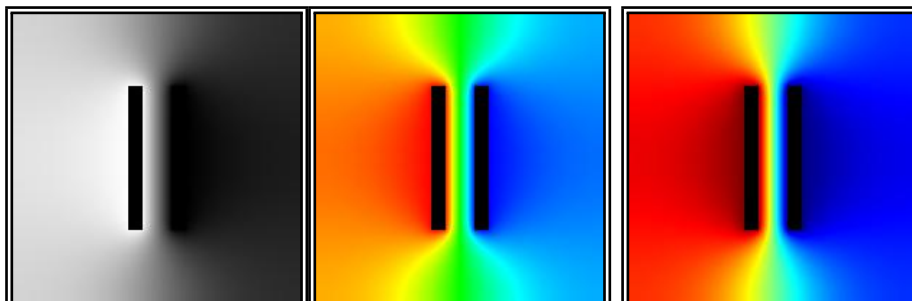


1

Liebmann technical documentation

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3

Graphics.

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Mapping voltages to colours
(colormaps).

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9

version 10

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2024.07.18

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21 1 Liebmann technical documentation series

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| 22 | 1. Wyznaczanie rozkładu pola elektrostatycznego w próżni metodą relaksacyjną Liebmann. (Polish version) | |
| 23 | | |
| 24 | 2. Determination of electrostatic field distribution by using Liebmann relaxation method. (English version) | |
| 25 | | |
| 26 | 3. Graphics. Mapping voltages to colours (colormaps). | |
| 27 | 4. Laplace equation 2D (XY). (Cartesian coordinates). Relaxation scheme explained (5 - point star) | |
| 28 | | |
| 29 | 5. Laplace equation 2D (ZR). (Cylindrical coordinates). Relaxation scheme explained (5 - point star). | |
| 30 | | |
| 31 | 6. Liebmann source code (ANSI C programming language). | |

32 2 Versions of this document

- | | | |
|----|---------------------------|--|
| 33 | 1. version 1 - 2023.11.03 | |
| 34 | 2. version 2 - 2024.01.26 | |
| 35 | 3. version 3 - 2024.02.02 | |
| 36 | 4. version 4 - 2024.02.05 | |
| 37 | 5. version 5 - 2024.02.27 | |
| 38 | 6. version 6 - 2024.05.18 | |

- 39 7. version 7 - 2024.05.26
- 40 8. version 8 - 2024.06.06
- 41 9. version 9 - 2024.07.17
- 42 10. version 10 - 2024.07.18

43 **3 Mapping value V to parameter t**

44 Liebmann software uses PPM graphic file format, which has been described in
45 Wikipedia [1] (package Netpbm).

46 We want to transform value of parameter V to colour value (3 pixel compo-
47 nents: red/green/blue).

48 Parameter V can be potential of electric field, but it can be other value, such
49 as electric force E .

50 Some Liebmann colour mapping recipes (Hot-To-Cold and Jet) work with
51 paramter t , which has values in range $[-1.0, \dots, +1.0]$, whereas the value of
52 parameter V lies in range $[V_{min}, \dots, V_{max}]$ (they must be determined before
53 mapping, because we want to know the range of V).

54 That's why the value of V must be „normalized“ - transformed from range
55 $[-V_{min}, \dots, V_{max}]$ to range $[-1.0, \dots, +1.0]$

56 The transformation is done by linear function shown below.

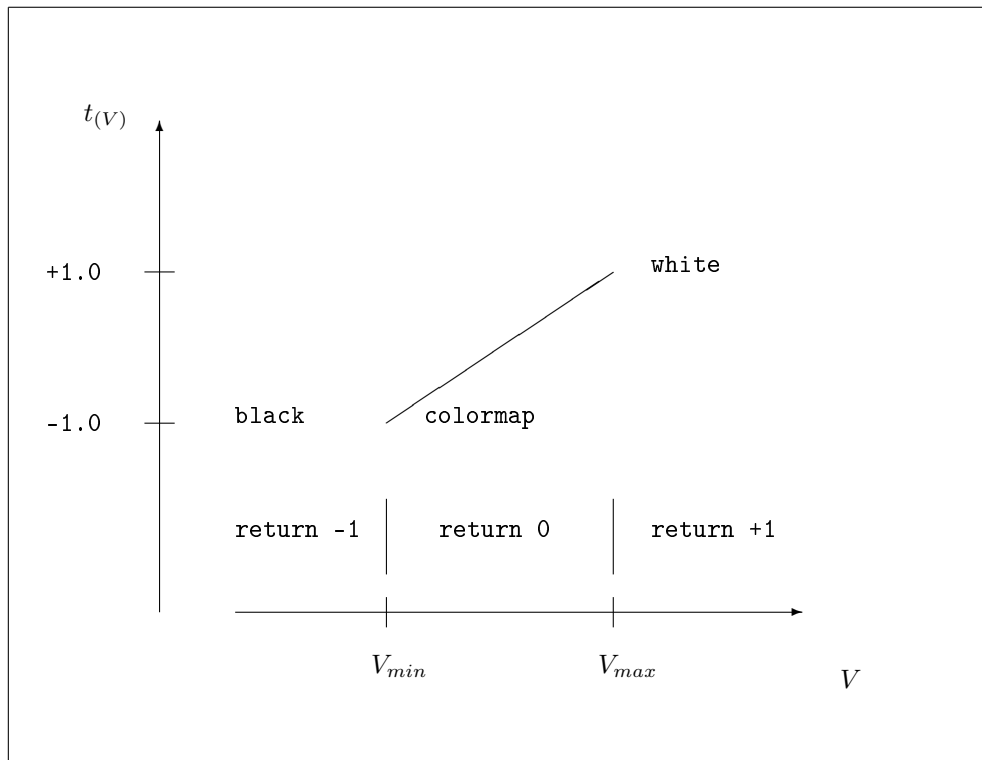


Figure 1: Mapping value V to parameter t

57 It is also worth to say about return value. If value of parameter V lies in
 58 range $[V_{min}, ..., V_{max}]$, then value 0 is returned (interpolation done properly). In
 59 other cases return value is -1 ($V < V_{min}$) or +1 ($V > V_{max}$).

60 Summary:

- 61 1. if $V < V_{min}$ then colour is black and return -1
- 62 2. if $V_{min} \leq V \leq V_{max}$ then we use colormap to determine colour and
 63 return 0
- 64 3. if $V > V_{max}$ then colour is white and return +1

65 For „inverted” colour mapping (reversed), transformation is done by function
 66 below.

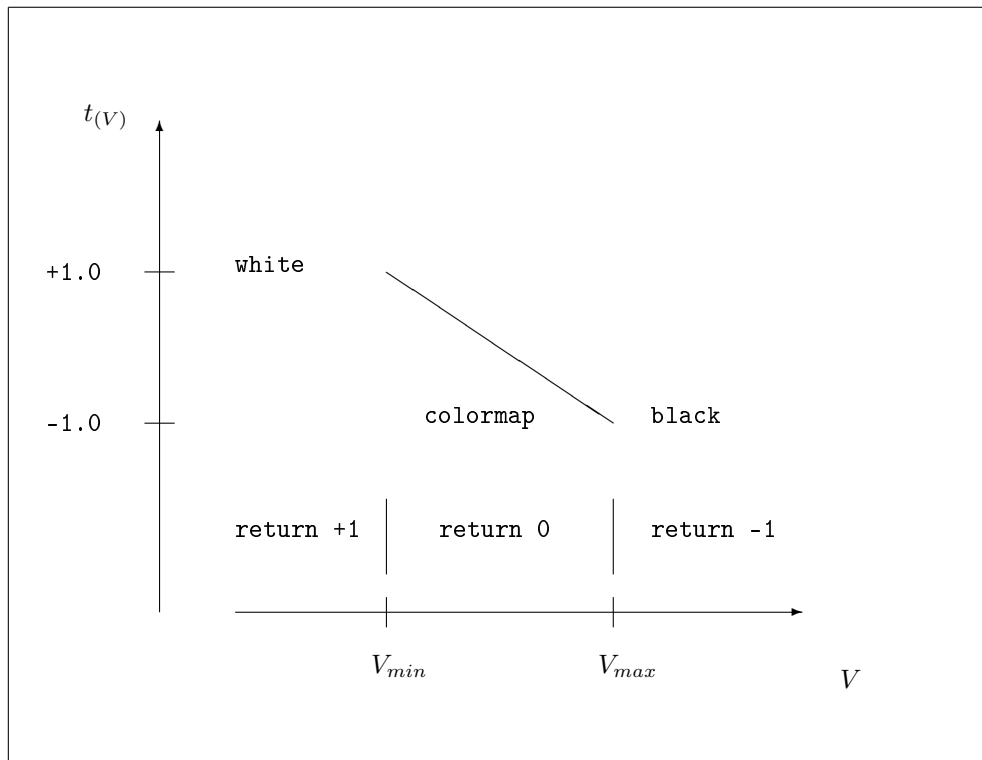


Figure 2: Inverted mapping value V to parameter t

67 In this case the return value is also „inverted”.

68 Summary for inversed colour mapping:

69 1. if $V < V_{min}$ then colour is white and return +1

70 2. if $V_{min} \leq V \leq V_{max}$ then we use colormap to determine colour and
71 return 0

72 3. if $V > V_{max}$ then colour is black and return -1

73 4 clamp function

74 Some Liebmann colour mapping uses also function `clamp` , which was found
75 on Stackoverflow forum [2].

$$\text{clamp}_{[0,1]}(x) = \begin{cases} 0 & \text{if } x < 0 \\ x & \text{if } 0 \leq x \leq 1 \\ 1 & \text{if } x > 1 \end{cases} \quad (4.1)$$

76 5 Grayscale colormap

77 This colour mapping does not use parameter t and `clamp` function.

78 We have parameter V such that: $V_{min} \leq V \leq V_{max}$.

79 In our grayscale colormap any shade of grey has all the 3 parameters r/g/b
80 the same.

$$r = g = b = \frac{V - V_{min}}{V_{max} - V_{min}} \quad (5.1)$$

81 All the r/g/b have values in range $[+0.0, \dots, +1.0]$. For PPM (P3) graphic
82 file format these r/g/b values should be multiplied by maximal unsigned char
83 value (255). Liebmann software uses Netpbm PPM P3 file format with unsigned
84 char values (0, 1, 2, ..., 255).

85 For inverted grayscale colour mapping we use different formula:

$$r = g = b = \frac{V_{max} - V}{V_{max} - V_{min}} \quad (5.2)$$

86 And also all the r/g/b have values in range $[+0.0, \dots, +1.0]$. For PPM (P3)
87 graphic file format these r/g/b values should be multiplied by maximal unsigned
88 char value (255). Liebmann software uses Netpbm PPM P3 file format with
89 unsigned char values (0, 1, 2, ..., 255).

90 6 Hot-to-cold colormap

91 This colour mapping was also found on Stackoverflow forum [2].

92 This colour mapping uses parameter t and `clamp` function.

93 If we determine value of parameter t , we can map its value to 3 values of
94 pixel colour (red/green/blue).

$$\begin{aligned} r(t) &= \text{clamp}_{[0,1]}(2 - |2t - 2|) \\ g(t) &= \text{clamp}_{[0,1]}(2 - |2t|) \\ b(t) &= \text{clamp}_{[0,1]}(2 - |2t + 2|) \end{aligned} \quad (6.1)$$

$$-1.0 \leq t \leq +1.0 \quad (6.2)$$

95 $r/g/b$ have values in range $[+0.0, \dots, +1.0]$. For PPM (P3) graphic file format
96 these $r/g/b$ values should be multiplied by maximal unsigned char value (255).

97 Liebmann software uses Netpbm PPM P3 file format with unsigned char
98 values (0, 1, 2, ..., 255).

99 7 Jet colormap

100 This colour mapping was also found on Stackoverflow forum [2].

101 This colour mapping uses parameter t and `clamp` function.

102 If we determine value of parameter t , we can map its value to 3 values of
103 pixel colour (red/green/blue).

$$\begin{aligned} r(t) &= \text{clamp}_{[0,1]}(1.5 - |2t - 1|) \\ g(t) &= \text{clamp}_{[0,1]}(1.5 - |2t|) \\ b(t) &= \text{clamp}_{[0,1]}(1.5 - |2t + 1|) \end{aligned} \quad (7.1)$$

$$-1.0 \leq t \leq +1.0 \quad (7.2)$$

104 $r/g/b$ have values in range $[+0.0, \dots, +1.0]$. For PPM (P3) graphic file format
105 these $r/g/b$ values should be multiplied by maximal unsigned char value (255).

106 Liebmann software uses Netpbm PPM P3 file format with unsigned char
107 values (0, 1, 2, ..., 255).

108 **References**

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110 [Online; accessed 05-January-2024].
- 111 [2] Amro, "Grayscale to Red-Green-Blue (MATLAB Jet) color
112 scale." [https://stackoverflow.com/questions/7706339/](https://stackoverflow.com/questions/7706339/grayscale-to-red-green-blue-matlab-jet-color-scale)
113 [grayscale-to-red-green-blue-matlab-jet-color-scale](https://stackoverflow.com/questions/7706339/grayscale-to-red-green-blue-matlab-jet-color-scale), 2011.
114 [Online; accessed 20-February-2023].