Identifying Manufacturing Errors in Helicopter Blades

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The Problem

We are tasked with approximating the shape of a manufactured piece of a helicopter blade, given a discrete data set consisting of thousands of points. The problem is complicated by the fact that there is a measurement error associated with the laser which is of the same order as the manufacturing errors. We aim to solve the problem using a combination of linear regression and other techniques.

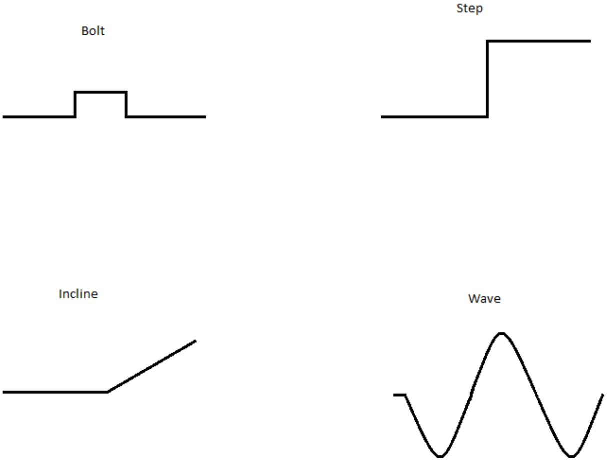
Assumptions

We make a number of assumptions:

- The bolts are of uniform size
- The white noise is distributed normally
- The beginning of the blade conforms exactly to the design intent

Types of Errors

We have 4 different types of errors: bolts, steps, inclinations and waves. 3 of these errors are linear, so we are going to use linear regression.



Least Squared Error

To quantify the accuracy of linear regression, we use the least squared error (LSE). Linear regression on large data sets is inefficient as the LSE will be small despite actual manufacturing errors. We now divide the data into subsets which correspond to sub-intervals of the blade.

White Noise Issues

Linear regression on small sub-intervals will be distorted by white noise. On a reference surface known to be flat, measure maximum distortion due to white noise α. We use α as a lower bound for the length of our sub-intervals.

Method

Let λ be the length of each sub-interval, and apply linear regression to each sub-interval and calculate corresponding LSE. If the LSE in a sub-interval is greater than ε for $\varepsilon \propto \frac{1}{\lambda}$, divide the sub-interval and repeat process on each division.

End result

If the LSE $< \varepsilon$, the linear regression is a strong approximation to the blade shape. In the case where the errors are non-linear, i.e. waves, we fit a Fourier series approximation to the zig-zag shape obtained by regression.

Method in action

The beginning of the method before division: