

## 1 Intensity-level entropy

Given a discrete random variable  $X$  on a probability space  $(\Omega, \mathcal{F}, P)$  with image  $\chi = \text{im}(X)$ , the *Shannon entropy* is

$$H = \sum_{x \in \chi} -P(x) \ln P(x).$$

The *intensity-level entropy* is the Shannon entropy of the empirical distribution of intensity values.

```
1 import numpy as np

2 def shannon_entropy(h):
3     """The Shannon entropy in bits"""
4     return -sum(p*np.log2(p) if p > 0 else 0 for p in h)
5
6 def intensity_entropy(data):
7     """The intensity-level entropy of 8-bit image data"""
8     hist, _ = np.histogram(data, bins=range(256+1), density=True)
9     return shannon_entropy(hist)
10
11 def intensity_expected(f, data):
12     """The intensity-distribution expected value of `f`."""
13     hist, _ = np.histogram(data, bins=range(256+1), density=True)
14     return sum(p*f(p) for p in hist)
```