# Illustration of Two-Fold Origami Axioms

For millennia, compass and straightedge have been the standard for constructions in Euclidean geometry. The use of origami as a mathematical tool is a relatively newly explored concept, despite it being the more powerful of the two models (Geretschläger, 2008).

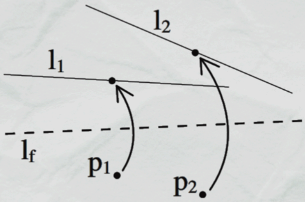

Figure: 06, The Beloch Fold.

In the 1930s, Italian mathematician Margherita Piazzolla Beloch published groundbreaking and, unfortunately, largely unnoticed work documenting the ability for paper folding to solve a generic cubic equation (Beloch, 1936). Later independent work from Humiaki Huzita and Jacques Justin outlined the seven one-fold origami axioms, or Huzita-Justin Axioms (HJAs), the distinct combinations of alignments of points, lines, and fold lines (Huzita, 1991; Justin, 1989).

Research has since progressed onwards from one-fold origami to two-fold origami, which required a new set of origami operational building blocks, the Alperin-Lang Alignments (ALA). These alignments provide constraints on the positions of fold lines and combine such that all fold line parameters' degrees of freedom are exhausted, producing finitely many possible positions (Alperin & Lang, 2009). In 2009, Alperin & Lang documented the full list of all 489 two-fold axioms (2FAs), however very few have been analysed since then. It was proven in 2015, by Yasuzo Nishimura, that specific 2FAs could be used to solve the general quintic; while Joachim König and Dmitri Nedrenco proved it possible to solve a generic septic using a different 2FA (Nishimura, 2015; König & Nedrenco, 2015).

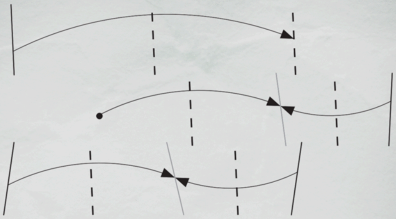
Figure: From top down, AL4, AL7, AL9.

Figure: Diagrams for the 2FAs AL2ab5a10a, AL3a6b7a10b, AL12a3b7b, and AL13a6b7a.

Due to the number of axioms, they had not been illustrated in full, only those studied further were ever drawn. This project aimed to illustrate all axioms using the programming language MATLAB and, using Maple, study the algebraic power of another axiom if within the project timeframe.

The diagrams were drawn in the same modular structure that the axioms are composed of. A MATLAB script reads an axiom's name, interprets the individual alignments that constitute it, then calls a function for each alignment to draw them. This allowed for complete automation of the illustration of the 489 axioms.


References: Alperin, R. C. & Lang, R. J., 2009. One, Two, and Multi-Fold Origami Axioms. In: Origami 4. 1st ed. s.l.:s.n., pp. 371-393. Beloch, M. P., 1936. Sulla risoluzione dei problemi di terzo e quarto grado col metodo del ripiegamento della carta. Scritti matematici offerti a Luigi Berzolari, pp. 93-95. Geretschläger, R., 2008. Geometric Origami. Shipley: Arbelos Publishing. Huzita, H., 1991. Understanding geometry through origami axioms: is it the most adequate method for blind children?. Birmingham, England, The British Origami Society. Justin, J., 1989. Resolution par le pliage de l'equation du troisieme degre et applications geometriques. Proceedings of the First International Meeting of Origami Science and Technology, pp. 251-261. König, J. & Nedrenco, D., 2015. Septic equations are solvable by 2-fold origami. Forum Geometricorum, 28 April, Volume Volume 16, p. 193–205. Nishimura, Y., 2015. Solving quintic equations by two-fold origami. Forum Mathematicum, Volume 27, p. 1379 – 1387.



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