

HSI-Wizard: A magical open-source Python package for medical hyperspectral imaging applications

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DOI: [10.xxxxxx/draft](https://doi.org/10.xxxxxx/draft)

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Submitted: 01 January 1970

Published: unpublished

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Summary

hsi-wizard is an open-source Python package for processing, analyzing, and visualizing hyperspectral datasets. While its methods are adaptable to other fields, the core emphasis is on analytics for medical applications. Hyperspectral data, in this context, refers to images where each pixel contains multiple pieces of information, typically intensity values at different wavelengths. The number of spectral bands per pixel (n) can range from just a few to over 2000. These datasets originate from various sources, including scanners, imaging devices, and tomographic slides. Since hyperspectral data can come with different resolutions and pixel offsets, hsi-wizard enables seamless integration of multiple data sources. hsi-wizard provides an intuitive environment for hyperspectral analysis. With the DataCube, a standardized class for representing hyperspectral data is presented. This ensures uniform and consistent processing of hyperspectral data. In addition, hsi-wizard provides tools to manipulate, explore, and analyze DataCubes.

A key feature of the DataCube class is a protocol functionality that records the methods used from the hsi-wizard library. The protocol serves as a reusable template for other datasets, enabling researchers to reproduce results with minimal programming effort. Another feature of the hsi-wizard is a method for merging DataCubes. This makes it easy to combine different modalities into one large dataset.

The hsi-wizard simplifies the workflow for processing, analyzing, and visualizing hyperspectral data. It is designed to cater to both beginners and experts. Students can use the straightforward methods for educational purposes, while researchers can leverage advanced functions for professional studies, with the advantage that the results are reproducible and transparently documented.

Statement of Need

Hyperspectral imaging (HSI) enables detailed analysis of the electromagnetic spectrum across multiple wavelengths for each pixel in an image. Originally developed for NASA applications, HSI is now used in a wide range of fields ([Bhargava et al., 2024](#)). This versatility has resulted in diverse methods for acquiring hyperspectral data, including different measurement techniques (reflection, transmission, fluorescence), wavelength ranges (ultraviolet, visible, infrared), and scanning methods (e.g., point scanning, line scanning, and Fourier transform infrared imaging (FTIR)) ([Lu & Fei, 2014](#)).

To streamline the analysis of these diverse datasets and eliminate the need for developing custom methods for each, hsi-wizard standardizes their representation through the DataCube class. It enables uniform analysis, manipulation, and visualization through well-defined functions. Furthermore, the standardization is essential for enabling data fusion across different scanning processes. Different scans from various scanners result in unique datasets with differing

41 resolutions, information and aspect ratios. Therefore, the first step in merging these scans
42 is to use a well-defined data representation combined with methods that can address these
43 challenges. hsi-wizard provides this capability, making it easier to combine datasets for
44 further analysis.

45 In addition, hsi-wizard allows users to log and save the manipulations of the DataCube.
46 These logs can be reused for similar DataCubes, ensuring consistent analysis across different
47 measurements with minimal effort. This feature reduces the need for programming expertise
48 and enhances reproducibility, thereby supporting the goal of increased transparency in research
49 (Burke et al., 2021) (Knottnerus & Tugwell, 2016).

50 Besides the supplied functionalities, hsi-wizard is also extensible, allowing users to integrate
51 additional methods and customize the package for diverse applications.

52 Future Work

53 The development of hsi-wizard is ongoing. Ideas, feedback, and contributions are happily
54 welcomed. All versions of hsi-wizard are available on the Python Package Index (PyPI).

55 Acknowledgements

56 hsi-wizard is the result of several published articles like (Marwick et al., 2024), (Heintz et al.,
57 2021), (T. et al., 2021), (Nachtmann et al., 2024), and (Manser et al., 2023). The work on
58 hsi-wizard was funded by CeMOS Research & Transfer Center and the University of Applied
59 Science Mannheim.

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