Grey in Print Is the Count of Dots in a Cell, Not Their Darkness, So the Levels Are Fixed by a Device Ratio

— the number of levels is the square of the cell side plus one for pure white, and it is fixed by the ratio of resolution to screen ruling alone — the separator is whether grey comes from the darkness of one dot or from the count in a cell — [Paper 731]

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— *From thinking to syncing.* —

Abstract

Grey in print is not pale black. It is binary dots, some number of them placed within a cell.So the number of levels has a ceiling, and that ceiling is fixed by a ratio of two numbers of the device.No new theorem or law is claimed. First, the number of levels is the square of the cell side plus one——600 dpi with 100 lpi gives a side of 6 dots and 37 levels (Section 2). **Second, and this is the core. That number involves neither the ink nor the paper——it is fixed by resolution over ruling alone: 17 levels at 600/150 and 65 at 1200/150** (Section 2). **Third, 256 levels take a factor of 16——a side of 16 dots is needed, hence 2400 dpi at 150 lpi** (Section 3). **Fourth, a finer screen costs levels——at a fixed 600 dpi, doubling the ruling takes the levels from 37 to 10, a factor of 0.270270** (Section 3). **Fifth, the side is fixed by truncation——600/150 gives a side of 4 and 17 levels, and truncating the area first gives a different answer** (Section 3). **Sixth, the separator is whether grey comes from the darkness of one dot or from the count in a cell——in the first the levels are continuous, in the second discrete** (Section 4). **Keywords**: halftone, area modulation, screen ruling, resolution, discreteness of levels, a ratio of the device.

Scope of this paper (scope note): **No new theorem or law is claimed——halftone area modulation, the setting of the number of levels by the pixels in a cell, and the trade between resolution and ruling are all standard (Yule 1967, Kipphan 2001).Only a regular grid is considered——error diffusion, dithering and stochastic screening are not treated.Dot behaviour is not treated——dot gain, ink density and absorption into the paper are not treated.The eye is not discussed——how many levels a person distinguishes, and at what ruling the screen becomes invisible, are not treated.No real device is claimed——values for presses and standards are not treated; the resolutions and rulings are examples.Counted in one ink——combinations from overlaying several inks are not treated.Relation to earlier papers**: **Paper 719 showed that colour mixing is not one operation, one side adding and the other multiplying transmittances, and stated in its scope note that mixing by juxtaposition would not be treated and only stacking considered——this is that juxtaposed case. Stacked mixing was a multiplication of transmittances; juxtaposed mixing is a count. Mixing that multiplies, and mixing that counts.**What is added is **deriving the number of levels as the square of the side plus one**, **showing it to be fixed by a ratio of the device**, **putting the condition for 256 levels at a factor of 16**, **putting the cost of a finer ruling at 0.270270**, and **placing the separator on the darkness of a dot against the count in a cell**.

1. Notation and the Question

Setting: **a printed dot is binary. Grey is made by how many dots are placed within a cell.**

$$s = \left\lfloor \frac{\mathrm{dpi}}{\mathrm{lpi}} \right\rfloor, \qquad L = s^2 + 1$$

s is the number of dots along the side of a cell and L the number of levels. The side is made an integer before squaring.

Question: **what is grey in print made of?**

2. The Number of Levels Is Fixed by a Ratio of the Device

Computation 2.1: **the cell side and number of levels were derived for each pair of resolution and ruling.**

resolution	ruling	cell side	levels
600 dpi	100 lpi	6 dots	37
600 dpi	150 lpi	4 dots	17
600 dpi	200 lpi	3 dots	10
1200 dpi	150 lpi	8 dots	65
2400 dpi	150 lpi	16 dots	257

Observation 2.2

this is the core: neither ink nor paper appears in that number.It is fixed by the ratio of two numbers of the device, the resolution and the ruling——darker ink or different paper does not add a single level.

Observation 2.3

and the levels are discrete.A cell of side 6 affords exactly 37 possibilities——because the dot is binary, the steps of grey can be counted.

Observation 2.4

one is added for pure white.To the $6^2 = 36$ ways of placing dots is added the case of placing none——this is easy to miscount, so it is stated.

3. A Finer Screen Eats Levels

Computation 3.1: **the resolution needed for 256 levels was derived for each ruling.**

ruling	resolution needed	levels then
100 lpi	1600 dpi	257
150 lpi	2400 dpi	257
175 lpi	2800 dpi	257

Observation 3.2

the condition folds into a single factor.256 levels take a side of 16, so the resolution need only be 16 times the ruling——choose the ruling and the required resolution follows.

Observation 3.3

conversely, at fixed resolution a finer ruling loses levels.At 600 dpi, doubling the ruling takes the levels from 37 to 10, a factor of 0.270270——a finer screen hides the pattern and eats the steps of grey.

Observation 3.4

the side is fixed by truncation.600/150 is exactly 4, but a non-integer ratio is truncated——truncating the area first gives a different answer, so the side is made an integer first.

Observation 3.5

so two finenesses compete.The fineness of the screen and the fineness of the grey share one resolution——wanting both leaves only raising the resolution.

4. The Separator

> **Observation 4.1**
>
> **the separator is whether grey comes from the darkness of one dot or from the count in a cell.In the first the levels are continuous, in the second discrete——asking for “finer grey” means different things, and calls for different equipment.**

> **Observation 4.2**
>
> **beside Paper 719.Paper 719 showed that colour mixing is not one operation, and stated that mixing by juxtaposition would not be treated——this is that case. Stacked mixing multiplied transmittances and was continuous; juxtaposed mixing counts and is discrete.**

> **Observation 4.3**
>
> **what is not said.Error diffusion, dithering, dot gain, the eye and the overlaying of several inks are not treated——what is shown is that the levels are discrete and that their number is fixed by a ratio of the device.**

5. Roll Call and Closing

1. **37 levels at 600/100** (Computation 2.1): **a side of 6.**
2. **17 at 600/150** (Computation 2.1): **a side of 4.**
3. **10 at 600/200** (Computation 2.1): **a side of 3.**
4. **65 at 1200/150** (Computation 2.1): **resolution doubled.**
5. **257 at 2400/150** (Computation 2.1): **256 is passed here.**
6. **no ink, no paper** (Observation 2.2): **the core.**
7. **one added to the square** (Observation 2.4): **for pure white.**
8. **256 takes a factor of 16** (Observation 3.2): **2400 dpi at 150 lpi.**
9. **double the ruling, 0.270270** (Observation 3.3): **it eats levels.**
10. **darkness or count** (Observation 4.1): **the separator; Paper 719.**

Closing: **Grey in print is not the darkness of a dot but the count of dots in a cell, so the number of levels is fixed by a ratio of the device.A single dot is binary, so grey is made by how many are placed in a cell, and the number of levels is the square of the cell side plus one for pure white——600 dpi with 100 lpi gives a side of 6 and 37 levels, 600/150 gives 4 and 17, 600/200 gives 3 and 10, 1200/150 gives 8 and 65, and 2400/150 gives 16 and 257.Neither ink nor paper appears in that number: it is fixed by resolution over ruling alone——darker ink or different paper adds not a single level, and because the dot is binary the steps of grey can be counted.Reaching 256 levels takes a side of 16, so the resolution need only be 16 times the ruling, that is 2400 dpi at 150 lpi.Conversely, at a fixed 600 dpi, doubling the ruling takes the levels from 37 to 10, a factor of 0.270270——the fineness of the screen and the fineness of the grey share one resolution.The side is fixed by truncation, and truncating the area first gives a different answer.The separator is whether grey comes from the darkness of one dot or from the count in a cell.Placed among the earlier papers——Paper 719 treated stacked mixing and set the juxtaposed case aside; this is that case, where a multiplication becomes a count.To be honest——error diffusion, dithering, dot gain and the eye are not treated.**

References

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