

openSUSE Conference



Accessibility of terminal color schemes

Jan Engelhardt <ej@inai.de>

2024-06-29

oSC24



@openSU
SE



opensuse-project@opensuse.org

good ol' textmode yast2

```
YaST2 - network @ localhost

Network Card Setup
General—Address—Hardware—
( ) No Link and IP Setup (Bond Ports)
( x ) Dynamic Address DHCP [redacted] ↓ DHCP both version 4 and 6 ↓
( ) Statically Assigned IP Address
IP Address        Subnet Mask      Hostname
[redacted]         [redacted]       [redacted]
Additional Addresses
┌──────────┴──────────┴──────────┐
│ Address Label | IP Address | Netmask │
│               │           │         │
│               │           │         │
│               │           │         │
└──────────┬──────────┬──────────┘
            [Add][Edit][Delete]
[Help]                    [Cancel]                    [Next]
F1 Help F3 Add F9 Cancel F10 Next
```

- You can do the same visual experiment with Midnight Commander



...“gnome” palette

```
YaST2 - network @ localhost

Network Card Setup
General—Address—Hardware—
( ) No Link and IP Setup (Bond Ports)
(x) Dynamic Address DHCP [redacted] ↓ DHCP both version 4 and 6 ↓
( ) Statically Assigned IP Address
IP Address      Subnet Mask      Hostname
[redacted]      [redacted]      [redacted]
Additional Addresses
┌───────────────────────────────────────────────────────────────────────────────────┐
│ Address Label | IP Address | Netmask │
│                                         │
│                                         │
│                                         │
└───────────────────────────────────────────────────────────────────────────────────┘
[Add][Edit][Delete]

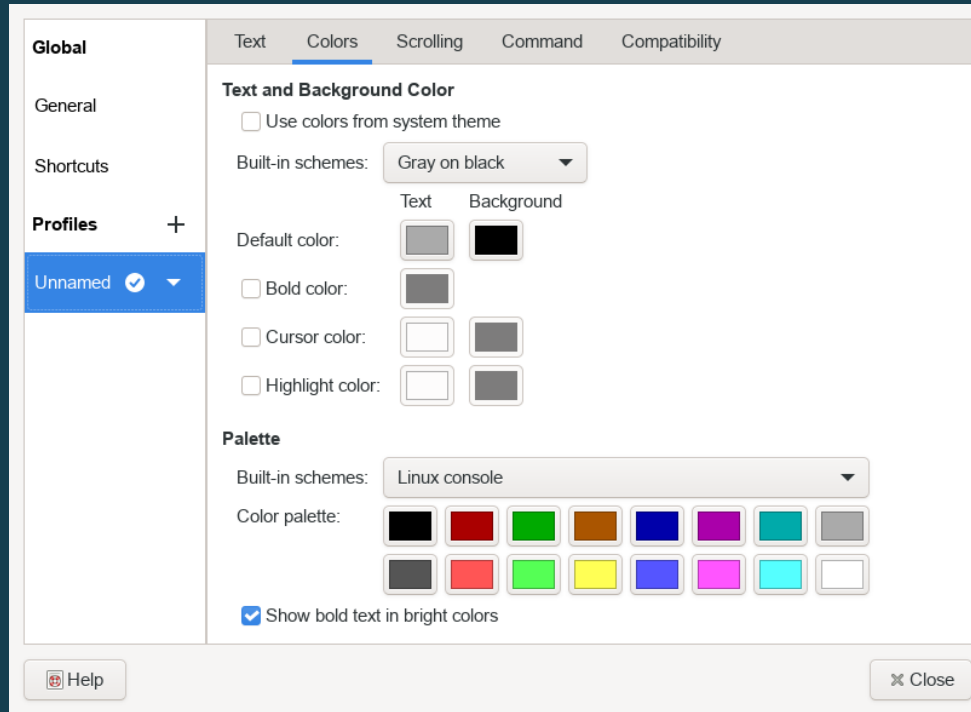
[Help]                                [Cancel]                                [Next]

F1 Help  F3 Add  F9 Cancel  F10 Next
```

- Open yast2 in gnome-terminal and it looks like this



ah yes, the choice



- terminal programs' defaults vary
- some offer a handful of built-in presets for personalization



...“tango” palette

```
YaST2 - network @ localhost

Network Card Setup
General—Address—Hardware—
( ) No Link and IP Setup (Bond Ports)
(x) Dynamic Address DHCP [redacted] ↓ DHCP both version 4 and 6 ↓
( ) Statically Assigned IP Address
IP Address       Subnet Mask       Hostname
[redacted]       [redacted]       [redacted]

Additional Addresses
┌──────────────────────────────────────────────────────────────────────────┐
│ Address Label | IP Address | Netmask                                  │
├──────────────────────────────────────────────────────────────────────────┤
│                                                                           │
│                                                                           │
│                                                                           │
│                                                                           │
└──────────────────────────────────────────────────────────────────────────┘

[Add] [Edit] [Delete]

[Help]                                     [Cancel]                               [Next]

F1 Help  F3 Add  F9 Cancel  F10 Next
```



...“solarized” palette

```
YaST2 - network @ localhost

Network Card Setup
  General—Address—Hardware—
  ( ) No Link and IP Setup (Bond Ports)
  (x) Dynamic Address DHCP [ ] DHCP both version 4 and 6 [ ]
  ( ) Statically Assigned IP Address
  IP Address      Subnet Mask      Hostname
  [ ] [ ] [ ]
  Additional Addresses
  Address Label | IP Address | Netmask
  [ ] [ ] [ ]
  [Add][Edit][Delete]

[Help] [Cancel] [Next]

F1 Help F3 Add F9 Cancel F10 Next
```



...“breeze” palette

```
YaST2 - network @ localhost

Network Card Setup
General—Address—Hardware—
( ) No Link and IP Setup (Bond Ports)
(x) Dynamic Address DHCP [ ] DHCP both version 4 and 6 [ ]
( ) Statically Assigned IP Address
IP Address      Subnet Mask      Hostname
[ ] [ ] [ ]
Additional Addresses
  Address Label | IP Address | Netmask
  [ ] [ ] [ ]
  [Add][Edit][Delete]

[Help] [Cancel] [Next]

F1 Help F3 Add F9 Cancel F10 Next
```

- used by KDE Konsole



Low contrast palettes

- bad accessibility
- want to quantify with numbers just how dire the situation is
- *I have just the tool for that...*
zypper in consoleet-utils or
<https://codeberg.org/consoleet/consoleet-utils>



Contrast analysis

- contrast is generally computed exclusively based on lightness (no hues)
- compute lightness: convert RGB to CIELAB (modern & perceptual), or YIQ (archaic)
- compute legibility: APCA W3 (modern & perceptual), or $abs(L_x - L_y)$ (trivial)



Contrast analysis

```
19:47 f3:~/terminal/colorschemes $ palcomp loadpal=vga.theme cxa
===== APCA lightness contrast =====

  19  47  29   7  24  50  59      20  46  89 103  30  53  94 108
21      27   9  11   4  30  39      0  27  69  84  10  34  74  88
49 26      15  39  21   2  11      25   0  41  56  14   6  46  61
32   9  17      22   4  20  29      8  16  59  73   0  23  64  78
 8  11  39  21      16  42  51      12  38  81  95  22  45  86 100
26   3  22   5  16      25  34      2  22  64  79   6  29  69  83
52 29   1  18  42  24      8      28   2  38  53  18   3  43  57
60 38  10  27  51  33   7      37  10  29  44  26   3  34  48
22   0  26   9  12   3  29  38      26  68  83   9  33  73  87
48 26   0  15  39  21   3  12      25      42  56  14   6  47  61
88 66  38  55  79  61  35  26      65  30      13  54  31   3  17
102 79  51  68  92  74  48  39      78  51  11      67  44   6   2
32  10  16   0  22   4  19  28      9  15  58  72      23  63  77
55 33   5  22  45  27   1   9      32   5  34  49  21      40  54
93 70  42  60  83  65  39  31      69  43   2   7  59  36      12
106 83  55  73  96  78  52  43      82  56  15   2  72  49  10

default gray bold dim italic underscore blink rapidblink reverse striketh
rough
[16x16] contrast Σ 9061 // minus 33 penalties: Σ 8960
[16x8 ] contrast Σ 4082 // minus 17 penalties: Σ 4029
[ 8x8 ] contrast Σ 1385 // minus 8 penalties: Σ 1353
19:47 f3:~/terminal/colorschemes $
```



Contrast analysis

```
19:47 f3:~/terminal/colorschemes $ palcomp loadpal=solarized.theme cxa
===== APCA lightness contrast =====
```

	24	37	37	32	25	38	85		25	20	26	37	26	44	94
25		12	12	7	0	12	60	28		3	0	12	1	19	69
37	10		0	3	10	0	48	41	10	15	9	0	9	6	56
37	10	0		3	10	0	48	41	10	15	9	0	9	6	56
32	6	4	4		5	5	53	36	5	10	4	5	4	11	61
25	0	11	11	6		12	60	29	0	3	0	12	0	18	68
38	11	0	0	3	10		47	41	11	16	10	0	9	6	56
83	56	43	44	48	55	43		86	56	60	55	43	54	36	7
1	27	40	40	35	28	40	88		27	23	28	40	29	47	97
25		12	12	7	0	12	60	28		3	0	12	1	19	69
20	4	16	16	11	4	17	65	24	4		5	17	5	23	73
26	0	11	11	6	0	11	59	29	0	4		11	0	18	68
38	11	0	0	3	10	0	47	41	11	15	10		9	6	56
27	0	10	10	5	0	11	58	30	0	4	0	11		17	67
44	17	5	5	10	17	4	40	48	17	22	16	4	16		49
91	64	51	51	56	63	51	5	94	64	68	63	51	62	44	

```
default gray bold dim italic underline blink rapidblink reverse striketh
rough
[16x16] contrast Σ 5960 // minus 72 penalties: Σ 5775
[16x8 ] contrast Σ 2848 // minus 38 penalties: Σ 2752
[ 8x8 ] contrast Σ 1338 // minus 18 penalties: Σ 1292
19:47 f3:~/terminal/colorschemes $
```

- 72 fg-bg pairs considered to be illegible



Helmholtz–Kohlrausch effect

25	0	12	12	7	0
20	4	16	16	11	4
16	0	11	11	6	0
18	11	0	0	3	10
27	0	10	10	5	0
14	17	5	5	10	17
11	14	17	17	10	11

25		12	12	7	
20	4	16	16	11	4
16		11	11	6	
18	11			3	10
27		10	10	5	
14	17	5	5	10	17
11	14	17	17	10	11

- Some fg–bg pairings reportedly have ratings of e.g. 7, 4 or even 0 despite being legible to some viewers
- If you look at it in grayscale, the ratings are justified though



Analyzing all the styles

- A whole lot of samples:

<https://github.com/termux/termux-styling>

- Contrast analysis based on APCA:

```
for i in *.properties; do
    palcomp loadpal=$i cxa;
done
```



The results are in

- almost every style has less contrast than VGA

<u>16×16</u>	<u>16×8</u>	<u>Name</u>
5775	2752	solarized
6701	3274	gnome
8533	4089	termux:zenburn
8563	4323	termux:argonaut
8960	4029	Standard EGA/VGA
9035	3970	Saturated VGA (e.g. #ff0000 instead of #ff5555)
9349	4237	Windows 3.0 (termux:e-ink-color)



“It's a feature not a bug”

- Low contrast in palettes sometimes advertised as a *design principle* (“for night-time coding”)
- Terminal programs provide no information about the palette's intent
- Preset files may have a description in them
- We need to distinguish between *application-specific* and *general-purpose* (GP) palettes



GP-palette requirements

- Programs *do not* know what palette is used by the terminal
- Broad assumption is that `\e[32m` produces some green
- ECMA-48 indeed defines the general hue that escape codes ought to produce; no requirements on saturation, lightness or contrasts
- Some palettes can lead to readable text even without adhering to the hue specification (such as a hue-rotated VGA palette, or monochromatic palette)



Monochromatic/amber CRT look

YaST2 - network @ localhost

Network Card Setup

General—Address—Hardware

No Link and IP Setup (Bond Ports)

Dynamic Address DHCP DHCP both version 4 and 6

Statically Assigned IP Address

IP Address

Subnet Mask

Hostname

.....

Additional Addresses

Address Label	IP Address	Netmask

[Add][Edit][Delete]

[Help]

[Cancel]

[Next]

F1 Help F3 Add F9 Cancel F10 Next



Towards an optimal palette

- If we equal-space the lightness of every color, $sum(abs(L_{fg}-L_{bg}))$ will be maximized in principle.
- $max sum(APCA(L_{fg},L_{bg}))$ harder to compute, left for another day
- 16 spots to fill in the palette, but the modeled human can only distinguish 14–15 brightness levels



Improved Win3 palette

```

6.666667(3) 77.777778(8) 88.888889(7)
===== APCA lightness contrast =====
      9  28  54   3  17  41  88      71  38  87 103  16  46  92 108
10      18  44   5   7  31  78      60  27  76  93   6  36  82  98
30  18      26  25   9  12  60      42   9  58  74  19  18  64  79
56  44  24      51  35  11  33      15  14  31  48  36   6  37  53
 3   4  23  50      13  36  84      66  33  82  98  12  42  88 104
19   7  10  36  14      23  70      52  19  68  85   0  28  74  90
43  31  11  13  37  22      47      29   1  45  61  23   5  51  66
88  76  56  30  83  67  43      14  46   0  13  68  38   2  18
72  59  40  13  66  50  27  17      30  15  31  51  21  29  36
40  28   8  16  34  19   2  50      32      48  64  29   8  54  70
87  74  54  28  81  65  11   0      13  45      14  66  36   4  20
101 89  69  43  96  80  56  11      27  59  12      81  51   7   3
18   6  11  37  13   0  23  71      53  29  69  86      29  75  91
48  36  16   7  43  27   3  41      24   7  40  56  28      45  61
92  79  60  33  86  71  47   1      18  50   3   9  72  41      14
106 94  74  48 100  85  61  15      32  64  17   2  86  56  12
default gray bold dim italic underscore blink rapidblink reverse striketh
rough
[16x16] contrast Σ 10025 // minus 26 penalties: Σ 9931
[16x8 ] contrast Σ 4875 // minus 13 penalties:  Σ 4826
[ 8x8 ] contrast Σ 1904 // minus 6 penalties:   Σ 1875
23:02 f3:~/terminal/colorschemes $ palcomp win loeq cxa

```

- about 6% higher numerical contrast thanks to—in this case—equalization of the lower 8 colors



Challenges

- Problems inherent in CIELAB/CIELch:
 - poor blue constancy
(blue tones look quite purple)
 - $LCh=\{0,100,301^\circ\}$, despite no light, somehow equates to sRGB #00007f; stuff like that might be responsible for severe rounding errors
- wanted to use OKLAB, but OKLch is disabled in most builds of libbabl (poor distro penetration)



Takeaways

- We need a contrast-y palette as a default, make no assumptions about the user base nor the programs that are going to run in the terminal
- The bog-standard palettes we had for the past 30 years (VGA / Windows) have reasonably good contrast, the GNOME/KDE default palettes are behind



Thanks for your attention

<https://codeberg.org/consoleet/consoleet-utils>

A set of utilities for manipulating terminal fonts
and experimenting with color palettes.

