

Point Operation

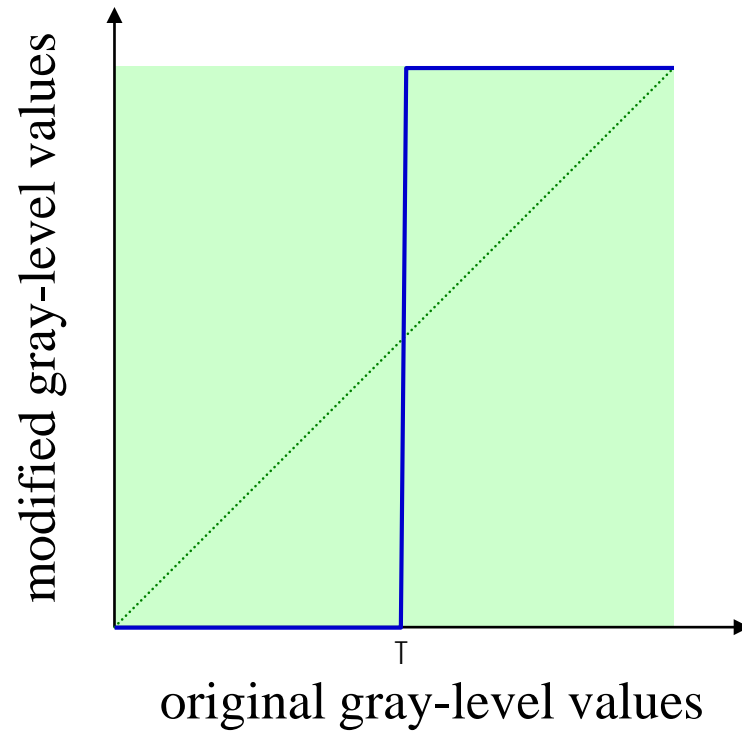
Grayscale Thresholding

김성영교수
금오공과대학교
컴퓨터공학과

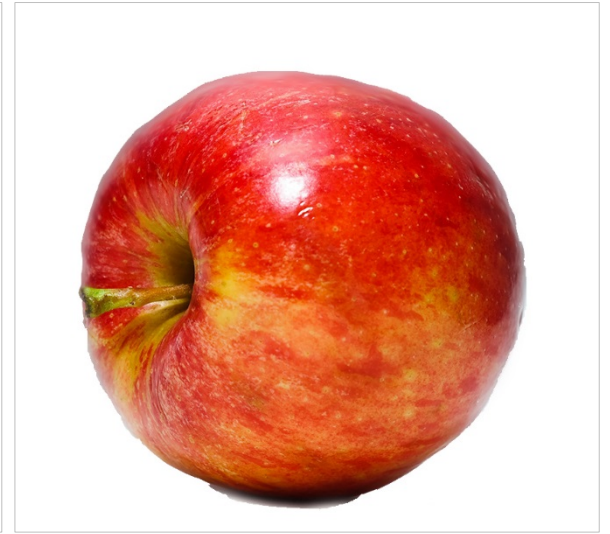
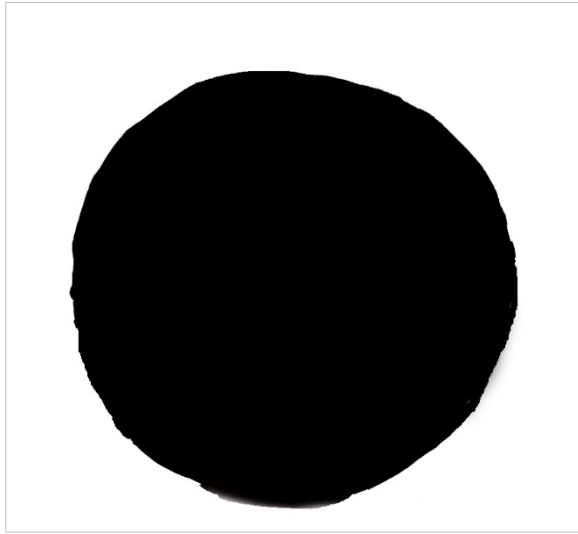
학습 내용

- DETERMINING THRESHOLD IN THRESHOLDING
- PROCESSING FOR COLOR IMAGES

GRAY-LEVEL THRESHOLDING

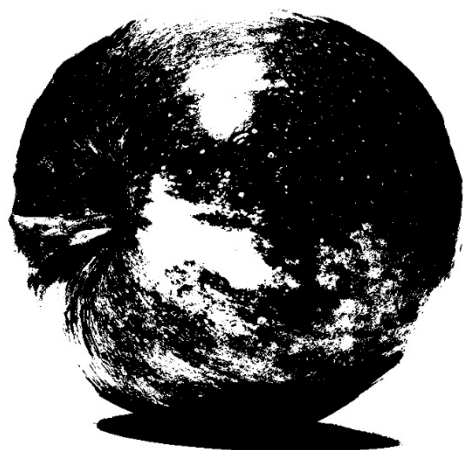


Binarization





110

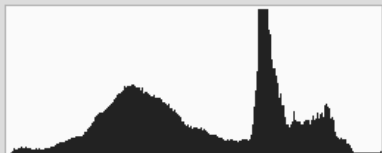


한계값 레벨(T): 110

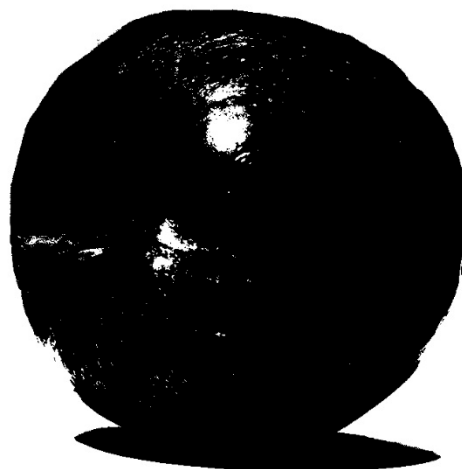
확인

취소

☒ 미리 보기(P)



160

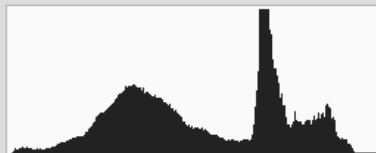


한계값 레벨(T): 160

확인

취소

☒ 미리 보기(P)



175

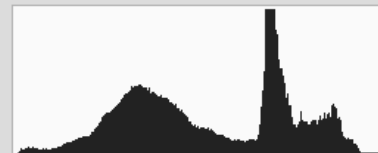


한계값 레벨(T): 175

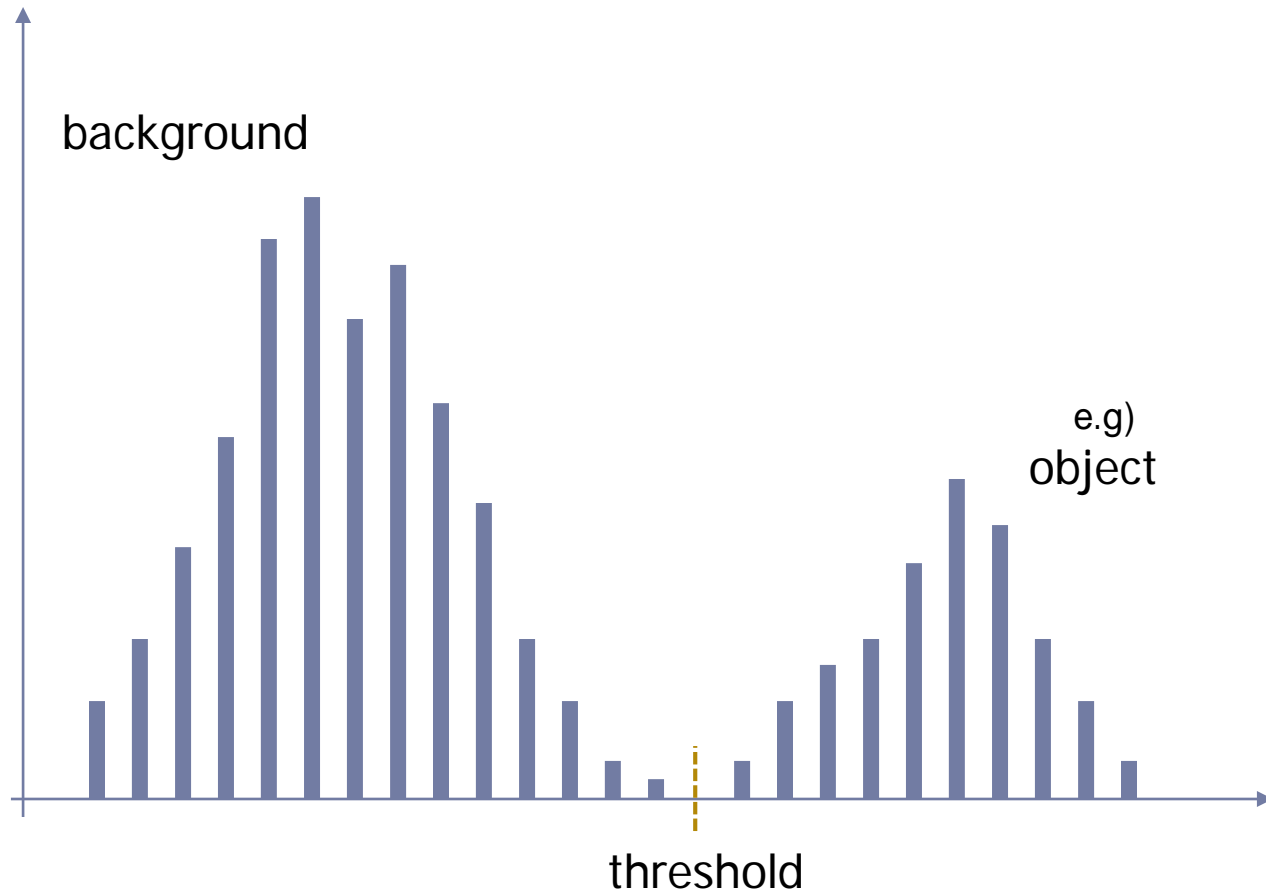
확인

취소

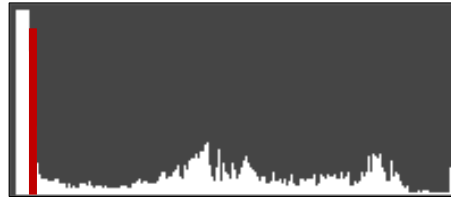
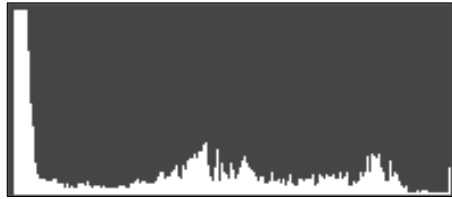
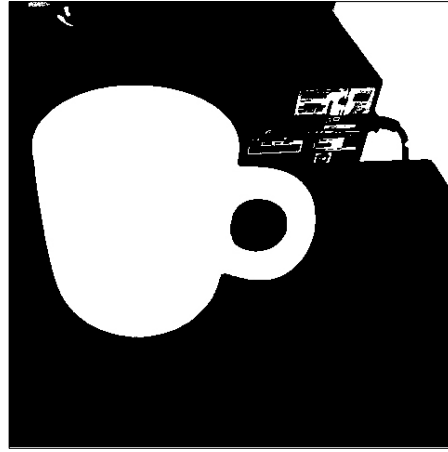
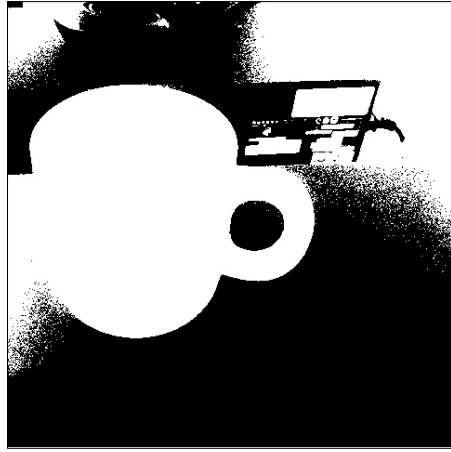
☒ 미리 보기(P)



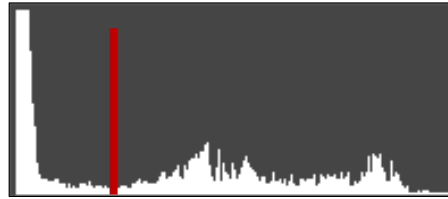
THRESHOLD의 결정



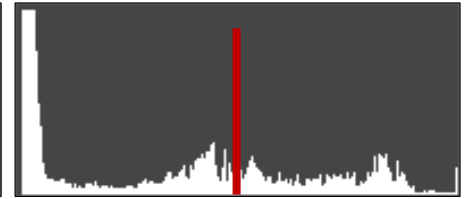
Bimodal histogram



8



26



130

OPTIMAL THRESHOLD BY OTSU (1)

● 기본 원리

- 임계값 T 를 기준으로 영역을 2개 그룹으로 나누었을 때 각 집합내의 명암 분포는 균일하고 집합 사이의 명암 차이는 최대화될 수 있도록 함
- 모든 가능한 T 에 대해 점수를 계산하여 가장 좋은 T 를 최종 임계값으로 선택함 \Rightarrow 최적화 알고리즘 (optimization algorithm)
 - 낱낱 탐색 (exhaustive search), 언덕 오르기 (hill climbing) 등의 탐색 방법을 사용 가능
- 최적화 알고리즘에서는 비용 함수 (cost function) 또는 목적 함수 (objective function)을 사용하여 점수 계산

OPTIMAL THRESHOLD BY OTSU (2)

목적 함수

$$T_{opt} = \operatorname{argmin}_{1 \leq k \leq L-1} (\sigma_W^2(k))$$

$$\sigma_W^2(k) = \omega_1(k)\sigma_1^2(k) + \omega_2(k)\sigma_2^2(k)$$

OPTIMAL THRESHOLD BY OTSU (3)

1) 히스토그램 계산

2) $T = k (k \geq 1)$ 에서 클래스 분리를 위한 확률 및 평균 계산

$$C_1(k) = \sum_{i=0}^{k-1} N_i, \quad C_2(k) = \sum_{i=k}^{L-1} P_i = N - C_1(k)$$

$$\omega_1(k) = \frac{C_1(k)}{N}, \quad \omega_2(k) = \frac{C_2(k)}{N} = 1 - \omega_1(k)$$

$$\mu_{T1}(k) = \sum_{i=0}^{k-1} i \cdot N_i, \quad \mu_{T2}(k) = \sum_{i=k}^{L-1} i \cdot N_i, \quad \mu_T = \sum_{i=0}^{L-1} i \cdot N_i$$

$$\mu_1(k) = \frac{\mu_{T1}(k)}{C_1(k)}, \quad \mu_2(k) = \frac{\mu_{T2}(k)}{C_2(k)} = \frac{\mu_T - \mu_{T1}(k)}{N - C_1(k)}$$

OPTIMAL THRESHOLD BY OTSU (4)

3) $T = k (k \geq 1)$ 에서 클래스 분리를 위한 분산 σ_W^2 계산

$$\sigma_1^2(k) = \sum_{n=0}^{k-1} [n - \mu_1(k)]^2 \frac{N_n}{C_1(k)}, \quad \sigma_2^2(k) = \sum_{n=k}^{L-1} [n - \mu_2(k)]^2 \frac{N_n}{C_2(k)}$$

$$\sigma_W^2(k) = \omega_1(k)\sigma_1^2(k) + \omega_2(k)\sigma_2^2(k)$$

4) 모든 레벨에 대해 반복하여 최적 임계값 선택

$$T_{opt} = \operatorname{argmin}_{1 \leq k \leq L-1} (\sigma_W^2(k))$$

OPTIMAL THRESHOLD BY OTSU (5)

$$\sigma^2 = \sigma_B^2 + \sigma_W^2$$

Within class variance: $\sigma_W^2 = \omega_1 \sigma_1^2 + \omega_2 \sigma_2^2$

Between class variance: $\sigma_B^2 = \sigma^2 - \sigma_W^2$

$$\begin{aligned} &= \omega_1 (\mu_1 - \mu)^2 + \omega_2 (\mu_2 - \mu)^2 \\ &= \omega_1 \omega_2 (\mu_1 - \mu_2)^2 \\ &= \omega_1 (1 - \omega_1) (\mu_1 - \mu_2)^2 \end{aligned}$$

OPTIMAL THRESHOLD BY OTSU (6)

$k = 0$ 일 때

$$\omega_1(0) = N_0, \quad \mu_1(0) = 0$$

$k \geq 1$ 일 때

$$\omega_1(k) = \omega_1(k-1) + N_k$$

$$\mu_1(k) = \frac{\omega_1(k-1)\mu_1(k-1) + kN_k}{\omega_1(k)}$$

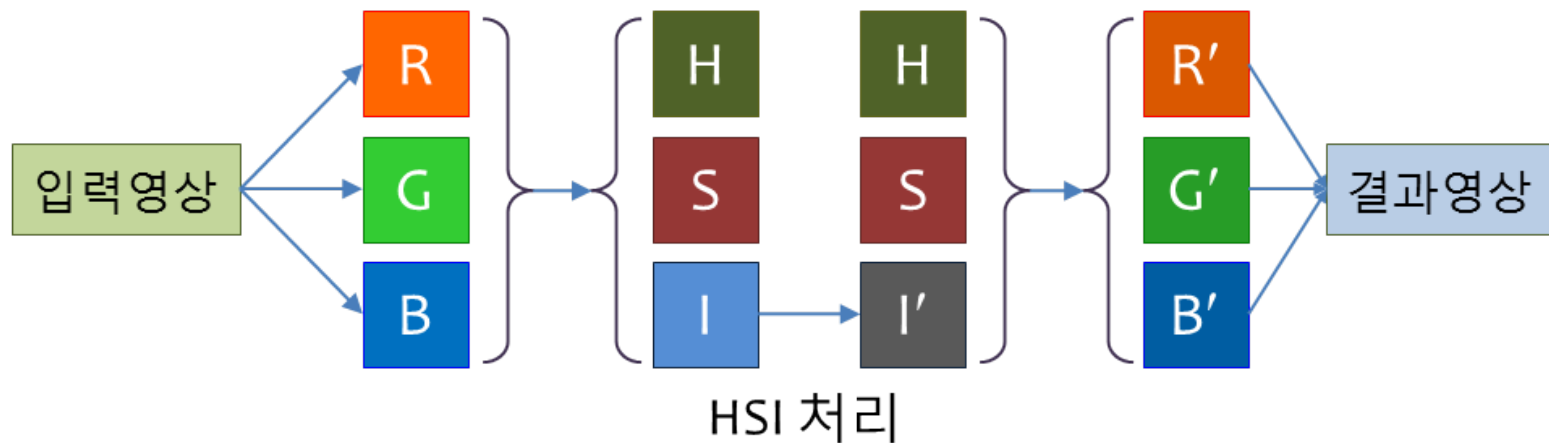
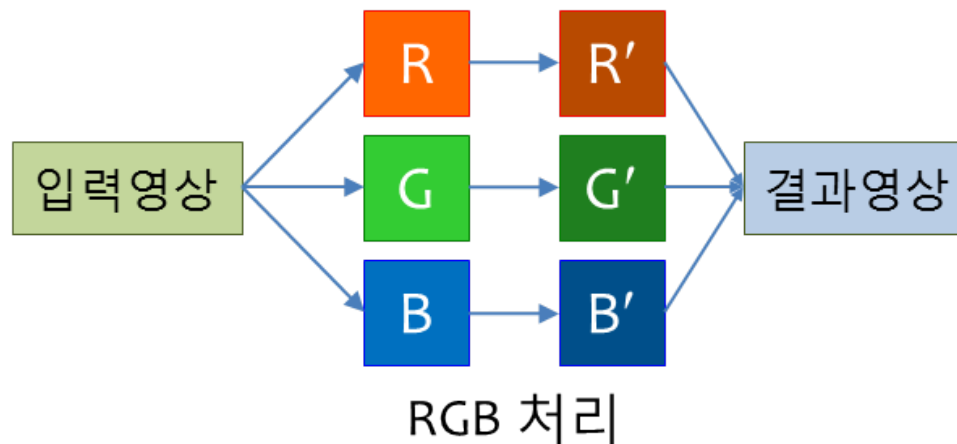
$$\mu_2(k) = \frac{\mu - \omega_1(k)\mu_1(k)}{1 - \omega_1(k)}$$

ALGORITHM

1. 히스토그램 계산
2. $\omega_1(0)$ 과 $\mu_1(0)$ 계산
3. 각 threshold $k(1 \leq k < L)$ 에 대해
 - 3-1. $\omega_0(k), \mu_1(k), \mu_2(k)$ 계산
 - 3-2. $\sigma_B^2(k)$ 계산
 - 3-3. 최대 σ_B^2 와 비교하여 현재 $\sigma_B^2(k)$ 가 더 크면
 - ① 현재 σ_B^2 를 사용하여 최대 σ_B^2 를 갱신
 - ② threshold k 를 optimal threshold (T_OPT)로 선택

※ Coarse to fine approach 사용 가능

PROCESSING FOR COLOR IMAGES



- point operations

- 이웃 픽셀과는 독립적으로 입력 영상의 각 픽셀 값을 변환한 후 결과 영상의 동일한 위치에 출력하는 연산
- Improving image contrast and brightness

- Arithmetic operation

- Scalar operation 및 Image operation

- Grayscale transformation

- Improving image contrast and brightness by using mapping function
- Brightness scaling by multiplication, Gray-level Thresholding, Gray-level Negative 등

Reference

- 오일석, **Computer Vision**, 한빛 아카데미, 2014
- Scott E Umbaugh, **Computer Imaging**, CRC, 2005
- Mark Nixon and Alberto Aguado, **Feature Extraction & Image Processing**, ELSEVIER, 2008
- Frank SHIH, **Image Processing and Pattern Recognition**, IEEE Press, 2010