Entropic Forces in Brownian Motion

Phys 160 Journal Article Report
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Link to video presentation:

https://www.youtube.com/watch?v=hjmek4pmBJ4&list=PLlTM2LUMMTGrnFzYMk5mpvfbSER_krg7l&index=2

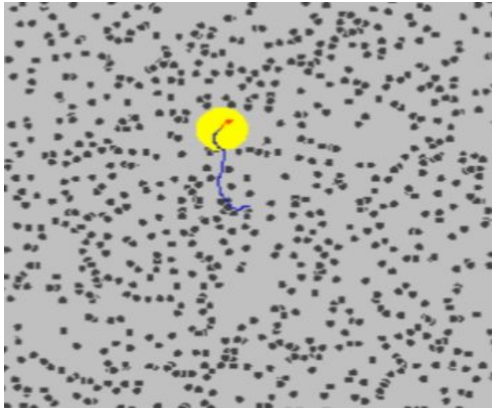
Random Walks

Brownian Motion

(Drift, continuous process)

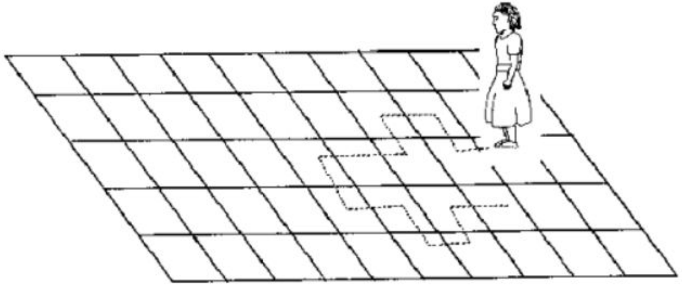
Random Walks

(No drift, discrete process)



Yellow particle submerged in a fluid

Simplification

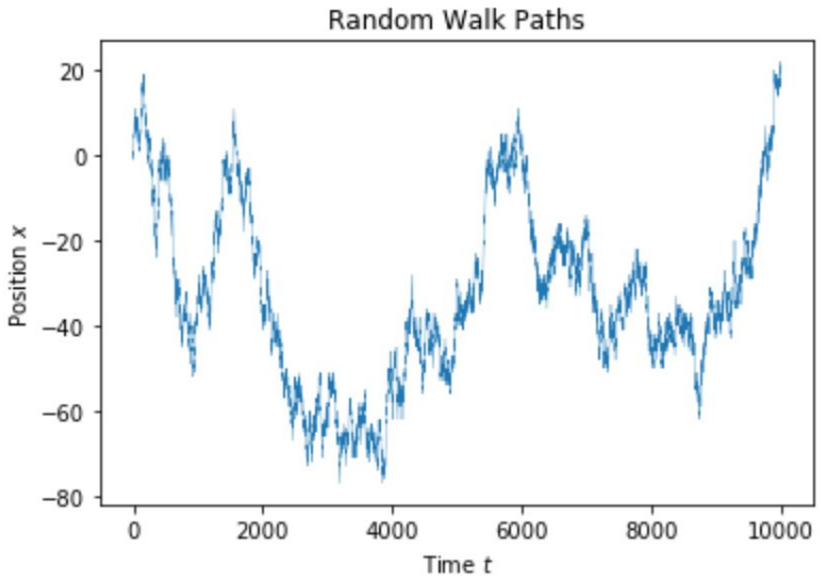


A drunk person making equal steps in random directions

Random Walks In 1D

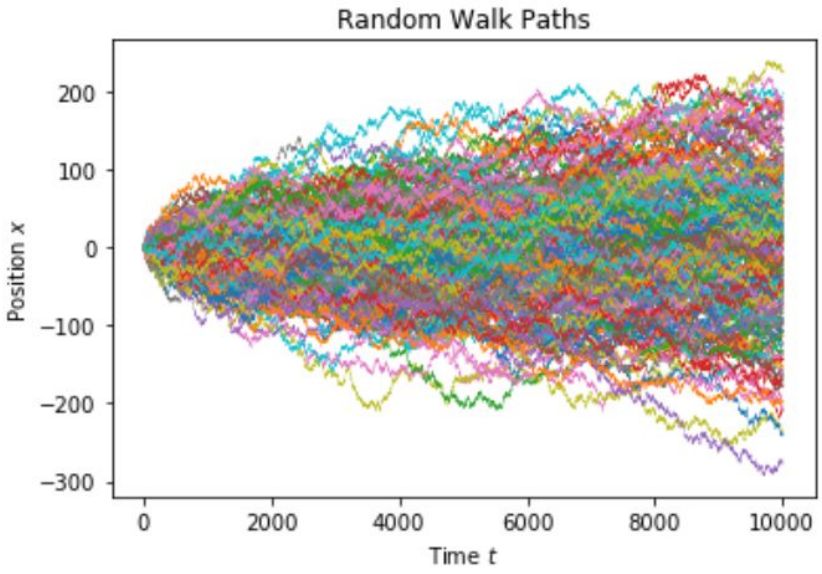
A Single Random Walk

- Not very interesting

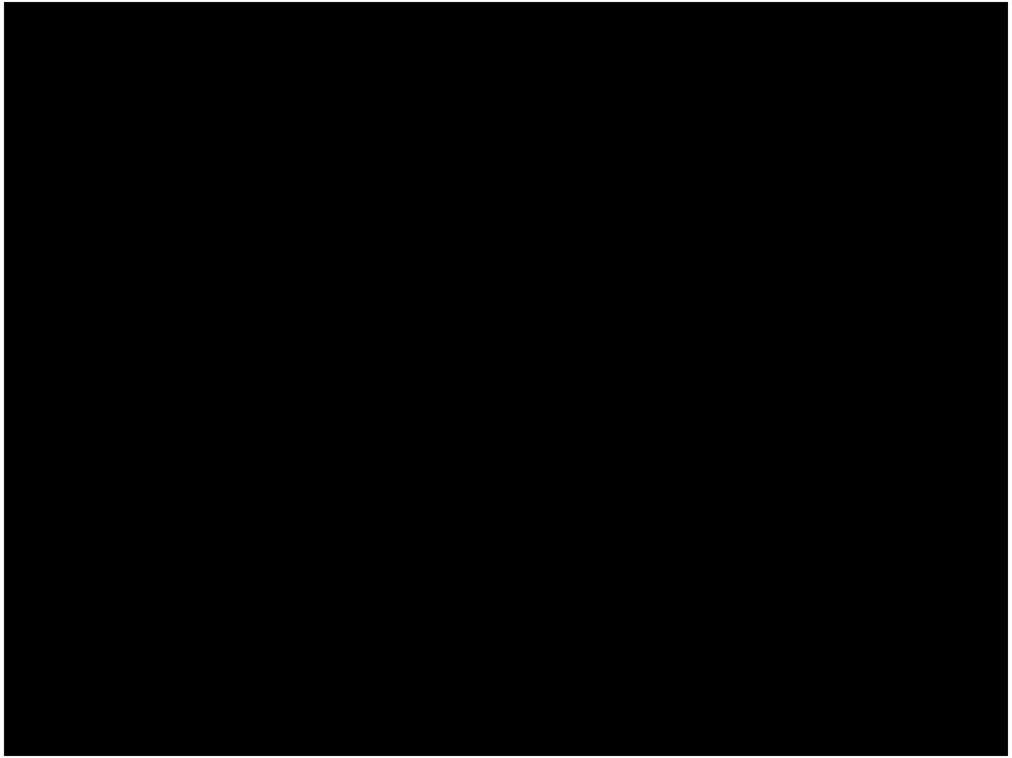


Several Random Walks

- Very Interesting behavior… _Normal Distribution_



Time Evolution of Random Walk Distribution



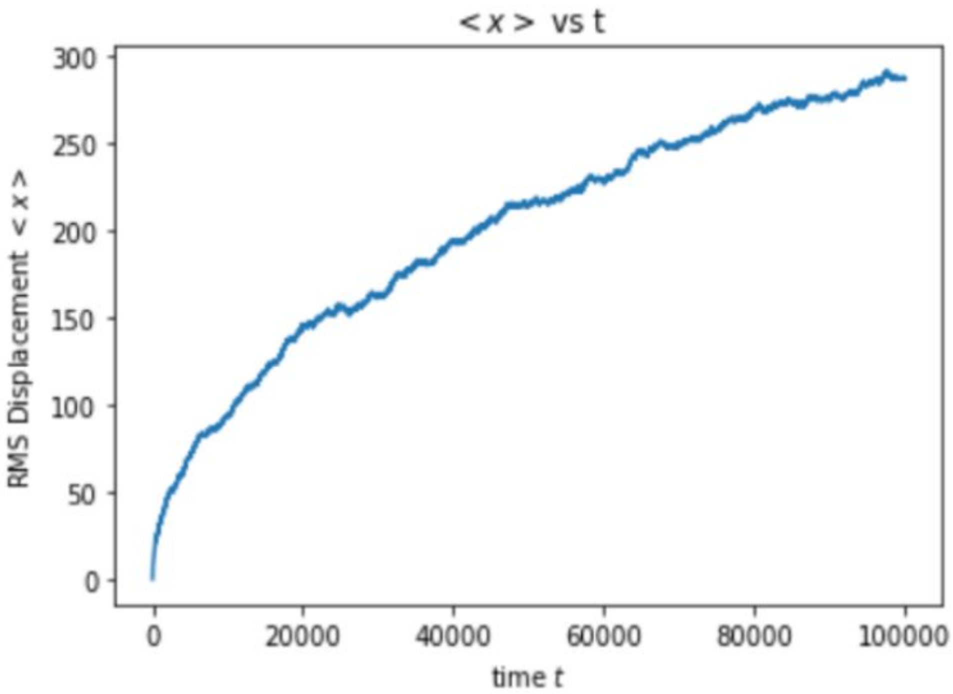
Diffusion Equation

$$\frac{\partial f(\mathbf{r},t)}{\partial t} = D\nabla^2 f(\mathbf{r},t)$$

Probability Distribution

$$f(x,t) = \frac{1}{\sqrt{2\pi[\sigma(t)]^2}} e^{-\frac{x^2}{2[\sigma(t)]^2}}$$

RMS Displacement as Function of Time



$$< x > \propto t^{1/2}$$

- Concavity in x(t) implies non-zero acceleration
- F=ma … there must be a force

- It's as if there is a macroscopic force pulling the random walkers away from the starting point

Entropic Force

$$< F > = -mD^2 / < x^3 >$$

Entropic Forces

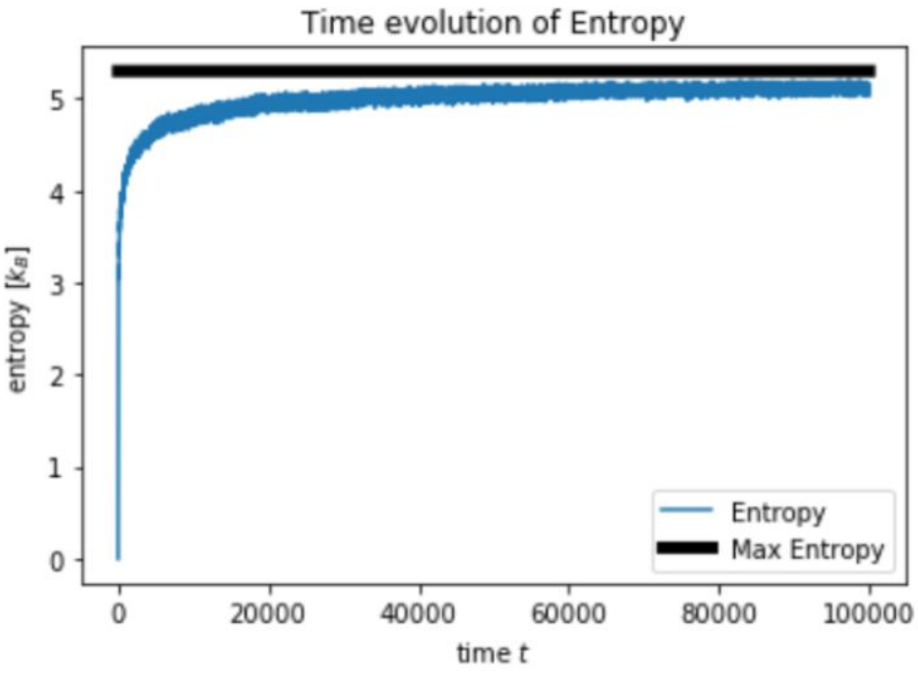


Figure 6: Entropy as a function of time for 200 Random Walks

- The entropic force pulls drunkards away from the origin in order to **maximize entropy** (Diffusive equilibrium)

Conclusion

- Use entropic force/entropy maximization approach to solve other Brownian motion problems
- We don't need the Central Limit Theorem anymore!