

# A Mathematical Exploration of Errors in Origami Structures

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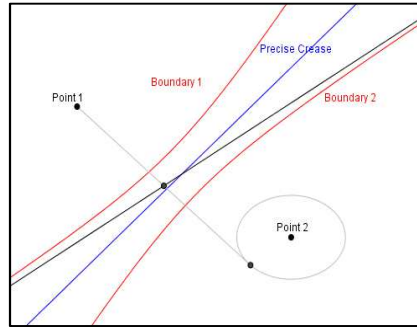
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## Abstract

In both Origami as an art form and its applications, the accuracy and precision of folding plays a key role in the aesthetics and functionality of the finished product. This paper presents several novel methods for minimising errors in Origami constructions. Our work reduces errors by simply changing the way instructions are presented or by changing the order of instructions.

Error modelling in Origami constructions has not been looked at from a mathematical basis. Although most Origami artists will be able to provide advice to a beginner to help them to make folds more precisely, many of these techniques have not been analysed mathematically. We analyse several of these to either prove or disprove them using our model. We also use results from this model to find other ways in which precision can be increased, both for a human folder and for applications folded by machine. We believe these methods will be useful for any application of Origami constructions where accuracy and precision are important.

Given that often there are multiple instructions that lead to the same crease, we build a mathematical model to show which instruction will lead to the fold with highest precision. Looking at Origami constructions from the ground up we analyse the basic concept of an Origami instruction. By introducing a margin of error to an alignment and building this up to model each of the one-fold Huzita-Justin Axioms[1], we create a model for any Origami constructions from which we can show the factors that most affect how precisely a fold is made. Figure 1, an example axiom using our model, shows the region in which any fold must lie to sufficiently fold Point 1 onto Point 2 such that the error is at most the radius of the circle about Point 2.



**Figure 1:** Point to point alignment with introduced error.

Expanding beyond one-fold Origami constructions we use the previous results to study how errors made in one crease affect the formation of subsequent creases in any Origami structure. We show there are creases in which errors have a greater impact on the final result than others and how; by changing the order of instructions, we can create the same end product with a greater precision.

We provide two methods to apply these results. Firstly, a simple method which minimises the number of dependant layers of constructions for all creases in a given crease pattern. Secondly, a more in depth calculation of which alignments should be made where there is a choice for any given step.

The paper concludes with several interesting results where iterations of creases act to increase the precision and reduce the error in a future fold. Noting that these have similar properties to the Fujimoto Approximation method [1], we are able to define mathematically the properties of a crease which will have the effect of reducing the error in future steps.

## References

[1] Robert J Lang. Origami and geometric constructions 1996.