Modelling of measurement uncertainties for x-ray radiograph analysis

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Any experimental measurement involves uncertainties and noise, which propagate through the data analysis routines and result in a confidence interval on the measured value. Determining valid ranges for these uncertainty intervals is particularly challenging in complex experiments with low statistics such as in high energy density experiments. However, if the properties of the instrument used to take the measurement are well understood, that knowledge combined with information about uncertainty ranges in the experimental setup can be propagated through the analysis procedure and used to refine error bars.

Currently, measurements of the ice-ablator mix width in imploding inertial confinement fusion capsules at the National Ignition Facility at the Lawrence Livermore National Laboratory are ongoing. The mix widths are obtained by analyzing x-ray radiographs taken with the Crystal Backlighter Imager, and an important part of the analysis is determining realistic error bars for the calculated values. By developing a software tool that accounts for all known contributing factors to the measurement, such as alignment uncertainties, shape analysis and noise, and propagating them through the data analysis, a set of solutions cumulating in a realistic uncertainty bar can be determined. In the implemented routine, the mix width measurement is based on an unparametrized, forward-fit Abel inversion solved by gradient descent, which calculates the density profile of the imploding capsules from the x-ray radiograph data. In addition to calculating error bars for specific measured values, the developed code library allows the generation and analysis of synthetic radiographs, which consequently can be used to study the impact of respective experimental uncertainties on the confidence interval around measured values.

This contribution presents the developed routine as well as its application to recent mix measurement experiments demonstrating the value to be gained from in-depth uncertainty analysis in x-ray radiography experiments.

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