Registering Each Colour to the Last Makes Neighbours Agree Better, Ties at the Third Colour and Loses from the Fourth

— registered to the paper every colour is off by $\mathbf{28.284271}$ µm, while registered to the previous colour the error $\sqrt{k-1}\sigma$ is better with the neighbour, ties at colour $\mathbf{3}$ and loses by $\mathbf{1.224745}$ from colour $\mathbf{4}$ — the separator is what each colour is registered to: the paper or the previous colour — [Paper 742]

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— From thinking to syncing. —

Abstract

In multicolour printing each colour must be laid down in register. Whether each pass is aligned to the paper or to the previous colour changes how misregistration grows.That the reference changes which pairs of colours agree is counted.No new theorem or law is claimed. First, registered to the paper, misregistration does not depend on the colour number——every pair is off by $\sqrt{2}\sigma = \mathbf{28.284271}$ µm (Section 2). **Second, registered to the previous colour, misregistration accumulates——$\mathbf{34.641016}$ µm at colour 4 and $\mathbf{52.915026}$ µm at colour 8** (Section 2). **Third, and this is the core. Registering to the previous colour agrees better with the neighbour——$\mathbf{20.000000}$ µm at colour 2, a tie at colour 3, and a loss by $\mathbf{1.224745}$ from colour 4** (Section 2). **Fourth, the fraction beyond tolerance nearly doubles——at the fourth colour, $\mathbf{0.077100}$ against $\mathbf{0.148915}$ beyond 50 µm, a factor of $\mathbf{1.931452}$** (Section 3). **Fifth, more colours widen the gap——$\mathbf{0.344704}$ at the eighth colour when registered to the previous one, while registration to the paper stays at $\mathbf{0.077100}$** (Section 3). **Sixth, the separator is what each colour is registered to: the paper or the previous colour——which is better is undetermined until one says which pair of colours matters** (Section 4). **Keywords**: registration, multicolour printing, accumulation of error, choice of reference, additivity of variance, fraction beyond tolerance.

Scope of this paper (scope note): **No new theorem or law is claimed——that variances of independent errors add, and the choice of reference in registration, are both known (Papoulis 1965, Kipphan 2001).One direction only——two-dimensional offsets, rotation and scale differences are not treated.Errors are kept simple——independent and normal; paper stretch, systematic drift, temperature and humidity are not treated.No real press is claimed——press accuracy is not treated, and 20 µm is a value for comparison.The correlated extreme is for comparison only——the 60.000000 µm for errors that always fall the same way is shown only against the independent case.Relation to earlier papers**: **Paper 334 showed that what is being added is not the values but the precisions——there fusing independent measurements added precisions (inverse variances) and the error shrank. Here chaining independent registrations adds variances and the error grows. Whether precisions or variances are added.**What is added is **misregistration by colour for both schemes, by formula and by trial**, **showing that the chain agrees better with the neighbour, ties at colour 3 and reverses from colour 4**, **the fraction beyond tolerance**, **the widening with more colours**, and **placing the separator on paper against previous colour**.

1. Notation and the Question

Setting: **let the registration error of colour k be e_k, independent with standard deviation σ. Registered to the paper, colour k sits at e_k; registered to the previous colour, at $e_1 + \cdots + e_k$.**

$$\text{to the paper: } p_k - p_1 = e_k - e_1, \qquad \text{to the previous colour: } p_k - p_1 = e_2 + \cdots + e_k$$

The standard deviations are therefore $\sqrt{2}\sigma$ and $\sqrt{k-1}\sigma$. Take $\sigma = 20$ µm.

Question: **which agrees better, registering to the paper or to the previous colour?**

2. Which Pair Agrees Better Changes Places

Computation 2.1: **the standard deviation of colour k relative to colour 1 was derived by formula and over 200000 sheets.**

colour	paper (formula)	paper (trial)	previous (formula)	previous (trial)
2	28.284271	28.264222	20.000000	19.957668
3	28.284271	28.157911	28.284271	28.261822
4	28.284271	28.229687	34.641016	34.622702
8	28.284271	28.289657	52.915026	52.909318

Observation 2.2

this is the core: registering to the previous colour agrees better with the neighbour.Colour 2 is off by e_2 alone, 20.000000 µm, against $e_2 - e_1$, 28.284271 µm, when registered to the paper——the two tie at colour 3, and from colour 4 the chain loses by 1.224745.

Observation 2.3

registered to the paper, misregistration is the same for every colour.Any two colours are compared through the same sheet, so only the difference of two errors enters——in the chain, errors add stage upon stage.

Observation 2.4

the first check got this wrong.It assumed the schemes coincide at colour 2, and the trial failed at 28.264222 against 19.957668——colour 1's error against the paper enters twice when registering to the paper and cancels against the neighbour in the chain.

3. The Fraction Beyond Tolerance

Computation 3.1: **the fraction of sheets off by more than 50 µm was derived by formula and trial.**

case	formula	trial
paper, fourth colour	**0.077100**	**0.076495**
previous colour, fourth colour	**0.148915**	**0.148685**
previous colour, eighth colour	**0.344704**	—

Observation 3.2

at the fourth colour the fraction beyond tolerance rises by 1.931452.A ratio of 1.224745 in standard deviation nearly doubles in the tail——a pass-fail tolerance makes a small difference look large.

Observation 3.3

more colours widen the gap.At the eighth colour the chain reaches 0.344704 while registration to the paper stays at 0.077100——adding spot colours makes the choice of reference count more.

Observation 3.4

if errors always fall the same way, it is worse.Fully correlated, the chain's fourth colour is off by 60.000000 µm——the figures here are for independent errors, and correlation would deepen the chain's loss.

4. The Separator

Observation 4.1

the separator is what each colour is registered to: the paper or the previous colour.The chain makes neighbours agree and distant colours disagree; the paper makes every pair agree equally——which is better is undetermined until one says which pair matters.

Observation 4.2

beside Paper 334.Paper 334 showed that what is being added is not the values but the precisions——there fusing independent measurements added precisions and the error shrank. Here chaining independent registrations adds variances and the error grows.

Observation 4.3

what is not said.Two-dimensional offset, paper stretch, systematic drift and real presses are not treated; only one-directional independent errors are placed——what is shown is that the reference decides which colours are brought into register.

5. Roll Call and Closing

1. **28.284271 µm to the paper** (Computation 2.1): **for every colour.**
2. **20.000000 µm at colour 2 in the chain** (Computation 2.1): **neighbours agree.**
3. **a tie at colour 3** (Observation 2.2): **the core.**
4. **34.641016 µm at colour 4** (Computation 2.1): **losing by 1.224745.**
5. **52.915026 µm at colour 8** (Computation 2.1): **accumulating.**
6. **trial 19.957668 against 28.264222** (Computation 2.1): **the corrected mistake.**
7. **beyond tolerance 0.077100 and 0.148915** (Computation 3.1): **fourth colour.**
8. **a factor of 1.931452** (Observation 3.2): **widened in the tail.**
9. **eighth colour 0.344704** (Observation 3.3): **more colours, more gap.**
10. **paper or previous colour** (Observation 4.1): **the separator; Paper 334.**

Closing: **Registering each colour to the last makes neighbours agree better, ties at the third colour and loses from the fourth.With 20 µm per pass, registration to the paper leaves every pair off by $\sqrt{2}\sigma = 28.284271$ µm, while registration to the previous colour leaves colour k off by $\sqrt{k-1}\sigma$: 20.000000 at colour 2, 28.284271 at 3, 34.641016 at 4 and 52.915026 µm at 8——colour 1's error against the paper enters twice in the first scheme and cancels against the neighbour in the second.The first check got this wrong, assuming the schemes coincide at colour 2, and failed at 28.264222 against 19.957668——the correction gave a stronger result than "chaining is always worse".The fraction of sheets whose fourth colour is off by more than 50 µm is 0.077100 against 0.148915, a factor of 1.931452, and the chain reaches 0.344704 at the eighth colour.The separator is what each colour is registered to: the paper or the previous colour——which is better is undetermined until one says which pair matters.Placed among the earlier papers——Paper 334 treated an addition of precisions that shrinks error; this is an addition of variances that grows it.To be honest——only one-directional independent errors are placed, with no paper stretch or systematic drift.**

References

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