

# Dynamic Planar Map Illustration

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Live Paint is a new illustration metaphor that combines the editability of traditional vector illustration with the straightforwardness of planar map illustration.

In conventional vector illustration programs, a user draws paths and assigns them fill and stroke attributes. Each path has fill and stroke attributes that apply to the entire path. Stacking order and transparency attributes determine the appearance of areas where paths overlap. Planar map illustration instead treats all the defining paths as being in a single plane, with no stacking order. Users apply fill attributes to faces bounded by the paths and stroke attributes to edges along paths between intersections.

Planar map illustration is not new; the seminal reference for it is Baudelaire and Ganget [1989]. Several commercial and research systems allow planar map illustration, but one thing they have in common is that paths that participate in a planar map are no longer editable as a whole. Instead they get broken into separate pieces at intersections. Even Baudelaire and Ganget identify this as a problem, and Live Paint offers a solution. Figure 1 shows the results of pulling the leftmost point of the circle to the left in previous planar editors and with Live Paint. Figure 2 shows an example of the kinds of edits that become easy with this tool.

An efficient planar map based upon work by Bentley and Ottmann [1979] forms the core of Live Paint. Each path in the artwork gets a unique identifier that persists as a user makes changes. After each change, Live Paint creates a new planar map and assigns fill and stroke attributes to the faces and edges, based upon the attributes of the faces and edges that were present before the edit.

Sometimes the fill and stroke assignment is straightforward. Adding a new path or extending an existing path divides existing faces into multiple faces that each get the fill of the previous face, and divides existing edges into multiple edges that each get the stroke of the previous edge. Deleting or truncating a path combines existing faces into a single face that gets the fill of the largest previous face, and combines existing edges into a single edge that gets the stroke of the longest previous edge.

Most cases require a more sophisticated assignment method. Live Paint characterizes each face in the current and previous planar maps with how they relate to the paths that bound them: a face can be to the left or right of an open path, and can be inside or outside a closed path. Heuristics are used to find the previous face that most closely matches each current face, and the current face receives the fill of that previous face. The paths' parameterizations along the boundary of the face helps resolve difficult cases. A similar process applies to edges.

Live Paint is very useful for coloring cartoon artwork. This kind of artwork frequently has paths that do not quite meet up, leading to areas that are not completely enclosed. Live Paint solves this problem with automatic gap detection. This gap detection is dynamic, finding gaps whenever they appear as the result of an edit (see Figure 3).

Live Paint is also useful for structured artwork that uses paths as construction lines. Some of the faces and edges will be filled or stroked, while others won't (see Figure 4).

Live Paint uses algorithms that are usually  $n \log n$  in the number of flattened segments in the paths that define the artwork. Additional terms that depend upon the number of path intersections do not normally come into play with the kinds of illustrations users actually create.

Live Paint is available as a feature in Adobe® Illustrator® CS2.

## References

- BAUDELAIRE, P. and GANGNET, M. 1989. Planar Maps: An Interaction Paradigm for Graphic Design. In *CHI'89 Proceedings*, Addison-Wesley, 313-318.
- BENTLEY, J. and OTTMANN, T. 1979. Algorithms for Reporting and Counting Geometric Intersections. *IEEE Transactions on Computers*, C-28, 9, 643-647.



Figure 1: Editing paths in a planar map

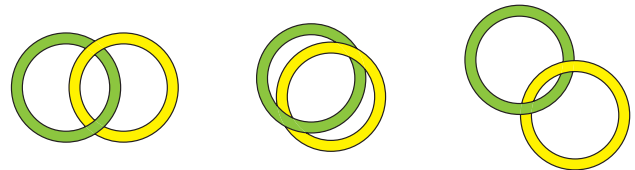


Figure 2: Edits that become easy with Live Paint

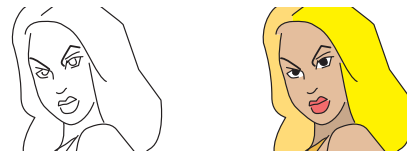


Figure 3: Gap detection

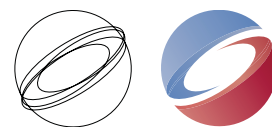


Figure 4: Construction lines and filled results

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