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imea: A Python package for extracting 2D and 3D shape measurements from images

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Summary

Quantitative measurement of 2D and 3D shapes from images is used in many research fields, for example, chemistry (Lau et al., 2013), mineral engineering (Andersson et al., 2012), medicine (Nguyen & Rangayyan, 2005), biology (Smith et al., 1996), and environmental engineering (Kandlbauer et al., 2021; Weissenbach & Sarc, 2021). In the past, a variety of shape measurements have been proposed in the scientific literature and as technical norms (DIN ISO 9276-6, 2012; Pabst & Gregorova, 2007; Pahl et al., 1973a, 1973b, 1973c; Steuer, 2010).

`imea` is an open source Python package for extracting 2D and 3D shape measurements from images. The current version of `imea` enables the extraction of 53 different 2D shape measurements, covering *macrodescriptors* such as minimal bounding boxes (Steuer, 2010), *mesodescriptors* such as the numbers of erosion to erase a binary image (DIN ISO 9276-6, 2012), *microdescriptors* such as the fractal dimension (DIN ISO 9276-6, 2012), as well as *statistical lengths* like Feret, Martin or Nassenstein diameters (Pahl et al., 1973a), as shown by the exemplary selection in Figure 1. Furthermore, 13 different 3D shape measurements ranging from volume (Pahl et al., 1973a) and minimal 3D bounding boxes (Steuer, 2010) to 3D Feret diameters and maximum dimensions (Steuer, 2010) can be extracted.

Both 2D shapes, represented as 2D binary images, as well as 3D shapes, represented as grayscale images where the grayvalue of each pixel represents its height, can be analyzed automatically with a single function call. Extracted shape measurements are returned as a *pandas* dataframe (McKinney, 2010), and by specifying the spatial resolution of inserted images, results are automatically converted into metric units for further quantitative analysis.

Statement of need

Only a minority of 2D and 3D shape measurements proposed in the scientific literature and as technical norms are available in existing open source packages for image processing, such as *scikit-image* (van der Walt et al., 2014) and *OpenCV* (Itseez, 2015). In the past, unavailable shape measurements had to be implemented manually by individual researchers or could not be used at all. Moreover, the utilization of different existing packages for shape measurement extraction requires switching between different coordinate systems and data formats. Both cases create unnecessary "reinventing the wheel" and may induce potential calculation errors.

`imea` solves this problem by simplifying the extraction of 2D and 3D shape measurements from images into a single function call. Researchers can focus on the analysis and utilization of extracted shape measurements, while the shape measurement extraction is handled by `imea`. A computationally efficient implementation of underlying algorithms makes even complicated shape measurements available to a wide variety of researchers from different fields.

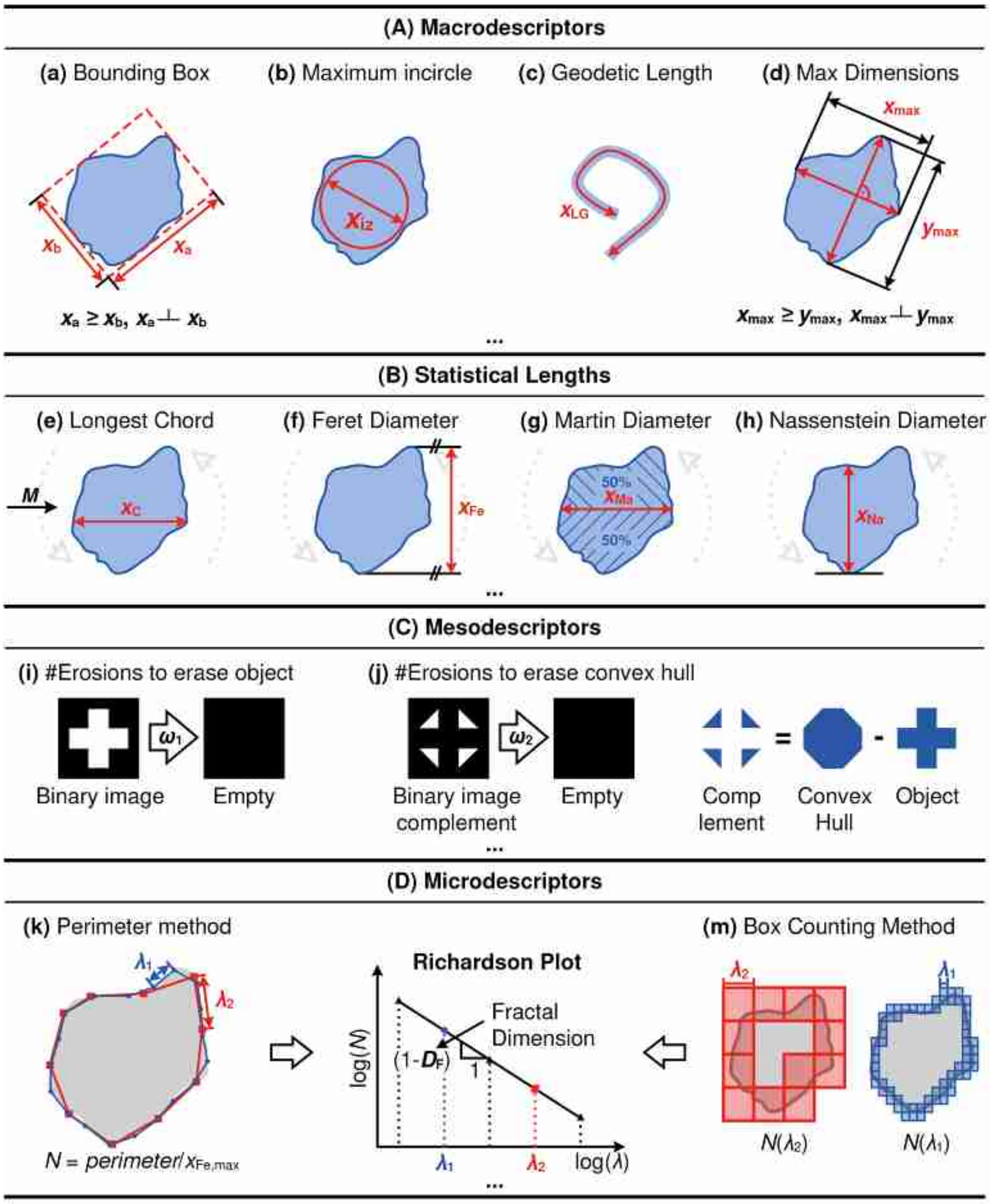

Figure 1: Exemplary selection of 2-dimensional shape measurements available in `imea`.

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