Intermission: What Have We Learned?

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ELEC2844: Probabilistic Systems Analysis

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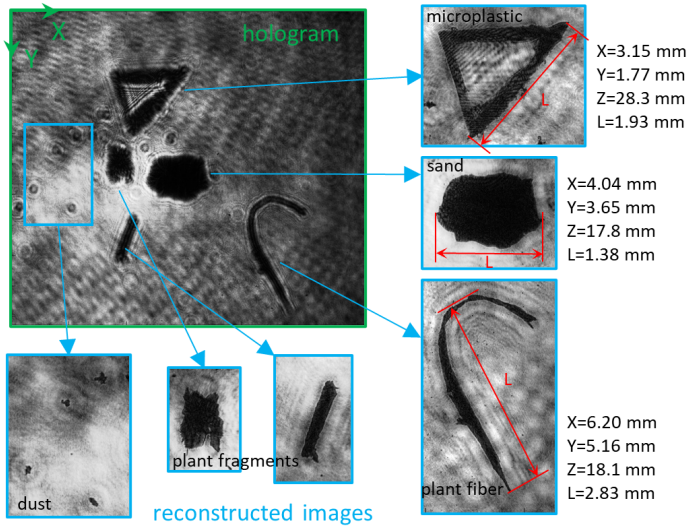
https://www.eee.hku.hk/~elec2844

Example: Counting



credit (left): https://www.croptracker.com/blog/computer-vision-in-agriculture-part-1.html
credit (right): J. Huang, Y. Zhu, Y. Li, and E. Lam, "Snapshot polarization-sensitive holography for detecting microplastics in turbid water," *ACS Photonics*, 10(12), 4483–4493, Dec 2023.

- Agtech — counting fruits
- Biotech — counting cells
- Commercial — counting people / vehicle
- Defense — counting drones
- Environment — counting microplastics

Counting Fruits

Integrates various technologies, e.g., computer vision, image processing, robotics, sensor, computational hardware, . . . , and *probabilistic analysis*, because <u>not all fruits are the same</u>.

- Natural variation, e.g., size
- Lighting
- Motion blur, out of focus, noise in the sensor
- Perspective and distance from camera
- Occlusion (partially covered)

Physical properties or features become random variables, e.g., $X = \text{width}$, $Y = \text{height}$, $Z = \text{color}$

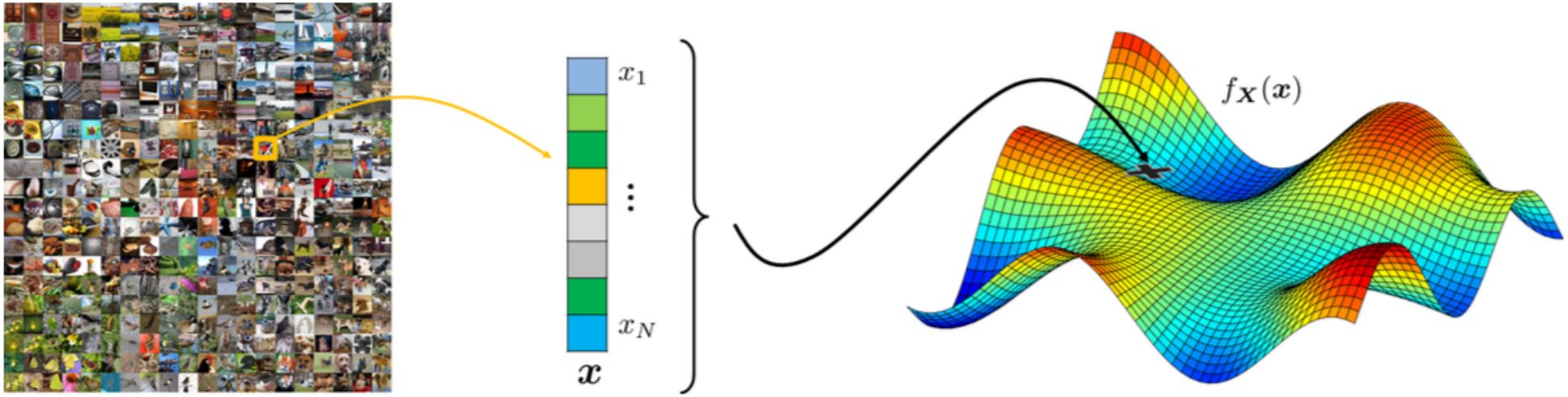
Counting Fruits

We may be interested to know:

- pmf of Z (assuming we "discretize" to a few colors)
- pdf of X, pdf of Y
- joint pdf of (X, Y)
- conditional pdf of $X \mid Y$
- questions of independence, e.g., between X and Y, or $X \mid Z$ and $Y \mid Z$
- summary statistics such as $\mathbb{E}(X)$, $\mathrm{var}(X)$
- derived distribution, e.g., pdf of X/Y
- covariance of (X, Y)
- ...

Counting Fruits

A significant shift in this data-driven era is that we now can consider the entire image (i.e., the pixels) as random inputs, rather than just features:



credit: Supplementary textbook

A single image is raster scanned to become a vector $\mathbf{x}$, which is random with a (joint) PDF $f_{\mathbf{X}}(\mathbf{x})$

Counting Fruits

We will learn more tools to enable us to ask:

- Based on X, Y, Z, or directly on $\mathbf{x}$, decide if a particular fruit is healthy?
- Based on X, Y, Z, or directly on $\mathbf{x}$, decide on the type of fruit?
- Optimize growth condition to obtain better fruits?