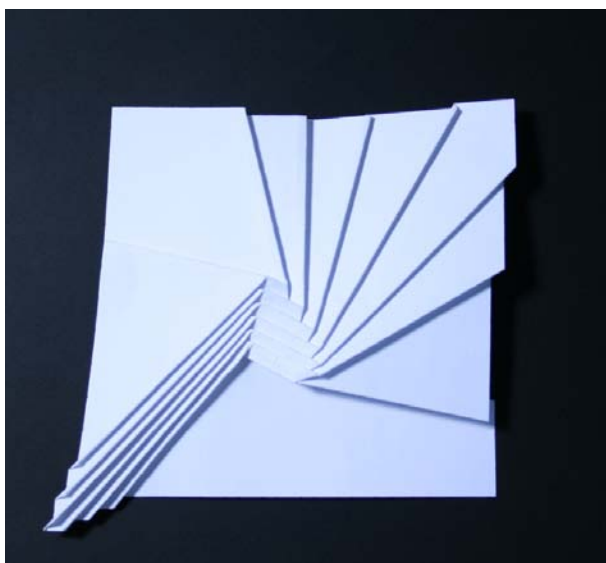


## Every Spider Web has a Simple Flat Twist Tessellation

Robert J. Lang<sup>1</sup> and Alex Bateman<sup>2</sup>

In the world of origami tessellations, one of the first families to be extensively explored was the family of patterns consisting entirely of interconnected simple flat twists. While most demonstrations of such tessellations are based on tilings of regular polygons, notably the  $k$ -uniform tilings, it is possible to create such a tiling from an arbitrary planar graph composed of convex polygons by shrinking and rotating the constituent polygons – provided, however, that the centers of shrinkage and rotation are properly chosen.

This “shrink-and-rotate algorithm” has been described by Palmer and used by several investigators, and is implemented by one of the authors in the program *Tess* for several classes of regular tiling. But the algorithm has only been applied in cases where defining the centers of shrinkage and rotation is relatively simple. The solution to the general problem has not been described before. In this paper, we present a complete description of this tessellation algorithm, including the solution to the all-important problem of the location of the centers of shrinkage and rotation. Surprisingly, the latter subproblem turns out to be provided by a geometric construction, called a reciprocal diagram, described by James Clerk Maxwell in an 1864 paper, which applied to the analysis of bridge trusses and the stresses and tensions in their members. As part of our description of this tessellation algorithm, we will describe the relationship to this old problem and its solution, which leads to the remarkable corollary that forms the title of this paper, and a general algorithm, a folded example of which is shown in the figure below. We also will review recent developments and advances in related algorithms for the creation of computer-generated tessellation patterns along with examples of their implementation.



**Figure 1.** A computer-generated tessellation from an arbitrary planar graph.

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<sup>1</sup> Langorigami.com, 899 Forest Lane, Alamo, CA, USA

<sup>2</sup> The Wellcome Trust Sanger Institute, Hinxton, Cambridge, UK