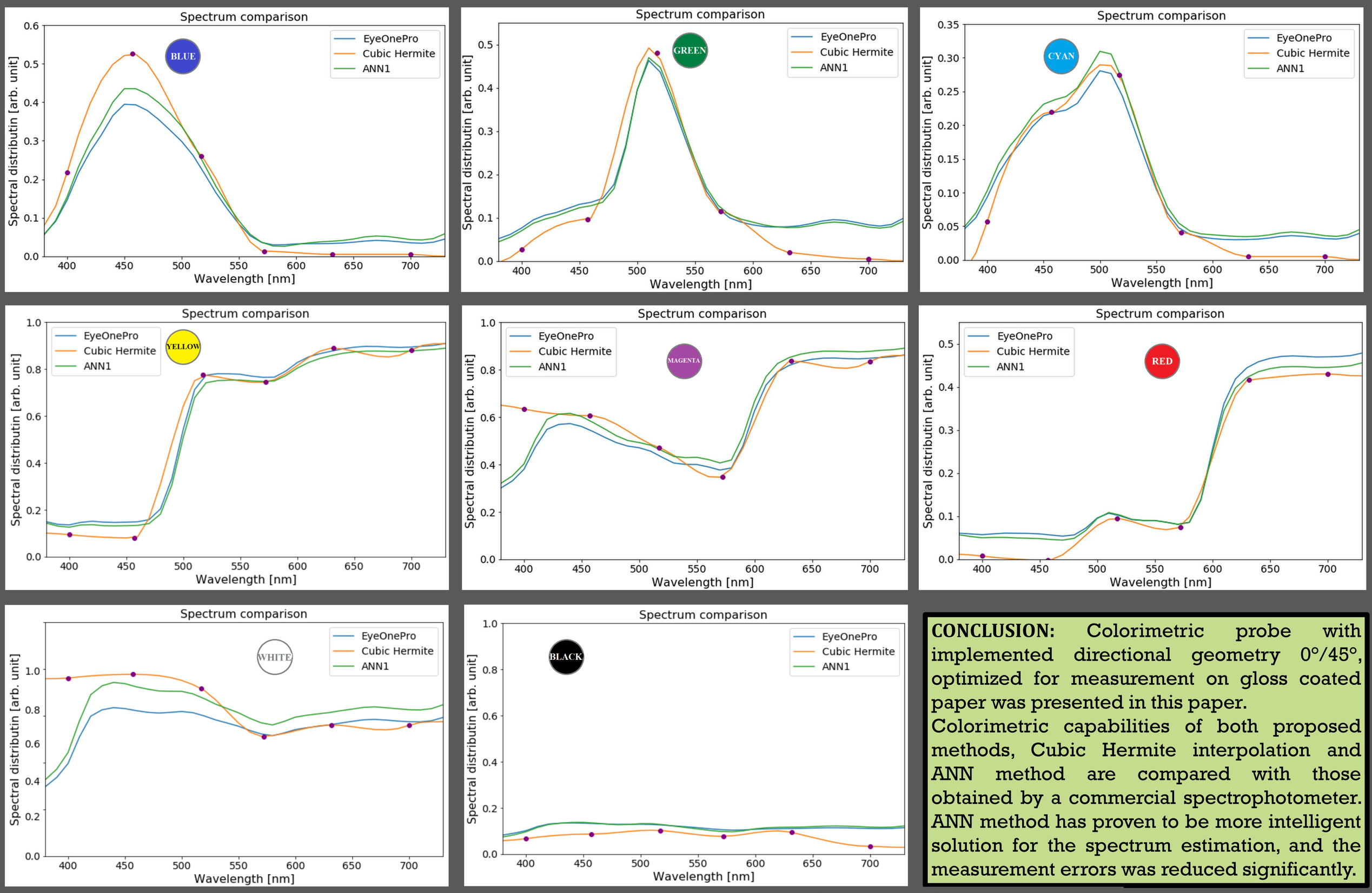
ΔE_{00}	Blue	Green	Cyan	Yellow	Magenta	Red	White	Black
Cubic Hermite	2.62	4.37	3.13	1.71	3.59	5.01	4.97	6.32
ANN	1.8	1.54	1.85	0.95	1.42	2.93	2.21	1.91

Specular reflection can have adverse effect in case of measuring gloss samples, since it would cause a mirror-like reflection of light from the surface. Diffuse reflection tend to reflect light in a multitude of directions, and the colorimetric probe is designed to collect only this type of reflection.



1 – Transmitting LEDs optical fibers
2 – Plastic housing with distancer (3)
4 – Probe head 5 – Focusing lens
6 – Focused light beam
7 – Receiving optical fiber
8 – Incident light causes specular reflection
9 – Diffusely reflected beam
10 – Glossy color sample

Fig. 1. Design of colorimetric probe with 0°/45° geometry implemented



CONCLUSION: Colorimetric probe with implemented directional geometry 0°/45°, optimized for measurement on gloss coated paper was presented in this paper.
Colorimetric capabilities of both proposed methods, Cubic Hermite interpolation and ANN method are compared with those obtained by a commercial spectrophotometer. ANN method has proven to be more intelligent solution for the spectrum estimation, and the measurement errors was reduced significantly.

Fig. 1. Cubic Hermite interpolation and implemented ANN compared to referent spectrophotometer EyeOnePro

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