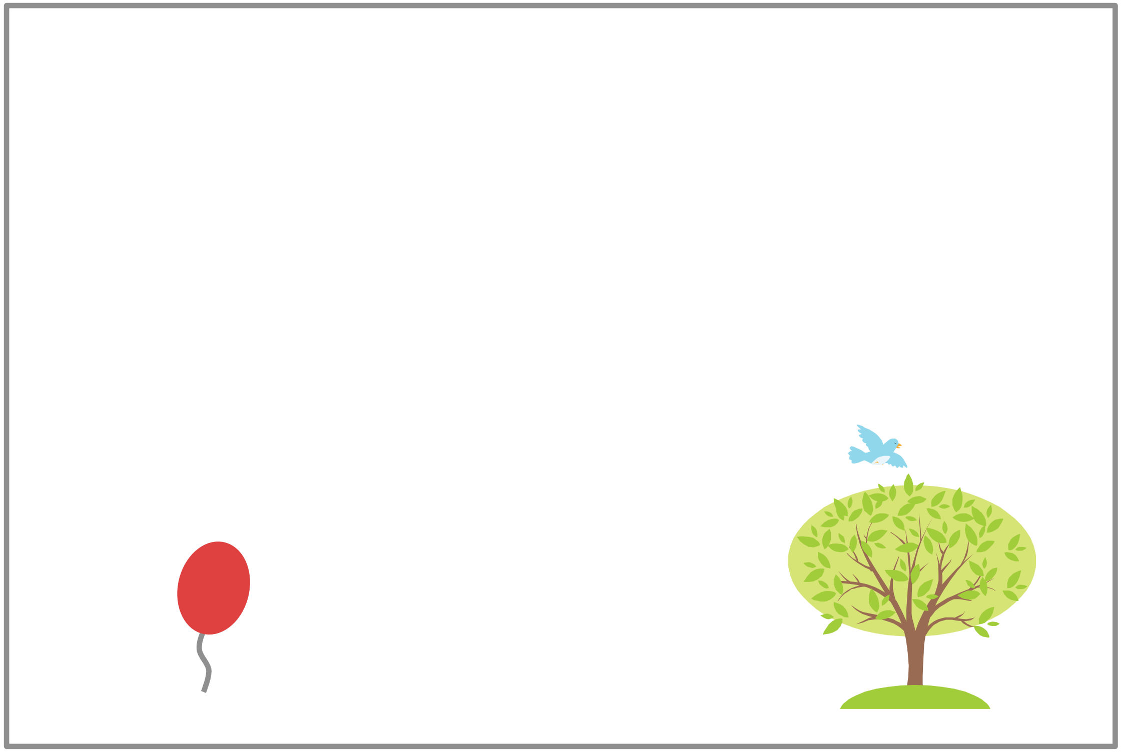
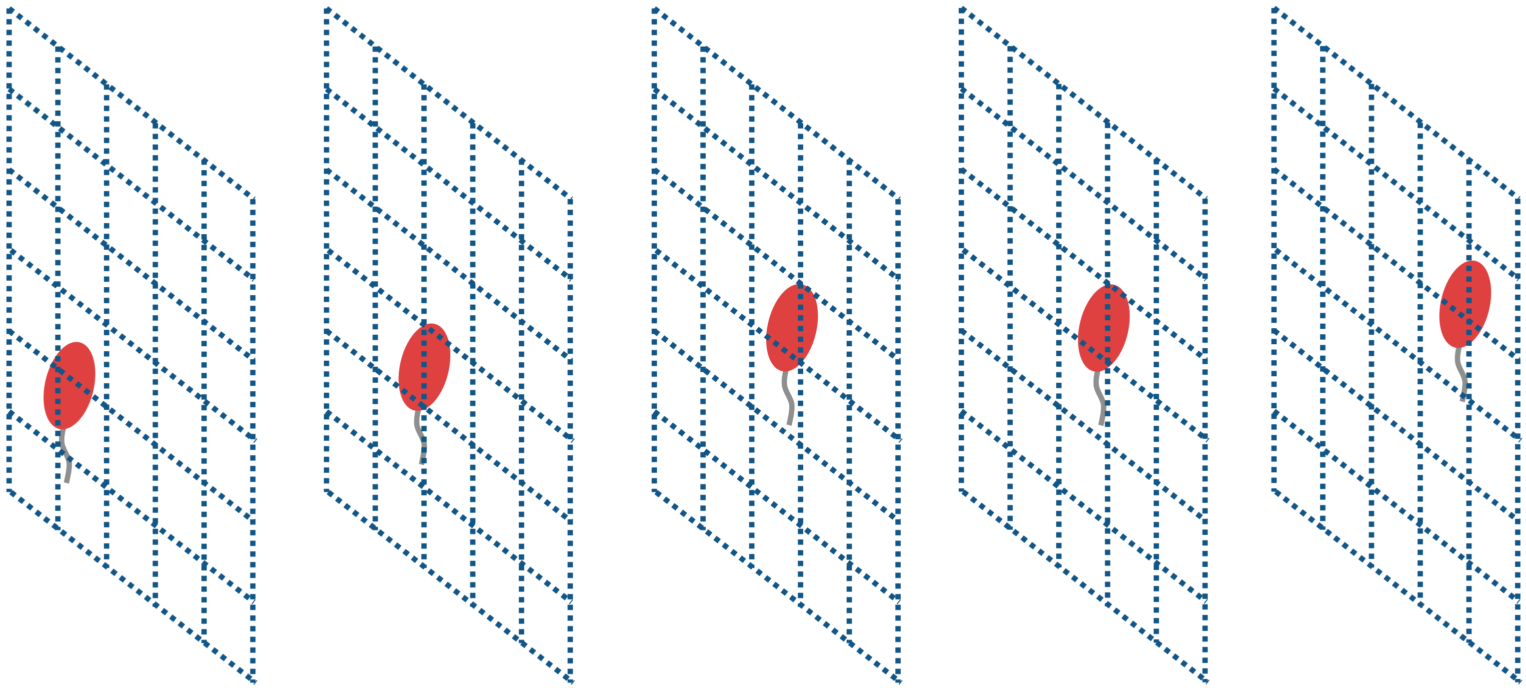
Object Tracking



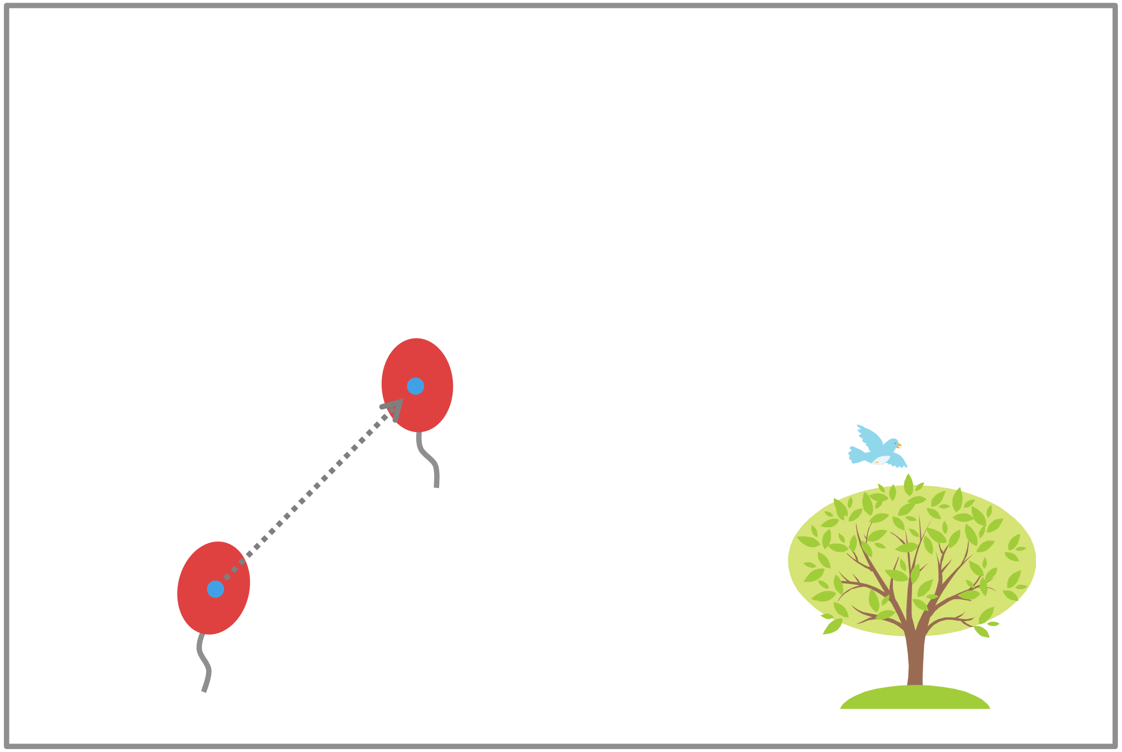
We are going to track a red object in a movie

Searching red object in each frame might be an idea … but



There might be more efficient way to do this work

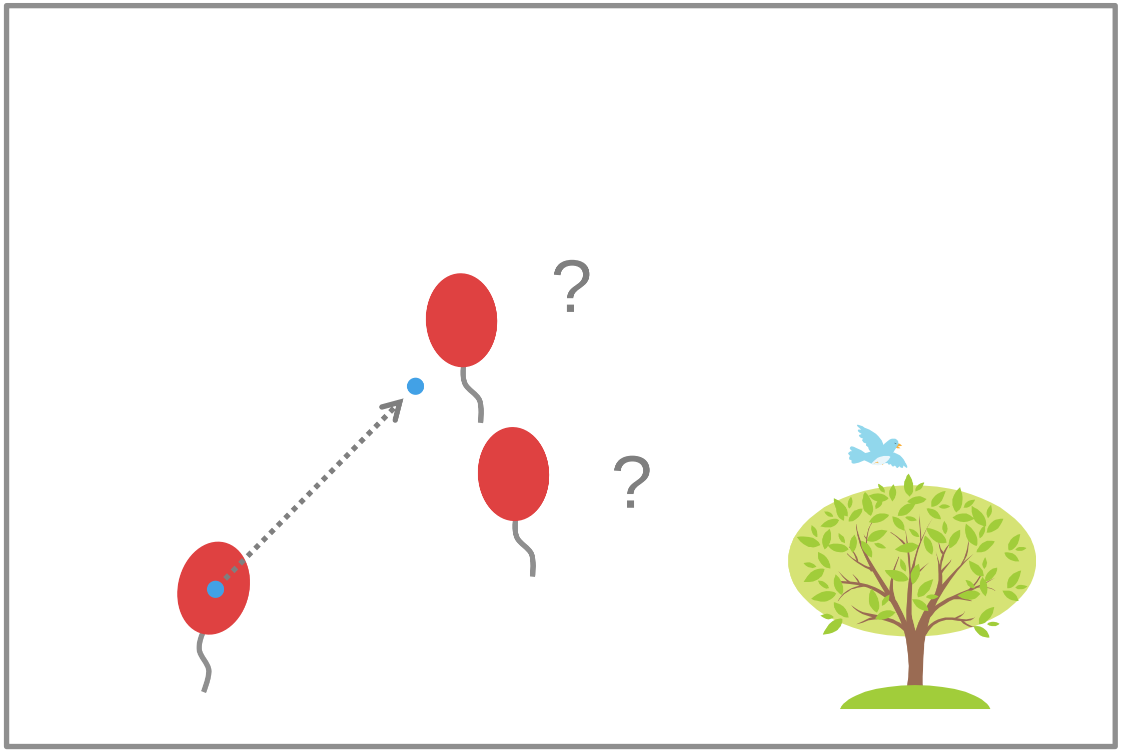
Object Tracking



If you know the location and speed of this object …

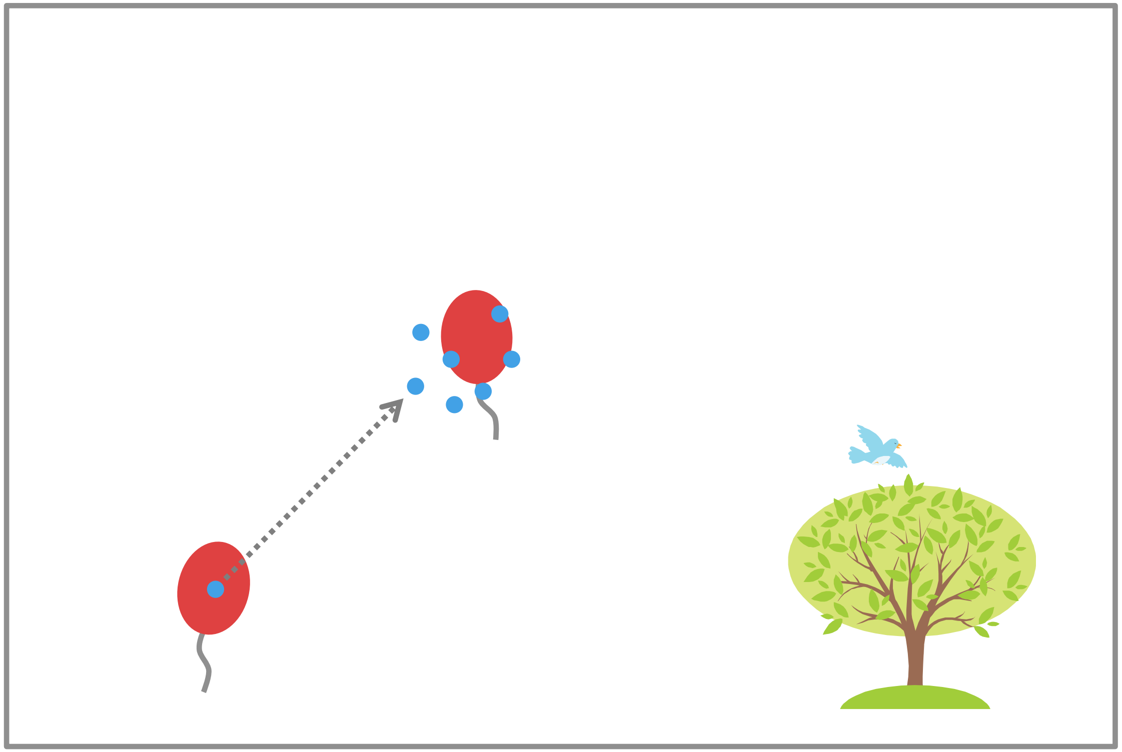
You can predict the future location assuming uniform linear motion for this object

Object Tracking



But your prediction might fail sometimes …

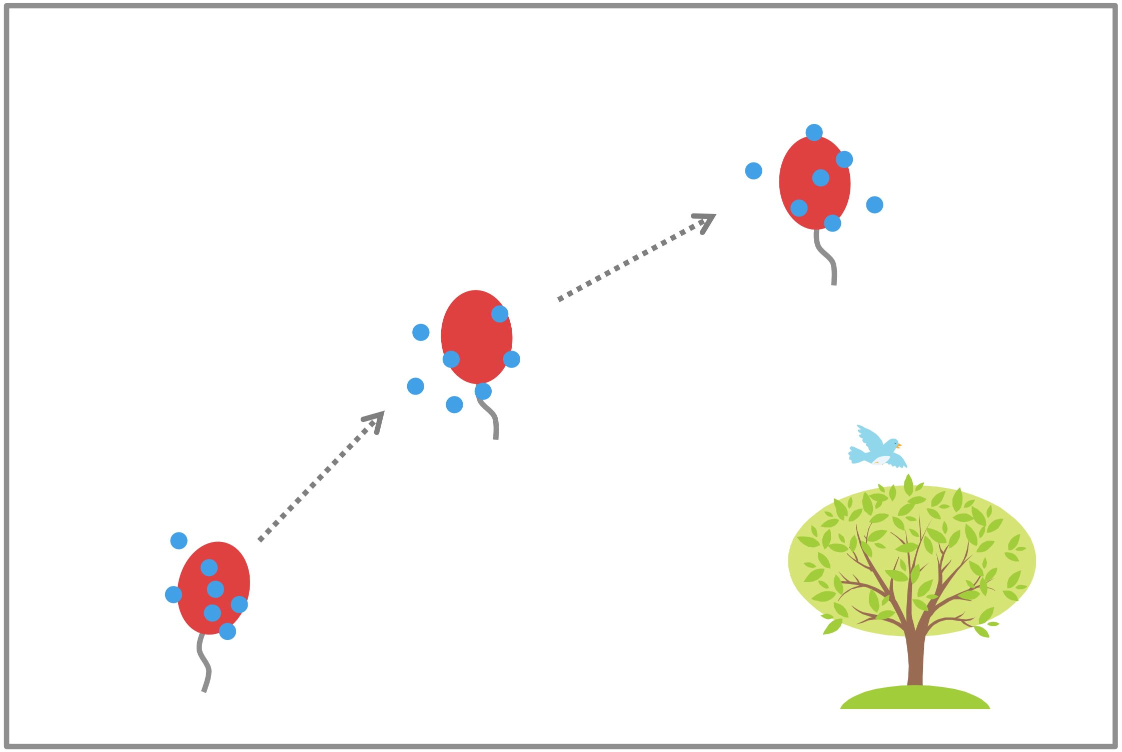
Object Tracking



If you have many slightly different predictions …

⇨ One of them might be near the right answer

Object Tracking



Let’s track this object by many particles which have slightly different location or speed

Algorithm (Particle filter / Condensation)

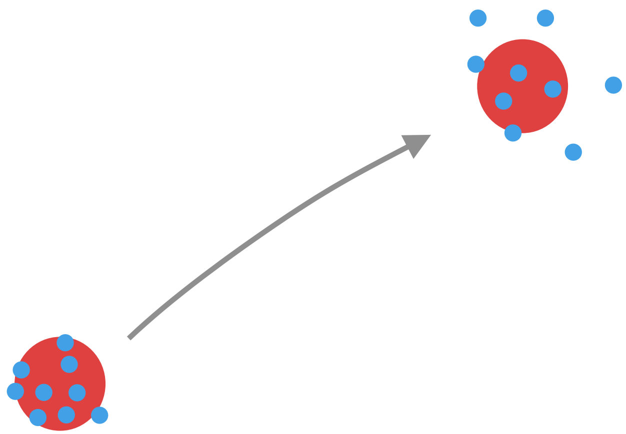
1. Prediction

Time evolution of particles according to system model

2. Filtering

Reselection particles according to their likelihood

Prediction (move particles)



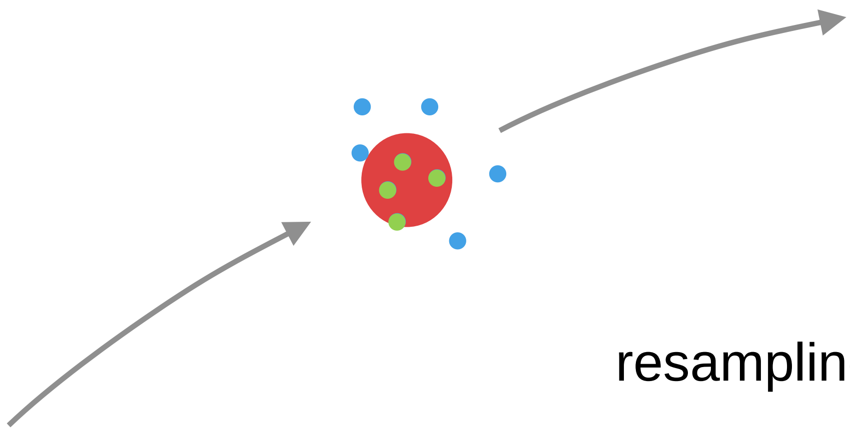
Location / Speed

Noise

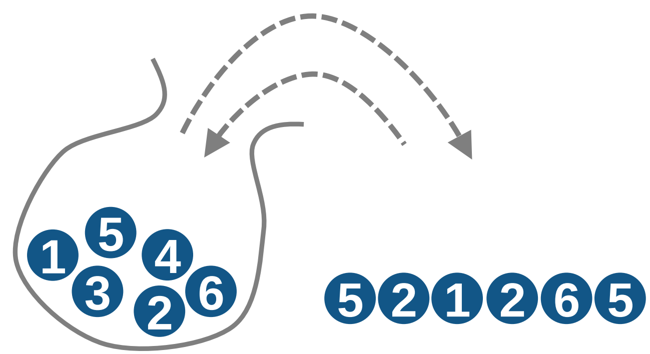
$$\begin{pmatrix} x_n \\ y_n \\ \dot{x}_n \\ \dot{y}_n \end{pmatrix} = \begin{pmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_{n-1} \\ y_{n-1} \\ \dot{x}_{n-1} \\ \dot{y}_{n-1} \end{pmatrix} + \begin{pmatrix} v_x \\ v_y \\ v_{\dot{x}} \\ v_{\dot{y}} \end{pmatrix}$$

Filtering (resample particles)

Multiple pick up of same particle is permitted



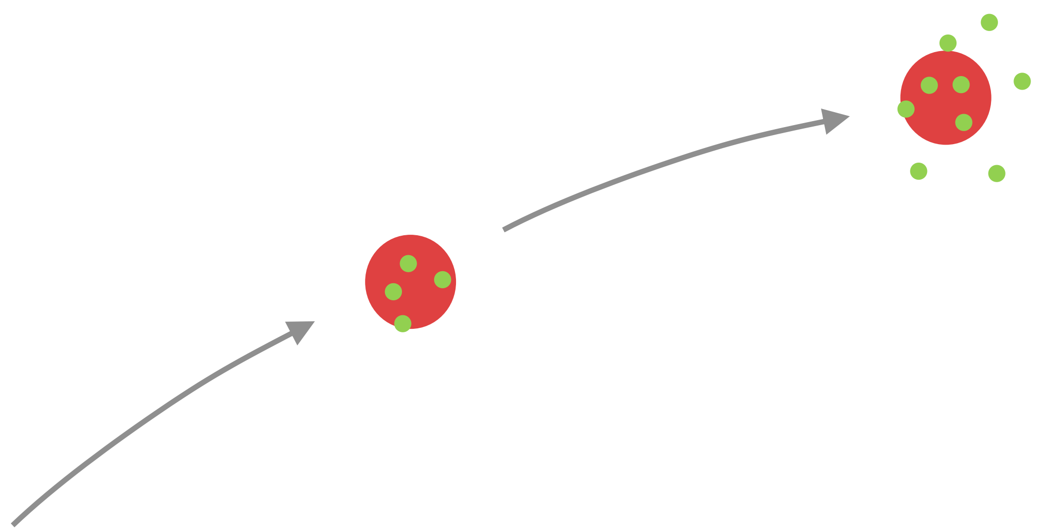
resampling with replacement



Picking up same number of particles

Particles which has large “likelihood” are more likely to be picked up

Prediction (move particles)



Location / Speed Noise

$$\begin{pmatrix} x_{n+1} \\ y_{n+1} \\ \dot{x}_{n+1} \\ \dot{y}_{n+1} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_n \\ y_n \\ \dot{x}_n \\ \dot{y}_n \end{pmatrix} + \begin{pmatrix} v_x \\ v_y \\ v_{\dot{x}} \\ v_{\dot{y}} \end{pmatrix}$$

Calculation of “likelihood”

1) Get the color of pixel on which particle exists (observation)

Location of particle

Observe

Color of pixel

(x, y)

(r, g, b)

2) Compare the RGB of pixel with red (255, 0, 0)

Color of pixel

Compare

Red

(r, g, b)

$(255, 0, 0)$

Calculation of likelihood

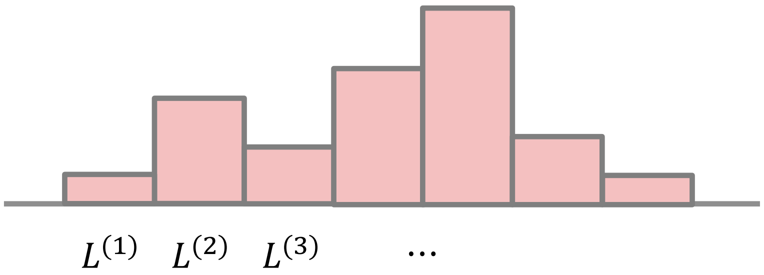
The closer the color we observe becomes red (255, 0, 0), the bigger the likelihood of particle becomes.

$$L = \frac{1}{\sqrt{2\pi\sigma}} \cdot \exp(-\frac{d^2}{2\sigma^2})$$ ← Likelihood

$$d = \sqrt{(r-255)^2 + g^2 + b^2}$$

Calculate likelihood for each particle

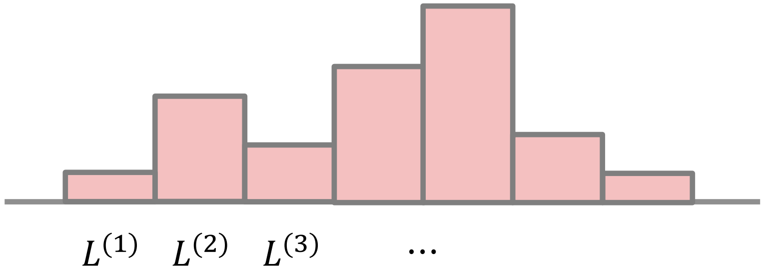
$$L^{(k)} \qquad (k = 1, \cdots, N)$$

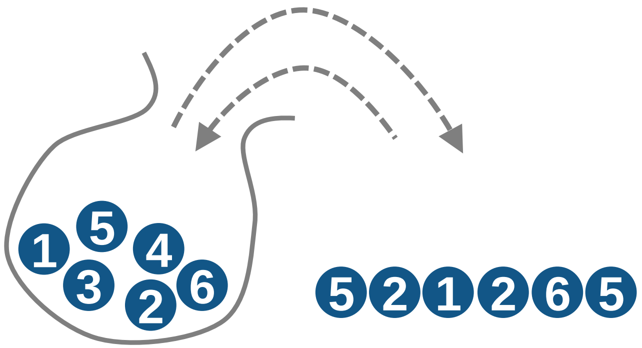


Filtering

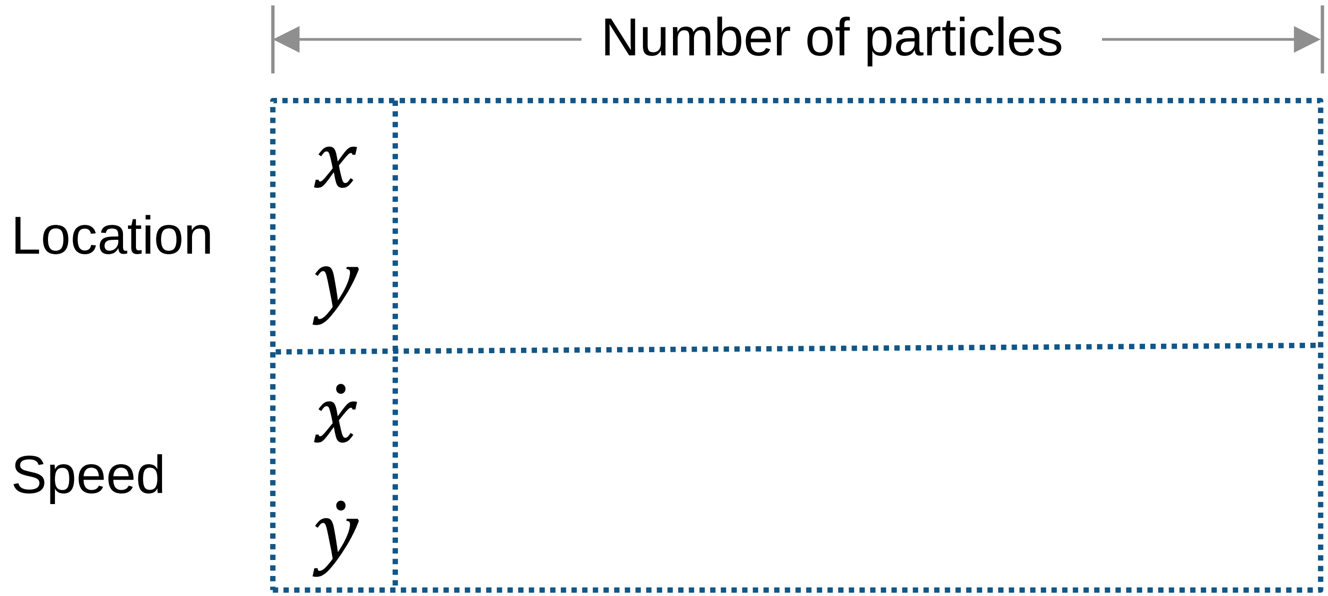
Execute “resampling with replacement” according to likelihood ratio

$$\frac{L^{(k)}}{\sum_{k=1}^{N} L^{(k)}} \quad (k = 1, \cdots, N)$$



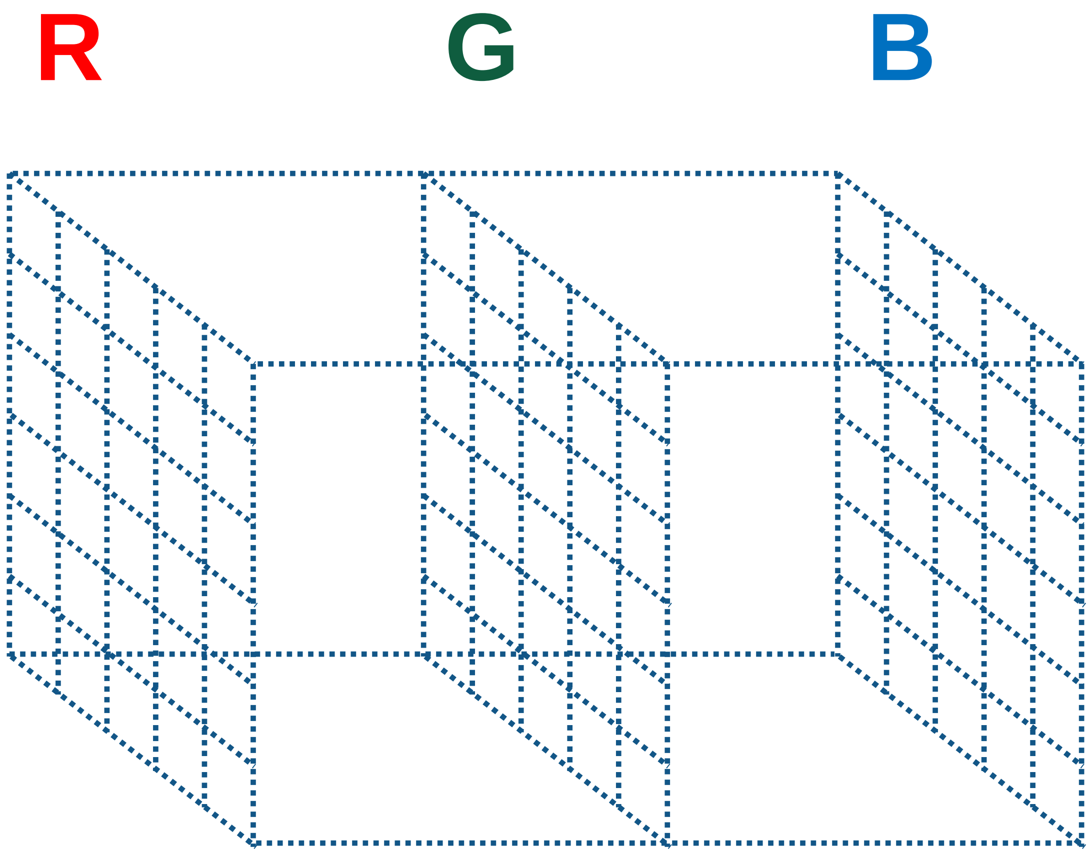


Explanation of variable (particles)



When you multiple matrix $F = \begin{pmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$ from left, particles move

Explanation of variable (color photo)



480 X 640 X 3