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Sensor and Image Model

★ Models

⇒ Simplifications of the real world that are easier to handle.

⇒ Models depends on the applications.

⇒ Models always make assumptions.

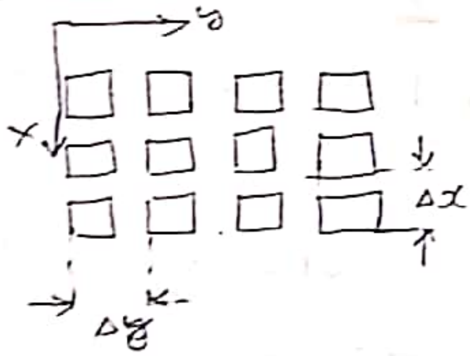
⇒ Awareness about the assumptions is essential.

★ Object Model

⇒ Strongly depends on the application.

- → Object recognition
- → Object reconstruction

★ Sensor Model



- **Sampling pitch** ⇒ Physical spacing between (the center of) adjacent sensor cell.

- **Fill factor** ⇒ Active sensing area size as a ~~[illegible]~~ fraction of the theoretically available sensing area.

number of Photon $\propto$ Intensity

* From Photons to Intensities

⇒ Photon flux $b(\lambda)$ is the average number of photons per unit area and time.

⇒ Let F be the area of the sensor cell and $q(\lambda)$ its efficiency,

$$N = F\Delta t \int q(\lambda)\, b(\lambda)\, d\lambda$$

⇒ Digital Image ⇒ 2D structure of measured intensity values (Natural numbers)

⇒ An image is an approximation of a continuous function of intensities $g(x,y)$.

↳ The approximation involves discretization and quantization.

$$g(x,y) \longrightarrow g(i,j)$$

* Poisson Distribution

$$\boxed{P(k) = \frac{\lambda^k}{k!} e^{-\lambda}}$$

{λ → Parameter}

{higher is λ, similar the distribution get to gaussian}

⇒ Let N = Number of photon

β = avg number of incomming photons per second.

t = exposure time.

$$\boxed{P(N) = \frac{(\beta t)^N}{N!} e^{-\beta t}}$$

$$\boxed{\mu = \beta t}$$

$$\boxed{\sigma_N^2 = \beta t}$$

↳ Allows for making statement about the number of photons at the sensors.

⇒ Relative accuracy $= \frac{\sigma_N}{\mu_N} = \frac{1}{\sqrt{\mu_N}}$

⇒ For a measured N, we obtain

$$\hat{\sigma}_N = \sqrt{N}$$

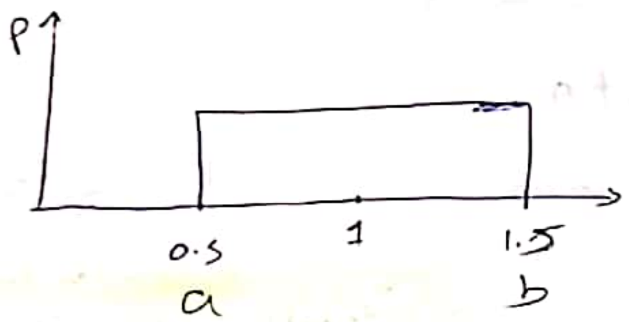
⇒ And then a relative accuracy of

$$\frac{\hat{\sigma}_N}{N} = \frac{1}{\sqrt{N}}$$

⇒ Brighter pixels shows a ~~higher~~ better relative accuracy compared to dark pixels.

★ Additional Sources of Noise

- Noise from the electronics.
- Quantization error



$$\mu = \frac{1}{2}(b-a) \approx 1$$

$$\sigma^2 = \frac{1}{12}(b-a)^2 \simeq 0.28$$

⇒ For a linear Sensor, we obtain for the intensity.

$$\boxed{g = \underbrace{N_E}_{\text{Noise from Electronics}} + \underbrace{N_R}_{\text{Noise from Rounding}} + \underbrace{f}_{\text{Scale factor}}\underbrace{N}_{\text{Number of Photons}}}$$

mean $E(g) = \rho \mu_N$

Variance $V(g) = \sigma_{N_E}^2 + \sigma_{N_R}^2 + \rho^2 g$

⇒ For good Cameras, we find,

$$\sigma_{N_E}^2 + \sigma_{N_R}^2 \approx 1$$

$$\boxed{V(g) \approx 1 + \rho^2 g}$$

★ Image Model

⇒ Four important Steps :-

- Ideal Image
- True Continuous Image
- True Discretized Image
- Read Discretized Image.

⇒ Two Interpretations of a pixel :-

- $g(i,j)$ is the value that corresponds to the area $(i \pm 1/2, j \pm 1/2)$
- $g(i,j)$ is the measured and rounded intensity value at the location (i,j).

⇒ 3D Vector for storing Color information.

$$\begin{pmatrix} r \\ g \\ b \end{pmatrix}$$