Color gamut volumes of ink-jet prints made on papers suitable for offset technique

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Ink-jet as a digital technology can be used for carrying out very short runlenghts. This constitutes a very important issue nowadays since the digital printing market was estimated to grow by 71% from 2008 to 2013 year. [1] [2]
There are many kinds of papers suitable for ink-jet, yet they are rather expensive. This is the reason why users of digital machines search for cheaper equivalents, i.e. offset papers. Unfortunately, such papers can give bad printing quality. Before using them, a considerable number tests should be carried out in order to check what types of offset paper are useful in ink-jet technique.
Key words: papers suitable for ink-jet, papers applied in offset printing technique, machine with pigment aqueous-based inks, machine with UV-curable inks, gamut volume, colorimetric spaces, color appearance model

Introduction

Gamut is a colorimetric space of offset or digital prints. It can be shown in CIELAB space, where dimension L* is lightness, a* and b* are color-opponent dimensions. L*, represents the darkest black at L* = 0, and the brightest white at L* = 100. The colour channels, a* and b*, at a* = 0 and b* = 0 will represent true neutral gray values. The red and green opponent colors are represented along the a* axis (green at negative a* values and red at positive a* values). The yellow and blue opponent colors are represented along the b* axis (blue at negative b* values and yellow at positive b* values). [3] [4]

Three-dimensional CIELAB space is shown on Figure 1. Sometimes it is shown as a simple ball (Fig. 1a), however the shape of space is much more complicated (Fig. 1b).

There were many publications and conferences materials connected with the gamut topic [6]÷[26]. However they describe only printing on papers suitable for digital printing. There is no publication connected with gamut volume of prints made by using digital technique but on papers suitable for offset. The aim of this article is to show that some papers theoretically not suitable for digital printing, can be used in this technique, because their gamut volumes are almost the same or even better than the ones of papers suitable for.

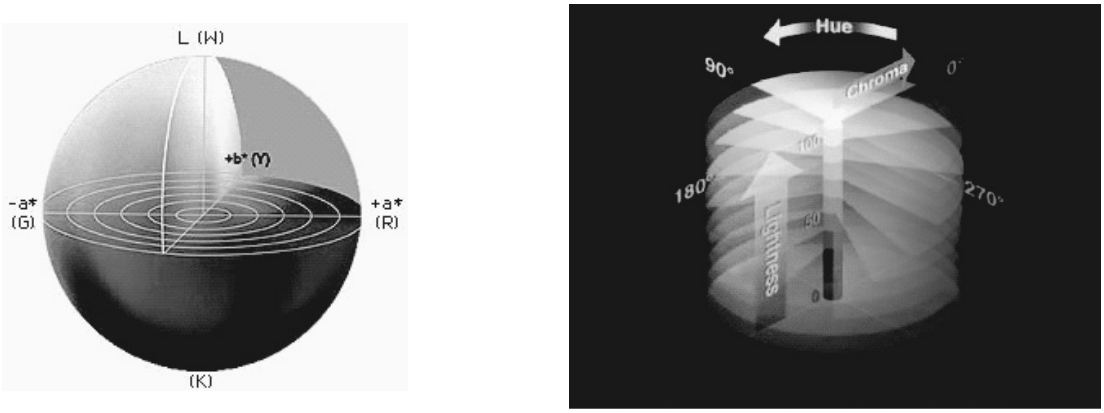

Figure 1. CIELAB space – a: shown as a ball; b: shown as three-dimensional layers [3][5]

Experimental

Papers suitable for ink-jet and papers usually applied in offset printing technique were printed using two types of ink-jet machine – with pigment aqueous-based inks and UV-curable inks. Before the production, these two machines were calibrated: transformation related to the linearization and the ink limit was carried out (Color Management disabled).

On papers was printed special test: ANSI IT8/7.3 color chart with 928 control patches. The spectral reflectance of all patches was measured using SpectroScan (Gretag Macbeth) and colorimetric properties: illuminant D50 and standard color observer, angle 2°.

Results

The results were presented in two colorimetric spaces: CIEXYZ, CIELAB and color appearance model space: CIECAM02.

In order to estimate gamut volume, the MatLab program was used. It calculated by starting from spectral reflectance λ.

Tone value of ink makes an intersection from 0 to 1 (<0,1>), where 0 is for the place on a print without any ink, 1 is for 100% value (solid). All inks give three-dimensional gamut. In this article only three inks were taken into consideration – Cyan, Magenta and Yellow. Black ink (K) was 0 value (K=0). This is the reason why, intersection <0,1> makes cube $<0,1>^3$, where exponent 3 is connected with three inks.

In the MatLab, first Delaunay's tetrahedralization of 250 points set in earlier mentioned cube $<0,1>^3$ was performed. After tetrahedralization, there were 863 tetrahedrons set available. In the next stage it was checked if cube tetrahedralization transferred to CIEXYZ, CIELAB and CIECAM02 was still tetrahedral division. It means that it was checked whether an intersection of tetrahedrons was a triangle, wall, segment, vertex or an empty set. This allowed to find out whether there were any errors in measurement or during calibration. [27]

Additionally, the volume of color gamut for all papers printed with two different ink-jet machines was estimated.

Discussion

Present analysis compares values of gamut volumes.

Papers suitable for digital printing have either the widest (the case of a device with aqueous-based inks) or one of the widest gamut volumes (as it happens in case of a device with UV-curable inks). However, especially in the case of printing with UV-curable inks, uncoated and coated papers in their maximum available grammage, have comparable volumes of gamut. As far as the CIELAB colorimetric space and CIECAM color appearance model space are concerned, they have even greatest values than papers suitable for ink-jet, whereas the uncoated and uncoated bulky papers in their minimum grammage possess the lowest gamut volume. This is probably due to the fact of thicker layer of papers with coating or papers without coating but in their maximum grammage. Such layers are more resistant to ink influence.

Papers suitable for machines with aqueous-based inks have the widest gamut volume in all color spaces. Only in CIEXYZ colorimetric space, two types of coated papers show comparable values. The other types of paper have much narrower gamut volume, although those coated ones display bigger values then uncoated ones.

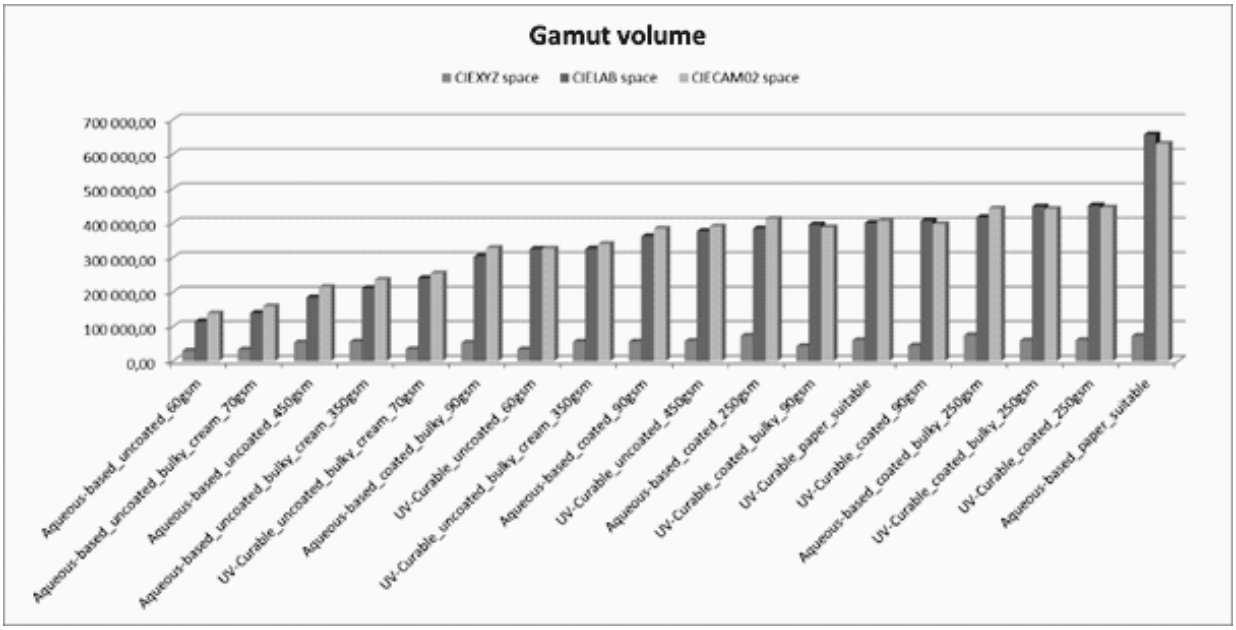

Figure 2. Gamut volumes from the lowest to the greatest

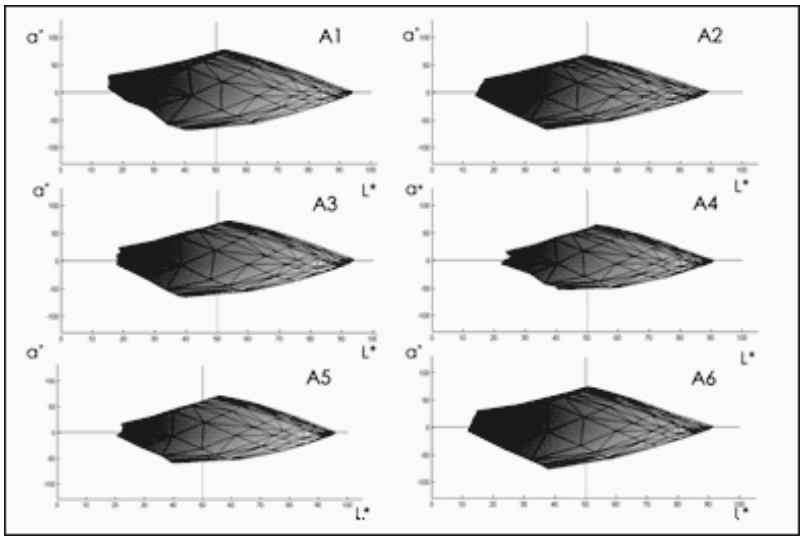

Fig. 3. Color gamut in CIELAB colorimetric space – "A" means printing device with UV Curable ink, 1 – paper suitable for ink-jet, 2 – uncoated paper 60 gsm, 3 – unoated board 450 gsm, 4 – uncoated bulky cream paper 70 gsm, 5 – uncoated bulky cream board 350 gsm, 6 – coated paper 90 gsm

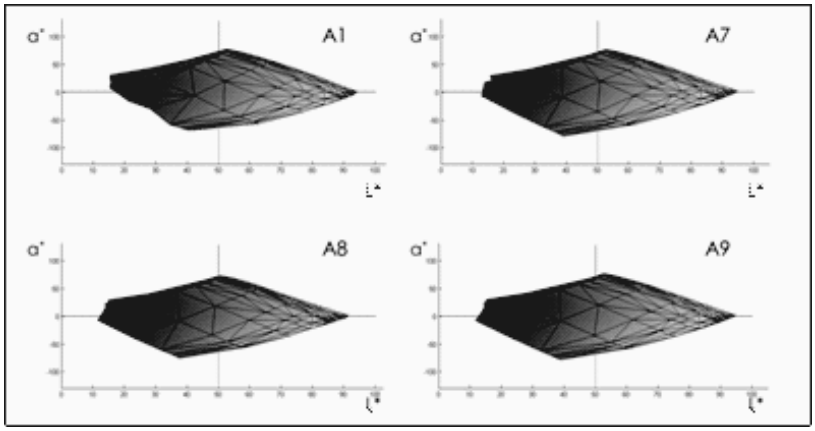

Fig. 4 Color gamut in CIELAB colorimetric space – "A" means printing device with UV Curable ink, 1 – paper suitable for ink-jet, 7 – coated paper 250 gsm, 8 – coated bulky paper 90 gsm, 9 – coated bulky paper 250 gsm

All gamut volumes ordered from the lowest to the greatest are presented on Figure 2. On this Figure it is shown that the lowest values of gamut characterize CIEXYZ space (it is much smaller than CIELAB and CIECAM). It is also shown that the order of prints is the same for all spaces.

In this article the visualization of CIELAB space is presented. This visualization was made in MatLab program which enable to turn around figures in various ways. In the article it was used projection on plane. This is the reason why on presented figures are shown only L* and a* coordinates.

In order to notice the difference between prints made on papers suitable for digital technique and prints made on papers suitable for offset, color gamut visualization of the first one (A1, C1) is repeated in every figure.

On Figures 3÷4 the CIELAB colorimetric space of papers printed in UV Curable ink machines is represented. The types of color gamut volume are similar to those in CIECAM02: yet, although the papers suitable for ink-jet (A1) possess wider than uncoated papers in small grammage (A2, A4), their gamut volume is slightly lower than the one of offset coated papers (A7, A8, A9). However those slightly differences are difficult to notice at first glance. That's why figures seem to be the same, but for real, they are not the same.

On Figures 5÷6 CIELAB colorimetric spaces color gamuts of papers printed in aqueous-based ink machines are represented. The dependences are similar to the ones in CIECAM02 space: Papers suitable for ink-jet (C1) have much wider gamut than the gamuts of uncoated and coated papers. The narrowest have uncoated ones.

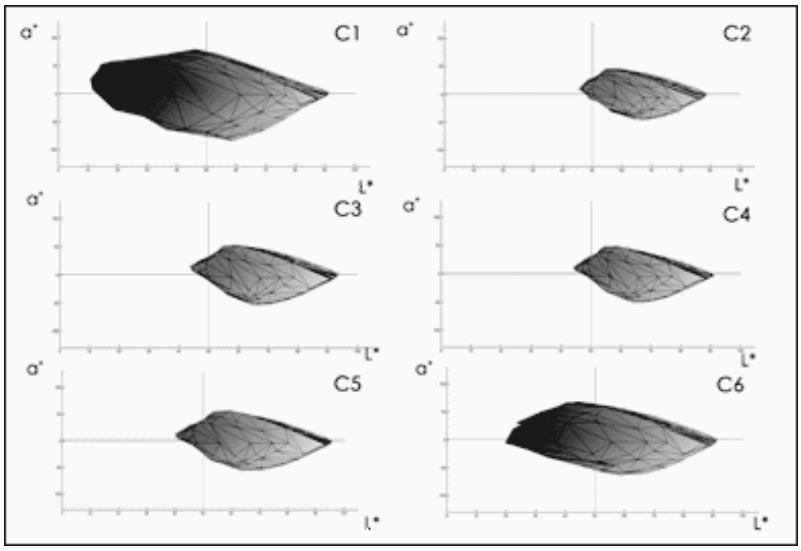

Fig. 5. Color gamut in CIELAB colorimetric space – "C" means printing device with aqueous-based ink, 1 – paper suitable for ink-jet, 2 – uncoated paper 60 gsm, 3 – unoated board 450 gsm, 4 – uncoated bulky cream paper 70 gsm, 5 – uncoated bulky cream board 350 gsm, 6 – coated paper 90 gsm

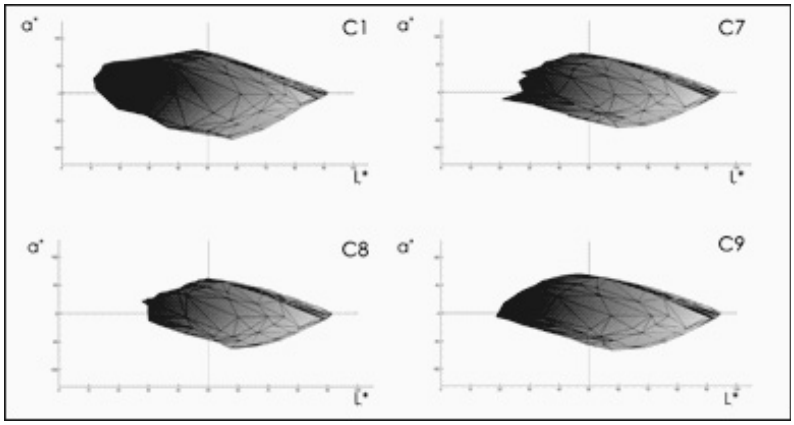

Fig. 6 Color gamut in CIELAB colorimetric space – "C" means printing device with aqueous-based ink, 1 – paper suitable for ink-jet, 7 – coated paper 250 gsm, 8 – coated bulky paper 90 gsm, 9 – coated bulky paper 250 gsm

Conclusions

Although papers suitable for the digital ink-jet technique have one of the widest gamut volume, there are papers, usually used in offset printing machines, which display similar characteristics. It is most visible for prints made in UV machines. It proves that ink-jet printers can use not only "digital papers" but also coated papers in their maximum grammages. In case of aqueous-based ink machines have achieved only two types of coated papers in 250 gsm good results. Uncoated papers in their minimum grammage have the narrowest gamut volume.

The uncoated papers are quite unsuitable for the high-quality inkjet. What is more likely to be their unique employment is the formproof. (layout-proof, ozalid process, etc.)

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