Layered Deposition

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1 Introduction

The *zuv* system was originally developed as a transported coordinate representation of the RGB cube together with a corresponding interpolation geometry. During implementation, however, the interpolation framework suggested a second and largely independent construction: a layered deposition model built upon transported color mixing.

The starting observation is that interpolation in transported coordinates already behaves differently from direct RGB averaging. Given two colors, transported interpolation preserves chromatic structure that is often lost under linear RGB traversal and produces mixtures that remain organized by the geometry of the transported coordinates. This observation naturally leads to the question of how such mixtures behave under repeated application.

Rather than treating painting as a sequence of independent blending operations, the model developed here separates three distinct concepts:

1. a transported color geometry,
2. a color interaction operator,
3. a layered accumulation operator.

The resulting framework is not intended as a physical simulation of pigments, fluids, or optical transport. Instead, it provides a simple path-dependent accumulation process in which color interaction and layered deposition are treated as separate mechanisms.

2 Transported Mixing

Let T denote the forward *zuv* transform and T^{-1} its inverse. Given substrate color $\mathbf{s}$ and brush color $\mathbf{b}$, define the transported mixing operator

$$M_t(\mathbf{s}, \mathbf{b}) = T^{-1}((1-t)T(\mathbf{s}) + tT(\mathbf{b}))\,,$$

where $t \in [0, 1]$.

The operator M_t defines a family of mixtures between two colors. When $t = 0$ the substrate color is recovered, while $t = 1$ yields the brush color. Intermediate values produce colors lying along a transported traversal through the RGB cube.

The important point is that M_t is independent of any painting process. It merely defines how two colors interact within the transported geometry. Different color systems produce different interaction operators, but the accumulation mechanism described below may be applied to any of them.

3 Layered Deposition

Conventional digital painting systems are largely memoryless. A pixel update depends only on the current substrate color, incoming brush color, and opacity. Repeated applications therefore reduce to a sequence of independent interpolation steps.

The layered deposition model introduces an additional state variable recording local contact history. Each pixel maintains a memory parameter m describing the degree of previous deposition. Color updates then depend not only upon the substrate and brush colors, but also upon the evolving local state.

We therefore define a deposition operator

$$\mathcal{S}(\mathbf{s}, \mathbf{b}, m, a) = (\mathbf{s}', m'),$$

where $\mathbf{s}$ denotes the current substrate color, $\mathbf{b}$ the incoming brush color, m a local accumulation state, and $a \in [0, 1]$ an application strength determined by pressure or coverage.

The color update is obtained through the transported mixing operator,

$$\mathbf{s}' = M_t(\mathbf{s}, \mathbf{b}),$$

but the interpolation parameter t is not supplied directly. Instead, it is determined by the accumulation state.

Each application increases the local memory according to the strength of the deposit, the local footprint, and the relationship between the incoming and existing colors. The memory state is then converted into a nonlinear takeover parameter which increases the influence of subsequent deposits. Newly contacted regions therefore respond weakly, while regions that have been worked repeatedly exhibit progressively stronger color takeover.

The resulting process resembles layered deposition. Incoming color is not immediately imposed upon the substrate. Instead, it becomes established gradually through repeated contact.

4 Path Dependence

The most important consequence of the deposition operator is path dependence.

Because the memory state evolves between successive applications, repeated deposits are not equivalent to a single interpolation of equal aggregate strength. A sequence of light applications generally produces a different result than a single heavy application, even when the total deposited amount is comparable.

This behavior arises because the accumulation state modifies future interactions. Each application alters both the visible color and the local memory, and the updated memory influences all subsequent deposits. The history of interactions therefore becomes part of the color evolution itself.

In this sense the model behaves more like a dynamical process than a simple blending rule. The final result depends not only on the participating colors, but also on the sequence through which they are applied.

5 Discussion

The construction described here separates color geometry, color interaction, and color accumulation into distinct components.

The transported coordinate system defines a geometry on the RGB cube. The mixing operator M_t defines how colors interact within that geometry. The deposition operator $\mathcal{S}$ determines how those interactions accumulate through time.

This separation makes it possible to compare different color systems under identical deposition dynamics. The accumulation process may remain fixed while the underlying mixing geometry is changed, allowing the influence of the color representation itself to be studied independently of the painting mechanism.

The framework was originally developed in conjunction with the *zuv* system, where transported interpolation produced extended chromatic traversals that persisted throughout repeated deposition. More broadly, however, the construction may be viewed as a general accumulation model whose only requirement is the existence of a color interaction operator.

6 Conclusion

The *zuv* project began as an investigation of transported coordinates for the RGB cube. During implementation it led to a second construction based on transported mixing and layered deposition. The resulting framework separates color interaction from color accumulation by combining a transported mixing operator with a local memory-driven deposition process.

Although simple, the model introduces a form of path dependence absent from conventional interpolation-based painting systems. Repeated applications modify both color and state, allowing accumulation history to influence future interactions. The result is a lightweight deposition framework in which transported color geometry and local contact history jointly determine the evolution of a painted image.