

ICC Display & 3D Print Meeting
MAY 06 2016

Color Gamut Mapping for 3D Printing

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EDUCATION

- B.S. in Electronic and computer engineering, NTUST 2010-2014
- Master in Color & Illuminance technology, NTUST 2014- 2016

RESEARCH INTEREST

- Color imaging processing
- Cross-media color management system

RESEARCH PROJECT

- Color gamut mapping for full color 3D printing
- Color reproduction from textile and tile
- System implementation and development of a photo curable Color 3D Additive Manufacturing Technique

PROJET® 460PLUS PROFESSIONAL 3D PRINTER



3DSYSTEMS

Build envelope capacity (W x D x H)	8 x 10 x 8 in (203 x 254 x 203 mm)
Color	White (monochrome)CMY
Resolution	300 x 450 DPI
Build material	VisiJet PXL
Layer thickness	0.004 in (0.1 mm)
Min. feature size	0.03 in (0.8 mm)
Max. vertical build speed	0.9 in/hour (23 mm/hour)
Number of print heads	2
Draft printing mode (monochrome)	No
Number of jets	604
Material recycling	Yes
Automatic build platform cleaning	Yes

Integrated part cleaning

Integrated



NO COLOR MANAGEMENT

Display

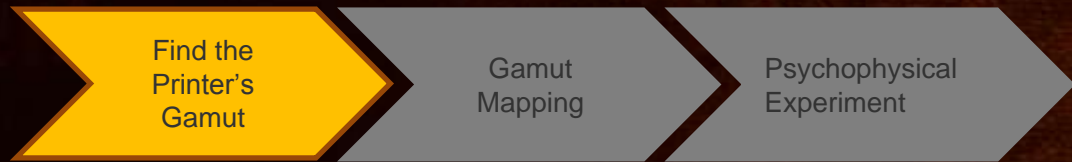


PROJET® 460PLUS
3D PRINTER



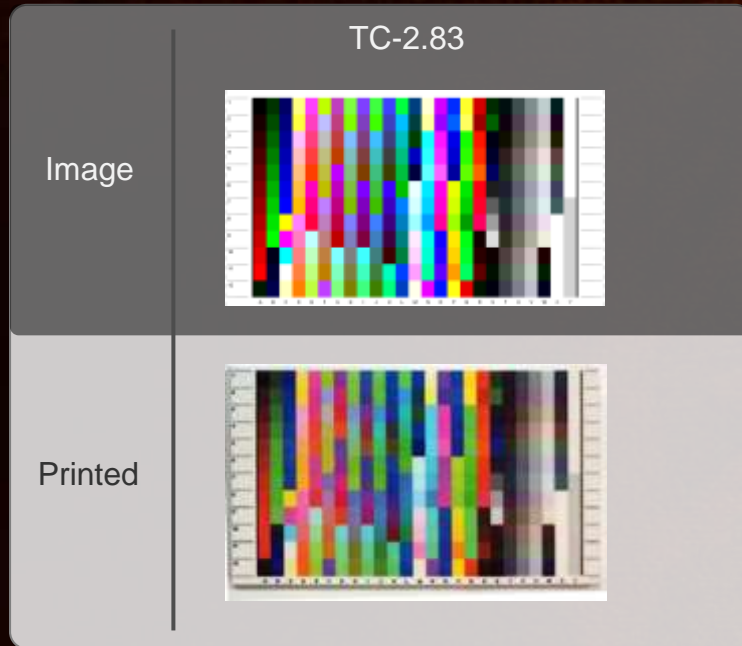
Printed





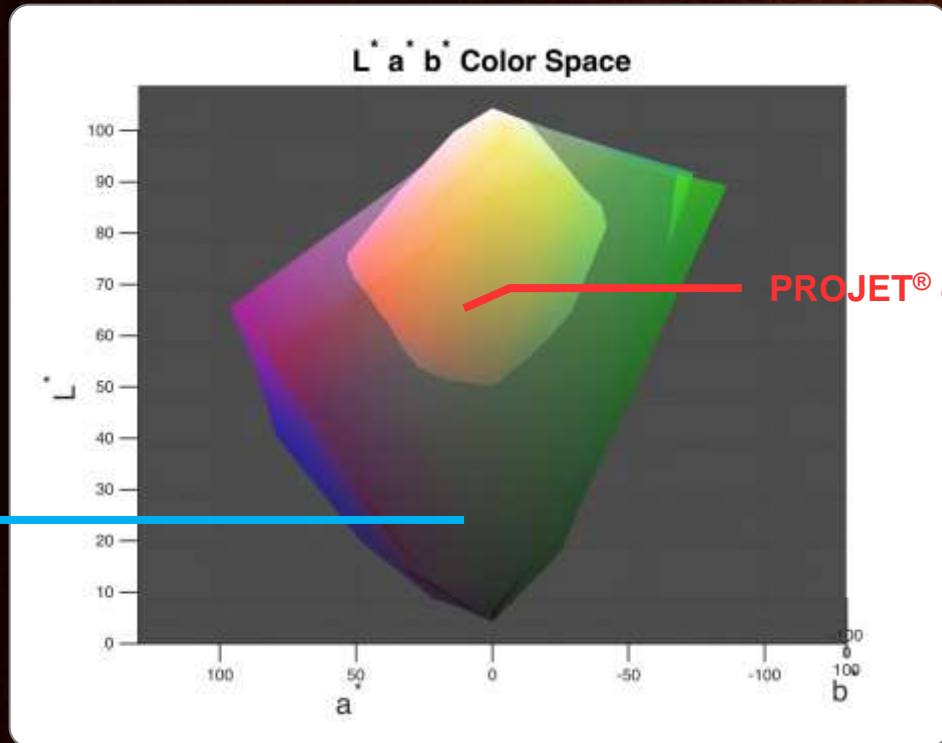
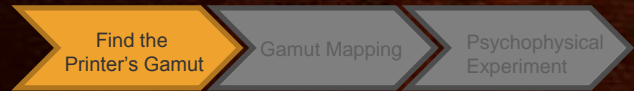
Finding the Gamut

Testchart



Gamut : range of realisable colors

Printer's Gamut



sRGB

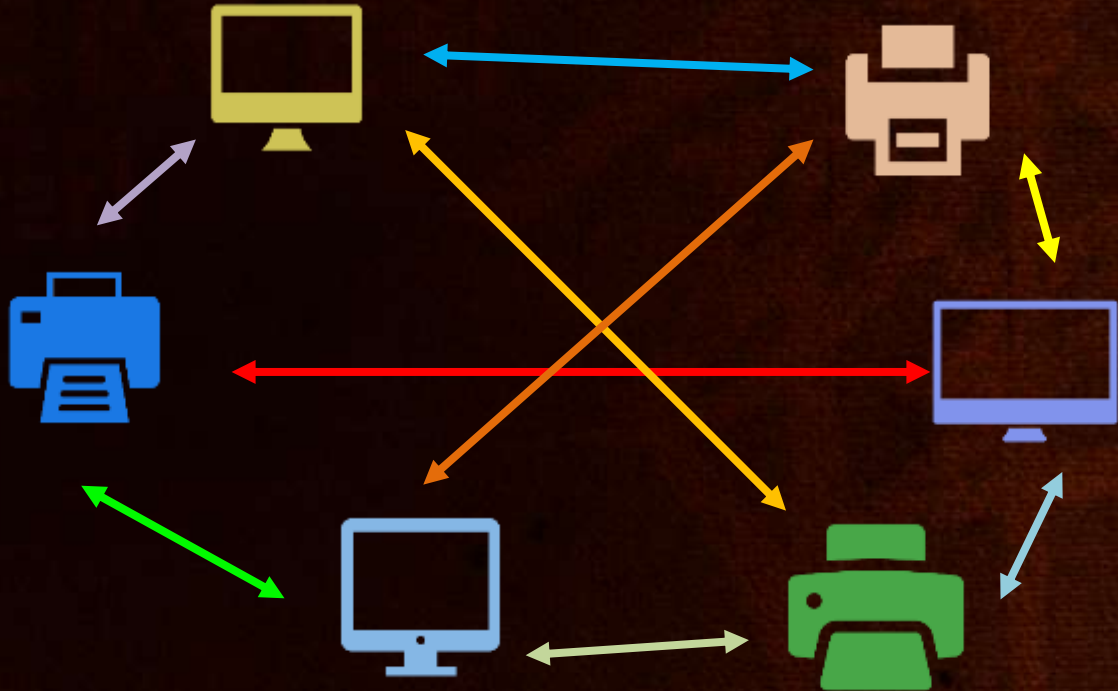
PROJET® 460PLUS



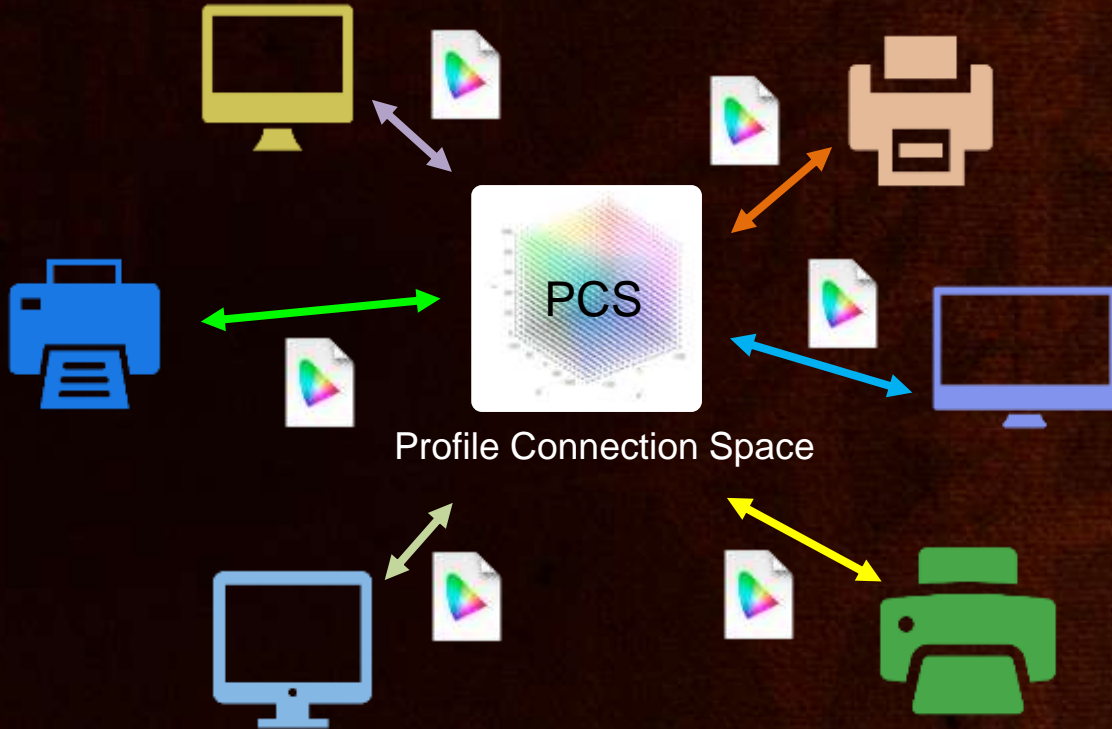
Model



Device Dependent Color Transformations

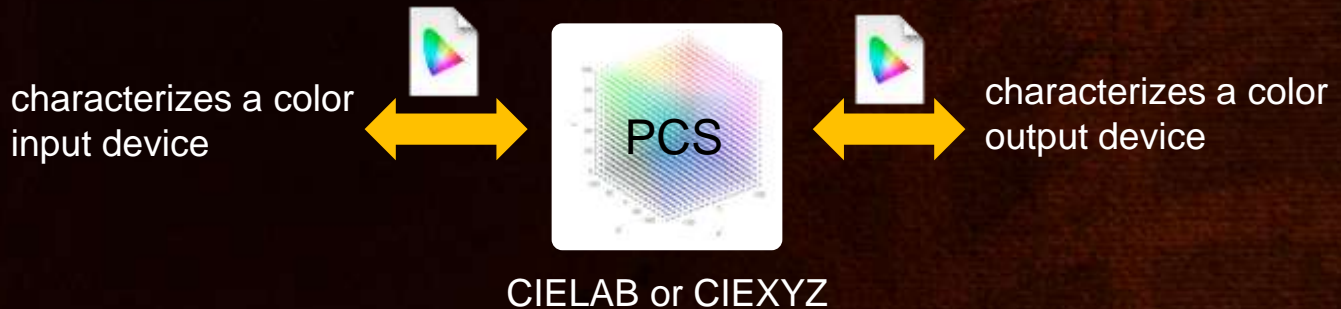


Device Independent Color Transformations

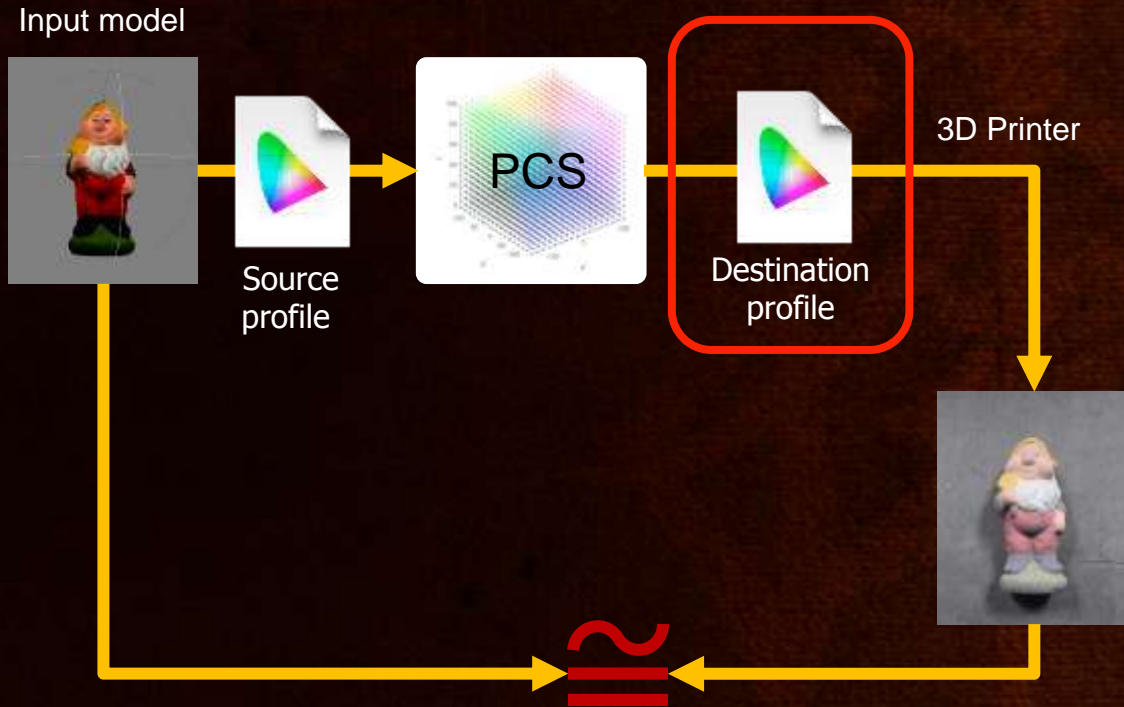


ICC Profile

ICC profile is a set of data that characterizes a color input or output device, or a color space.

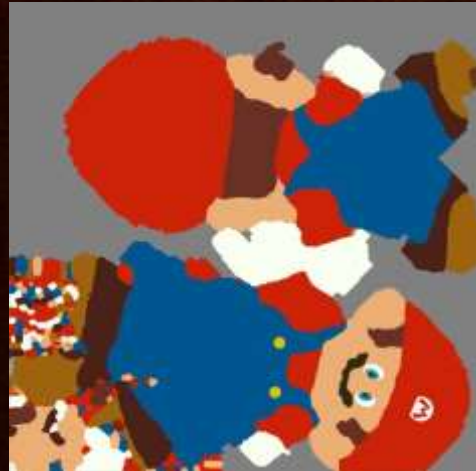


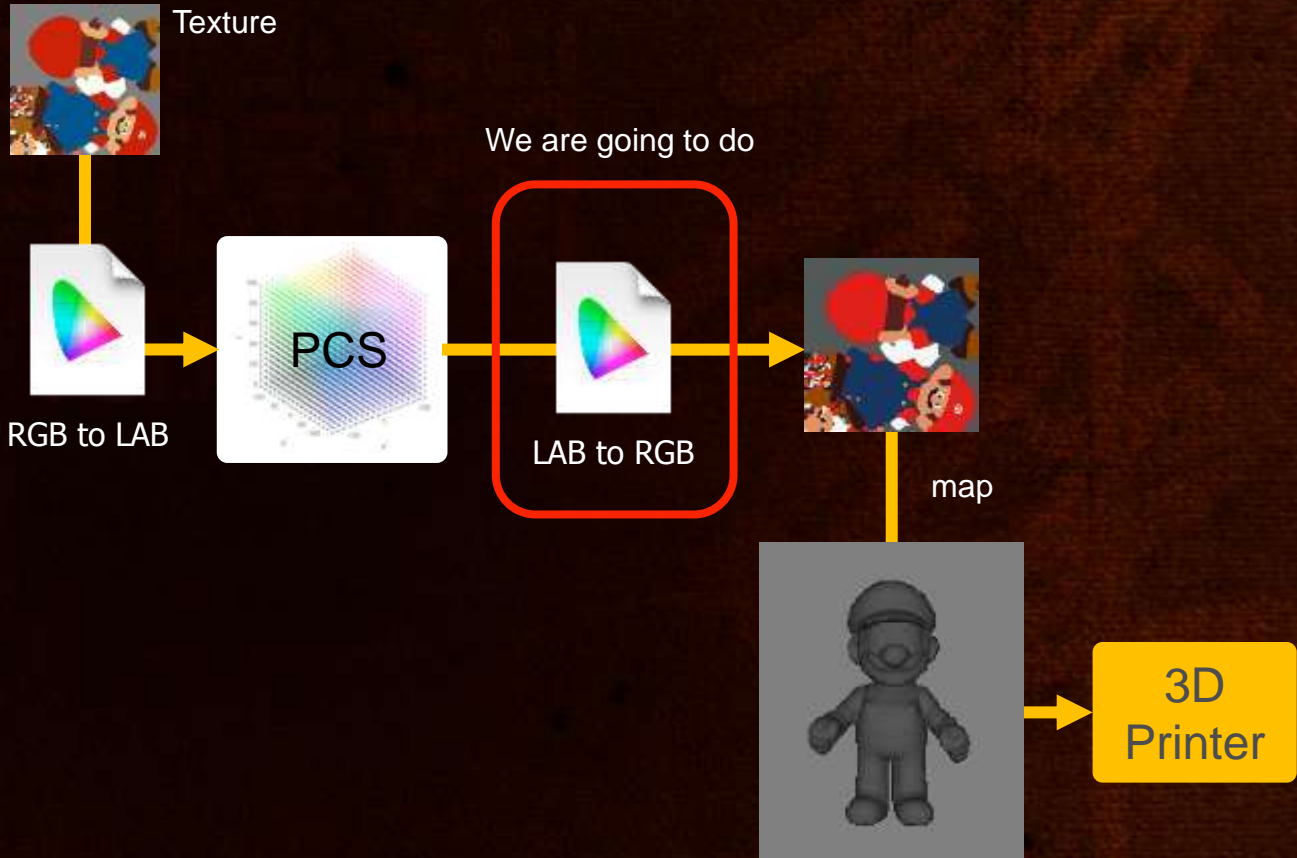
Printer with CMS



PROJET® 460PLUS 3D PRINTER → No CMS

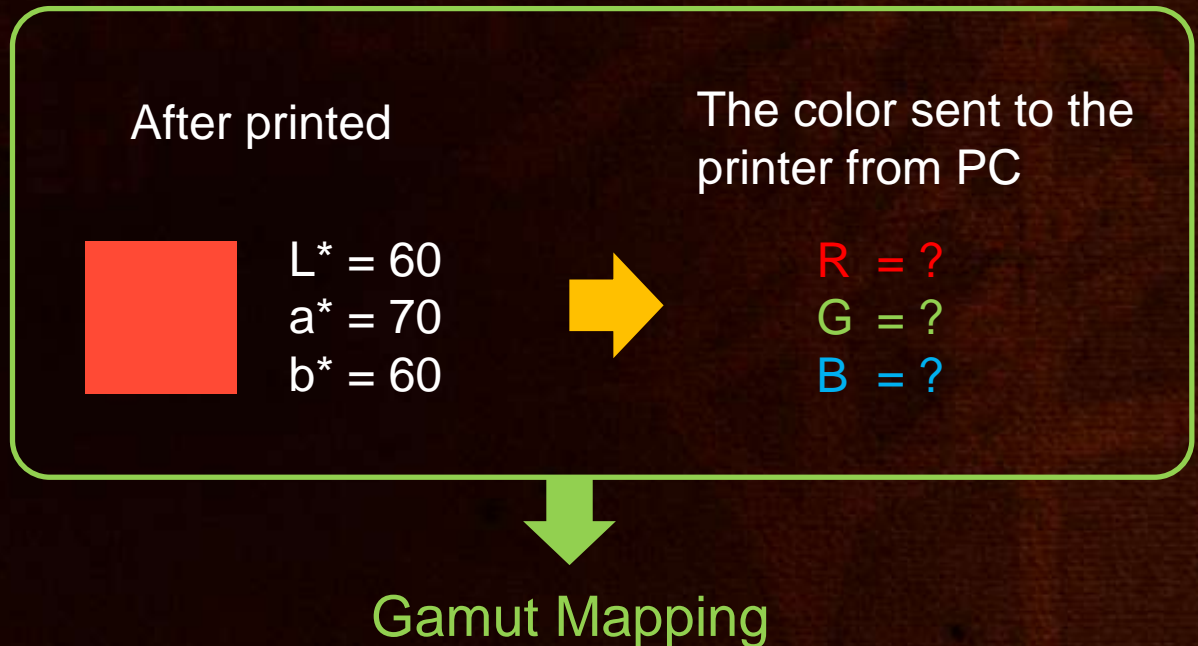
- Do the adjustment on the 3D model's texture






We are Going to Do

Make the LUT for from PCS to RGB



We are Going to Do

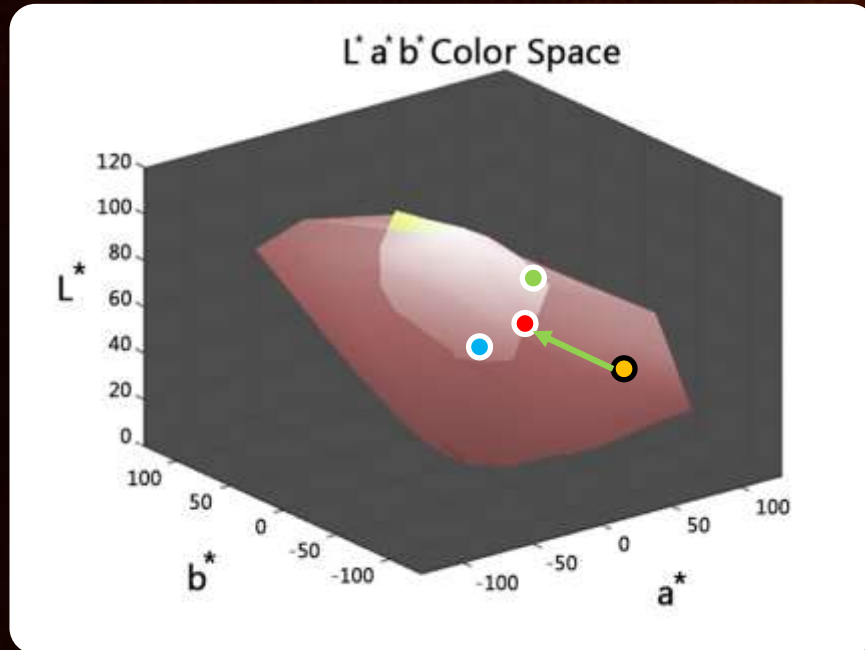
Make the LUT for from PCS to RGB  Gamut Mapping

- Clipping
- Hue-angle Preserving Minimum ΔE_{ab} Clipping (HPminDE)
- Chroma Dependent Sigmoidal Lightness Mapping and Cusp Knee Scaling (SGCK)



Color Management Method

Clipping

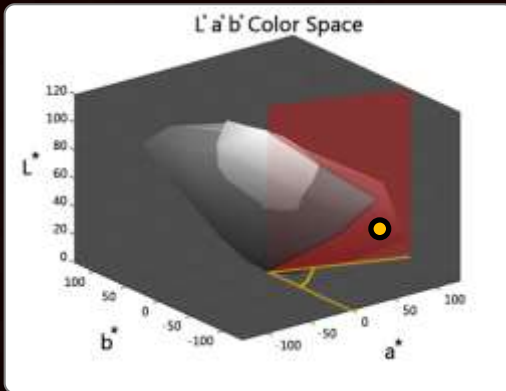


Find the minimum distance inside the printer's gamut

Color Management Method

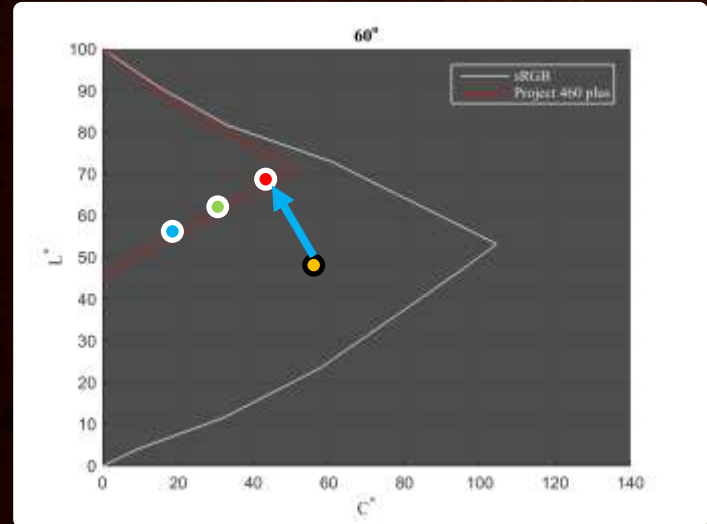
HPminDE

STEP 1



Find the hue angle

STEP 2



Find the minimum distance inside the printer's gamut

Color Management Method

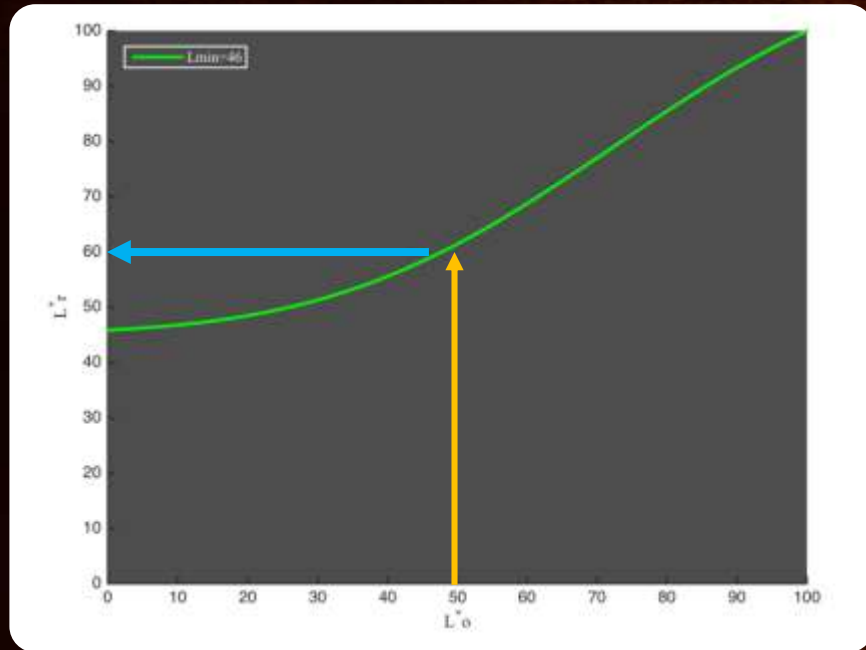
SGCK



Color Management Method

SGCK -Lightness Adjustment

Output

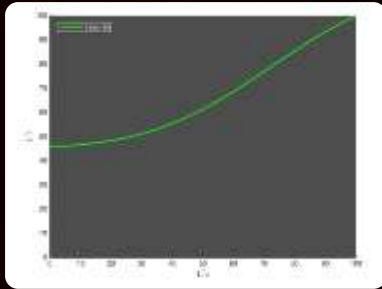


Input

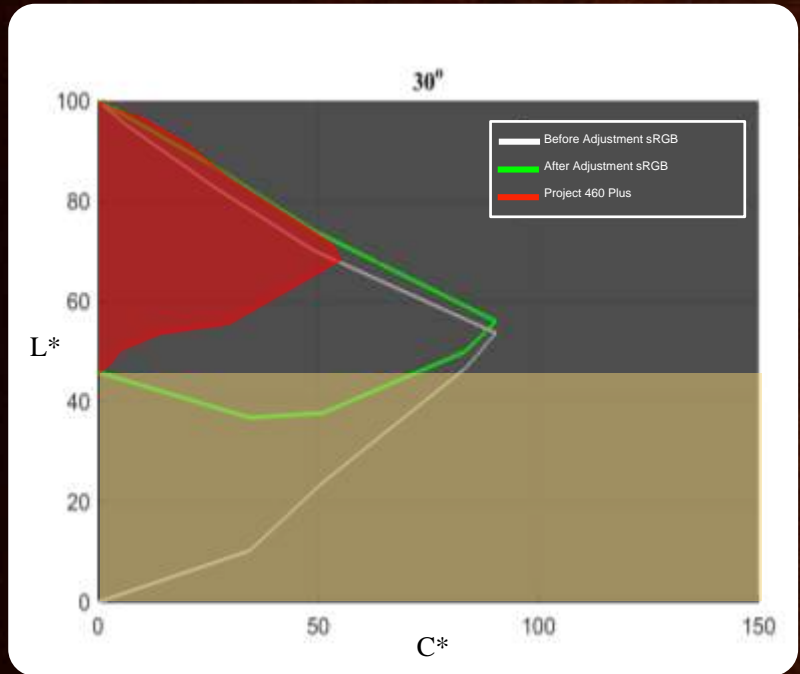
Color Management Method

SGCK -Lightness Adjustment

— White Line

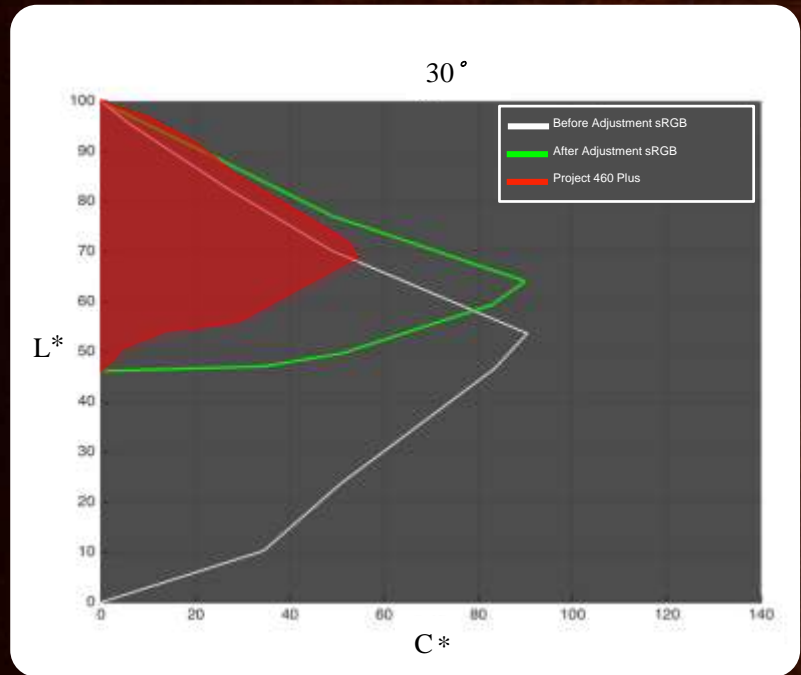
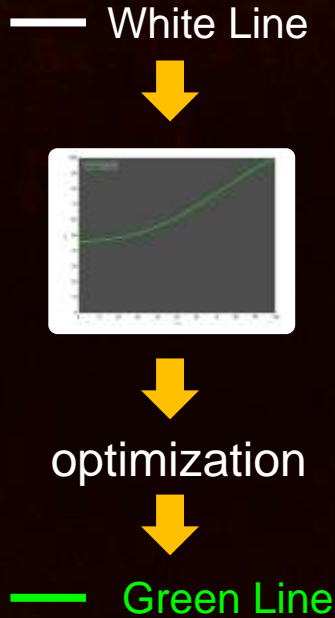


— Green Line



Color Management Method

SGCK -Lightness Adjustment



Color Management Method

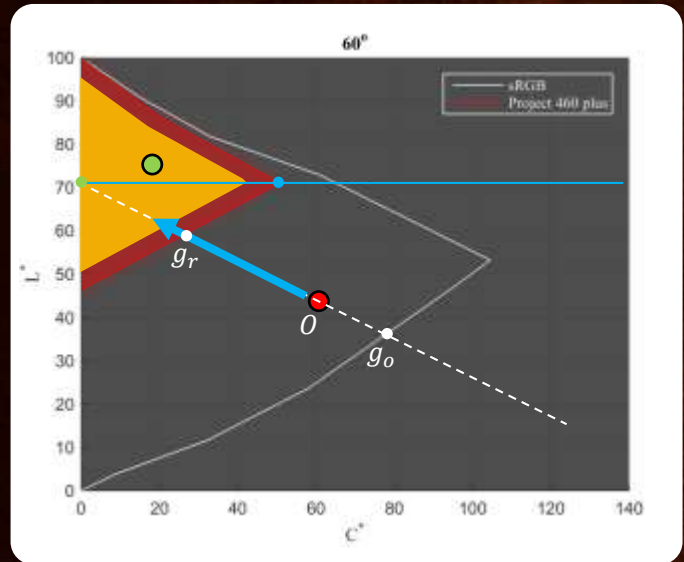
SGCK -Color Mapping



90% of the Printer's Gamut

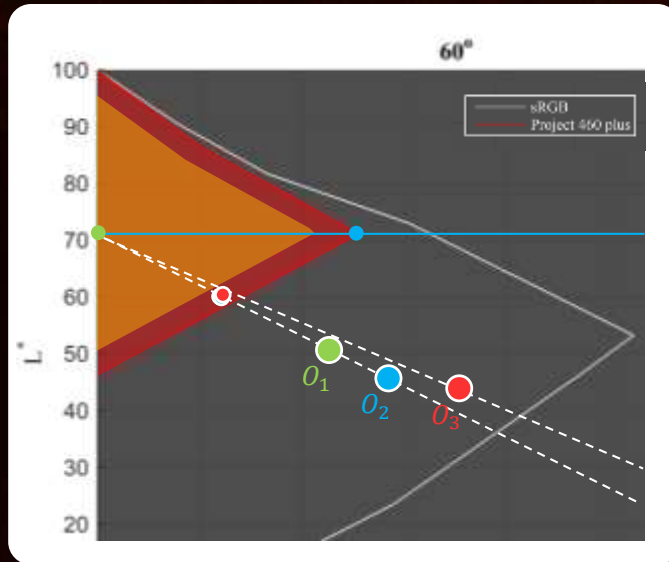
Inside : Hold Still

Outside : Do the Mapping



Color Management Method

SGCK -Color Mapping



Many colors look the same after mapping

Color Management Method

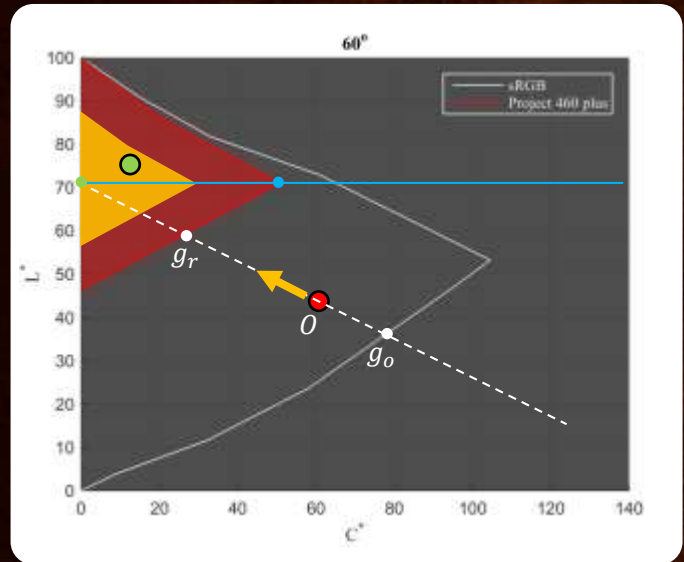
SGCK -Color Mapping



50% of the Printer's Gamut

Inside : Hold Still

Outside : Do the Mapping



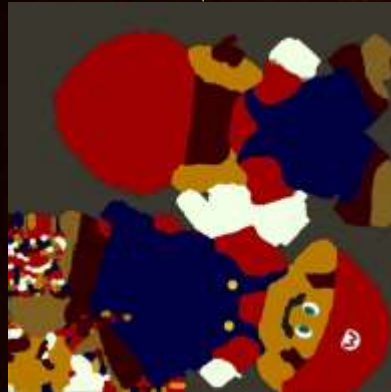
Result



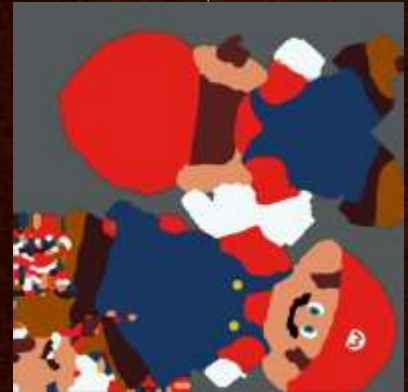
Initial texture



Clipping



HPminDE

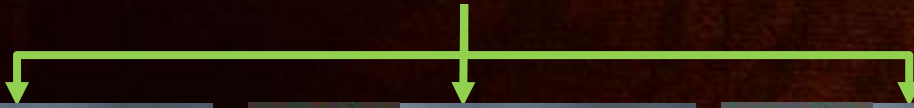


SGCK

Result



Initial texture



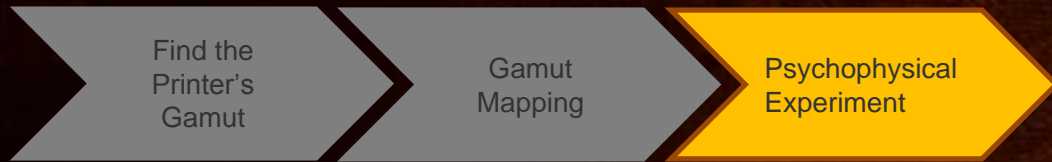
Clipping



HPminDE



SGCK



Psychophysical Experiment

Monitor : EIZO ColorEdge SG232W
set to sRGB

12 observers

Ambient light condition was set in
the dark room

Color Viewing Light Booth
- D65



Psychophysical Experiment - Pair Comparison Method



No CMS



Clipping



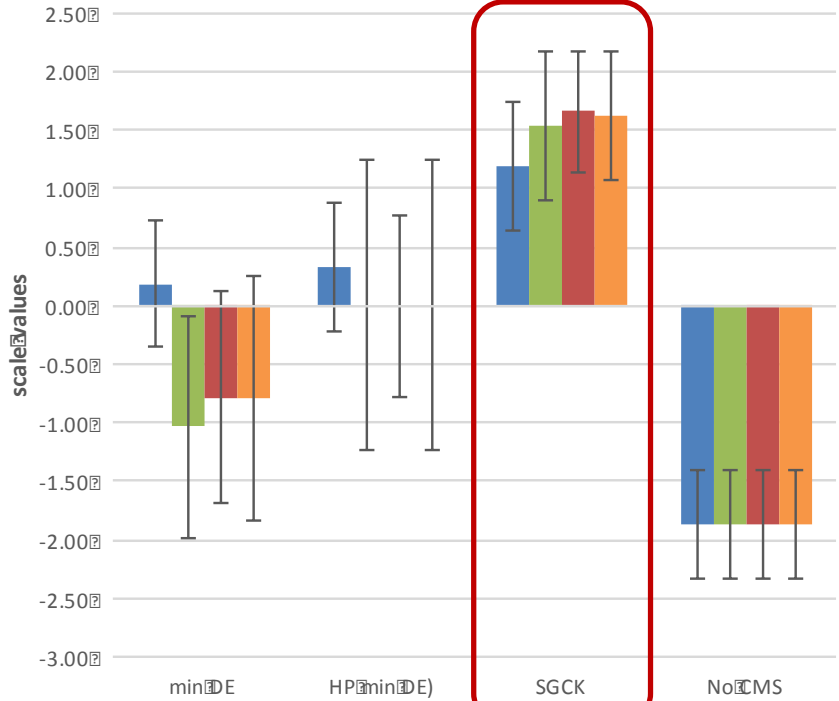
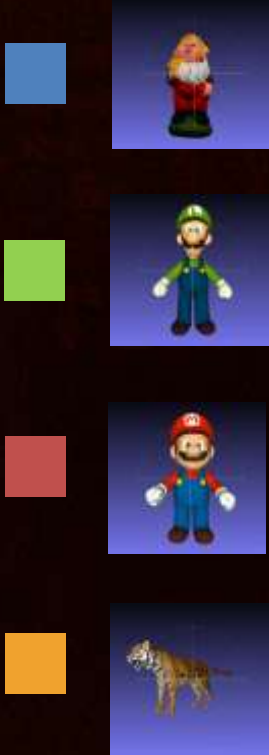
HPminDE



SGCK



For 4 model



Conclusion

Conclusion

SGCK is the best method for the 3D printer

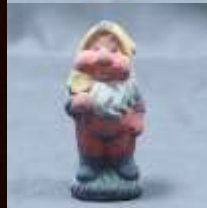
Monitor



No CMS



SGCK



End