UNSUPERVISED PERFORMANCE EVALUATION OF RESULTS

1) **Liu and Yang's evaluation function**:

$$F = \sqrt{N}\sum_{j=1}^{N}\frac{e_j^2}{\sqrt{S_j}}$$

where N is number of obtained regions after segmentation, S_j – area of region j and e_j^2 – squared color error (or the gray level) that is calculated as

$$e_j^2 = \sum_{k\in S_j}(x_k - \bar{x})^2 \qquad (2)$$

where x_k is the gray level of the pixel, and the $\bar{x}$ means gray level of the region.

2) Borsotti, Campadelli and Schettini **function F′**, to improve upon Liu and Yang's method:

$$F' = \frac{1}{1000\cdot S_I}\sqrt{\sum_{a=1}^{MaxArea}[N(a)]^{1+1/a}}\sum_{j=1}^{N}\frac{e_j^2}{\sqrt{S_j}}$$

were S_I – represents the image surface;
$N(a)$ – denote the number of regions in the segmented image having an area exactly a;
MaxArea – is the area of the largest region in segmented image.

3) **Borsotti et al. criterion**

$$Q = \frac{1}{10000\cdot S_I}\sqrt{N}\sum_{j=1}^{N}\left(\frac{e_j^2}{1+\log S_j} + \left(\frac{N(S_j)}{S_j^2}\right)^2\right)$$

were $N(S_j)$ – denote the number of regions in the segmented image having an area exactly S_j

4) **Intra-region uniformity criterion of Levine and Nazif** [13]:

$$Lev = \sum_j\sum_{x\in R_j}\left(f(x) - \frac{1}{S_j}\sum_{x\in R_j}f(s)\right)^2 = \sum_j\frac{\sigma_j^2}{C}$$

$f(x)$ – the intensity of pixel x
C –normalized coefficient, equal to the maximum possible variance

$$C = \frac{(f_{max} - f_{min})^2}{2}$$

5) **Entropy-based evaluation method** [12]
As the authors say the entropy is a measure of the disorder within a region and is a natural characteristic to incorporate into a segmentation evaluation method.
The entropy for region j is defined as:

$$H_v(R_j) = -\frac{L_j(m)}{S_j}\log\frac{L_j(m)}{S_j}$$

were $L_j(m)/S_j$ represents the probability that a pixel in region R_j has a luminance value of *m*.

The notation $H_v(R_j)$ was simplified to $H(R_j)$ with the default feature v being luminance. H. Zhang et al. define the expected region entropy of image *I*:

$$H_r(I) = \sum_{j=1}^{N} \left(\frac{S_j}{S_i}\right) H(R_j),$$

and the layout entropy:

$$H_l(I) = -\sum_{j=1}^{N} \left(\frac{S_j}{S_i}\right) \log \frac{S_j}{S_I}.$$

They propose to combine the both the layout entropy and the expected entropy in measuring the effectiveness of a segmentation method:

$$E = H_l(I) + H_r(I).$$