# Segmentation

Data knowledge : no of pixel, 2D-3D, gray scale or colored

Domain knowledge : which part or organ

## Otsu's thresholding techniques

* automatic thresholding
* determined by maximizing the inter-class variance of pixel intensities

| | | | | |
|---|---|---|---|---|
| 120 | 130 | 140 | 120 | 110 |
| 125 | 135 | 145 | 125 | 115 |
| 115 | 125 | 135 | 125 | 120 |
| 110 | 120 | 130 | 120 | 110 |
| 105 | 115 | 125 | 115 | 105 |

Calculate otsu's threshold for this image

① compute normalized histogram of image $p_i = \frac{n_i}{MN} \quad i = 0 \dots L-1$

② compute cummulative sums $P_1(k) = \sum_{i=0}^{k} p_i \quad k = 0 \dots L-1$

cummulative means $m(k) = \sum_{i=0}^{k} i p_i \quad k = 0 \dots L-1$

global intensity $m_G = \sum_{i=0}^{L-1} i p_i \quad i = 0 \dots L-1$

between class variance $\sigma_B^2(k) = \frac{[m_G P_1(k) - m(k)]^2}{P_1(k)[1 - P_1(k)]} \quad k = 0, \dots L-1$

obtain $k^*$ where $\sigma_B^2(k^*)$ is max if its not unique then obtain $k^*$ by averaging $k$

| Intensity | frequency | Probability | cummulative sums |
|---|---|---|---|
| 105 | 2 | $P_0 = 2/25$ | $P_1(0) = 2/25$ |
| 110 | 3 | $P_1 = 3/25$ | $P_1(1) = 5/25$ |
| 115 | 4 | $P_2 = 4/25$ | $P_1(2) = 9/25$ |
| 120 | 5 | $P_3 = 5/25$ | $P_1(3) = 14/25$ |
| 125 | 5 | $P_4 = 5/25$ | $P_1(4) = 19/25$ |
| 130 | 2 | $P_5 = 2/25$ | $P_1(5) = 21/25$ |
| 135 | 2 | $P_6 = 2/25$ | $P_1(6) = 23/25$ |
| 140 | 1 | $P_7 = 1/25$ | $P_1(7) = 24/25$ |
| 145 | 1 | $P_8 = 1/25$ | $P_1(8) = 25/25$ |
| | 25 | | |

$$m_6 = \sum_{i=0}^{L-1} i p_i$$

$$m_6 = \frac{2}{25}\times 0 + \frac{3}{25}\times 1 + \frac{4}{25}\times 2 + \frac{5}{25}\times 3 + \frac{5}{25}\times 4 + \frac{2}{25}\times 5 + \frac{2}{25}\times 6 + \frac{1}{25}\times 7 + \frac{1}{25}\times 8$$

$$= \frac{83}{25} = 3.32$$

cummulative means

$$m_k = \sum_{i=0}^{k} i p_i \; ; \; k = 0 \ldots L-1$$

$m(0) = 0 \times 2/25 = 0$

$m(1) = 0 + 1 \times 3/25 = 0.12$

$m(2) = 0 + 0.12 + 2 \times 4/25 = 11/25 = 0.44$

$m(3) = 0.44 + 3 \times 5/25 = 1.04$

$m(4) = 1.04 + 4 \times 5/25 = 1.84$

$m(5) = 1.84 + 5 \times 2/25 = 56/25 = 2.24$

$m(6) = 2.24 + 6 \times 2/25 = 2.72$

$m(7) = 2.72 + 7 \times 1/25 = 3$

$m(8) = 3 + 8 \times 1/25 = 3.32$

(5) between class variance

$$\sigma_B^2(k) = \frac{(m_G P_1(k) - m(k))^2}{P_1(k)\,(1 - P_1(k))} \qquad k = 0, \ldots, L-1$$

$$\sigma_B^2(0) = \frac{(3.32 \times (2/25) - 0.)^2}{2/25\,(1 - 2/25)} = 0.958$$

$$\sigma_B^2(1) = \frac{[m_G P_1(1) - m(1)]^2}{P_1(1)\,(1 - P_1(1))}$$

$$= \frac{[3.32 \times 5/25 - 0.12]^2}{[5/25 \times (1 - 5/25)} = 1.84$$

$$\sigma_B^2(8) = [m_G P_1(8) - m(8)]^2$$

$$= \frac{[3.32 \times (1) - 3.32]^2}{1\,(1-1)} = 0$$

$$\sigma_B^2(9) = \frac{[3.32 \times 24/25 - 3]^2}{\left[24/25\,(1 - 24/25)\right]} = 0.926$$

$\sigma_B^2(3) = 2.72$ ✓ max

$\sigma_B^2(4) = 2.559$

$\sigma_B^2(5) = 2.240$

$\sigma_B^2(6) = 1.51$

for $k = 3$ we got max value.

so intensity 120 is the ... ?

∴ If intensity $> 120$ then 1

$\leq 120$ then 0