

# mini-auspex: a Python library for ultrasonic data import, post-processing and imaging

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## 1 Abstract

Over the last two decades, features such as Full Matrix Capture and Arbitrary Waveform Generation have significantly enhanced the versatility of ultrasonic nondestructive testing (NDT) hardware. This trend has driven the development of methods and algorithms for post-processing ultrasonic data and image reconstruction. However, the research and development (R&D) of ultrasonic NDT methods often involves implementing routines for accessing raw data and reproducing the state of the art, which consumes time and resources from research teams. In this paper, we present mini-auspex, a free NumPy-powered Python library that provides a unified set of methods for (i) importing ultrasonic data from some of the most popular systems and simulators; (ii) signal preprocessing; (iii) estimation of inspection parameters (e.g., sound speed and surface profile), and (iv) imaging with state-of-the-art methods. Fully functional examples are provided in the form of Jupyter notebooks, which can serve as templates for the rapid implementation of post-processing routines. The library, available on the PyPI repository, helps teams accelerate the R&D of UT methods.

**Keywords:** Python, image reconstruction, nondestructive testing, ultrasonics.

## 2 Introduction

Research and development (R&D) of ultrasonic non-destructive testing (NDT) methods requires the development of extensive toolboxes with routines that perform a wide range of tasks, from importing equipment-specific raw data to running imaging algorithms. In this paper, we present mini-auspex, a NumPy-powered Python library that provides a unified framework for these common tasks, allowing researchers to focus on developing high-level routines. The library provides functions to load raw data created by Multix++, Panther (Eddify Technologies), and Pioneer (The Phased Array Company) systems, as well as the CIVA (Extende Inc.) simulator. Efficient implementations of state-of-the-art imaging algorithms, such as the Total Focusing Method (TFM) [1] and the Coherent Plane Wave Compounding (CPWC) [2], are provided.

## 3 The mini-auspex library

The mini-auspex library was designed for use in the Python language, allowing it to run on any operating system (Windows, Linux, and macOS). To achieve this, all functions and modules were implemented using packages and libraries independently of the environment. The main dependencies of the mini-auspex library are NumPy, SciPy, and Matplotlib.

The library is organized in four packages: (i) *framework*, which contains modules for defining data structures, reading files with inspection data from simulators and acquisition systems, performing preprocessing of inspection signals, and postprocessing of reconstructed images; (ii) *imaging*, which groups the modules that implement imaging algorithms

such as the TFM [1] and CPWC [2]; (iii) *surface*, whose modules implement algorithms to estimate the external surface of an object inspected by the immersion technique (e.g. [3]) as well as provide times of flight for a set of transducer elements and region of interest (ROI) points; and (iv) *parameter\_estimation*, which contains modules for estimating the internal surface of underwater pipes to assess internal corrosion of these pipes [3] and algorithms for calculating the propagation speed of ultrasonic waves in water [4].

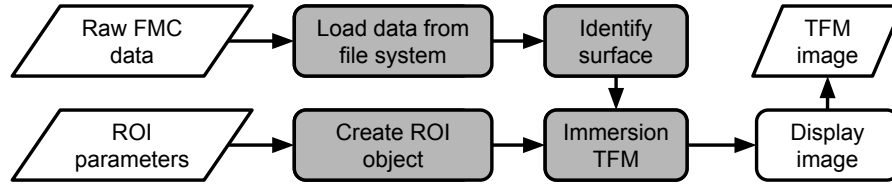


**Fig. 1.** Steps performed in the example script provided (TFM through a tilted plane surface). The shaded boxes represent steps performed using classes and functions from the *mini-auspex* library.

In order to provide quick installation, the library is available at the PyPI repository. The documentation, along with practical examples illustrating the use of its classes and methods, is available in the GitHub repository [github.com/lassip-utfpr/mini-auspex-examples](https://github.com/lassip-utfpr/mini-auspex-examples). The examples are provided as Jupyter Notebooks (including Google Colab Notebooks) and show image reconstruction from both experimental and simulated data. Here we highlight one example Notebook, *immersion\_TFM*, which uses packages *framework*, *surface* and *imaging* to perform a TFM imaging of a carbon steel sample from an immersion testing where the (flat) surface of the specimen was tilted with relation to the probe face. The flowchart of Fig. 1 summarizes the steps involved in this example.

## 4 Conclusion

The *mini-auspex* library can read data from the most commonly used proprietary acquisition systems and simulators, and is capable of reconstructing images using state-of-the-art imaging algorithms and estimation methods. With easy installation from PyPI repository and a comprehensive online documentation, and complete functional examples, we expect that the library will speed up R&D of NDT methods.

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