

What kind of random walk are these biological cells doing?

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Introduction

Cellular migration is a key aspect for cells growth and cells identification (which organism they belong to). Different cells move in different ways mainly depend on directional persistence and cellular speed.

Methods

Generating synthetic cell motion data using different models (PRW and R&T model) and apply analysis about the mechanism.

Persistent Random Walk (PRW): Cells moves on a lattice with different probabilities one step per unit time, with a higher probability of choosing the same direction as the previous step.

Run and Tumble (R&T): Cells move with fixed speed, after an exponentially distributed time, the cell turns in another random direction and continue the process

The parameters used to generate the data were chosen so that the mean distance between successive observation points was the same for both models.

Reference

Gorelik, R., Gautreau, A. Quantitative and unbiased analysis of directional persistence in cell migration. Nat Protoc 9, 1931–1943 (2014). <https://doi.org/10.1038/nprot.2014.131>.

Results

Speed measures and persistence measures.

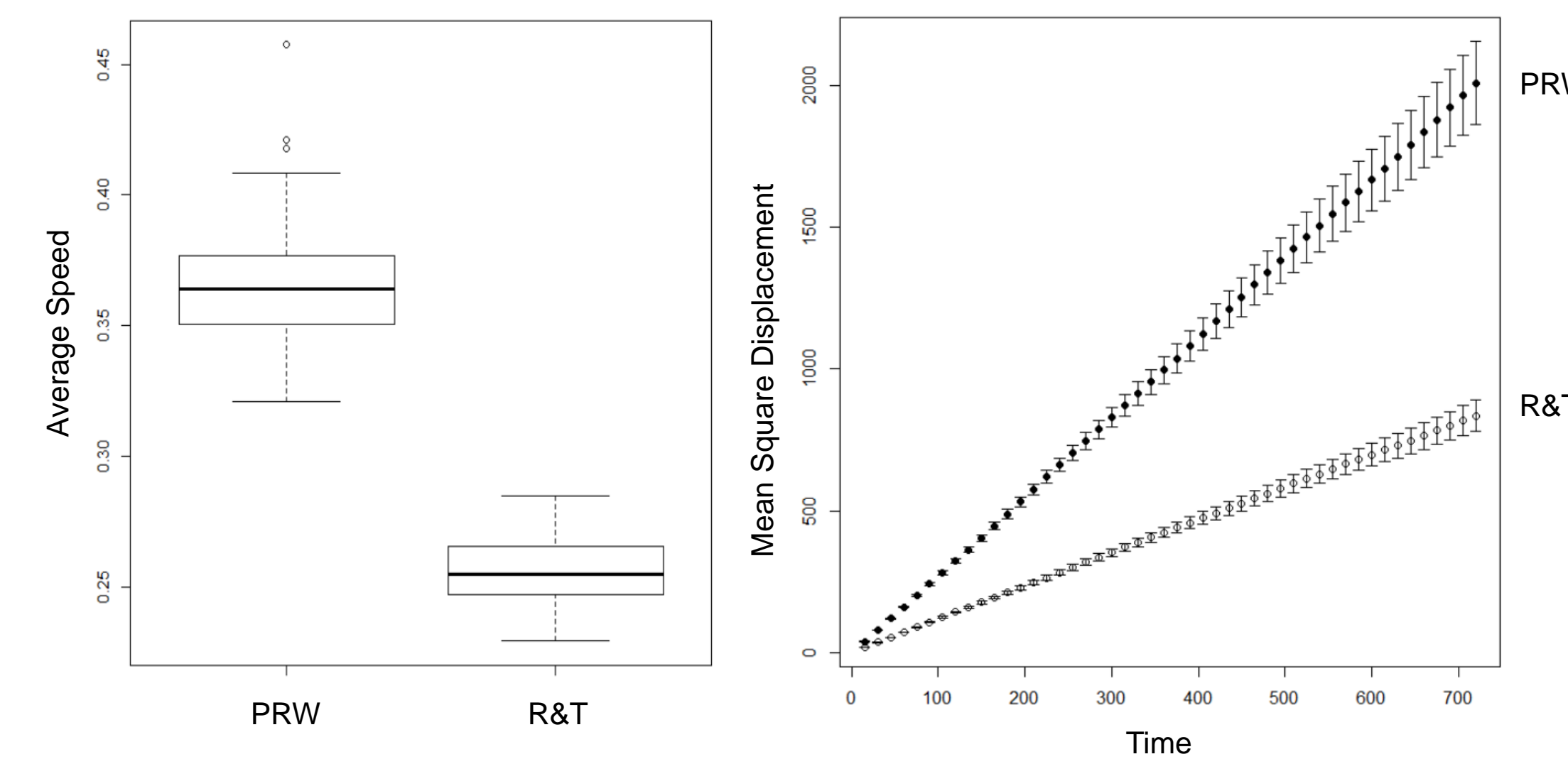


Figure1: Speed measures

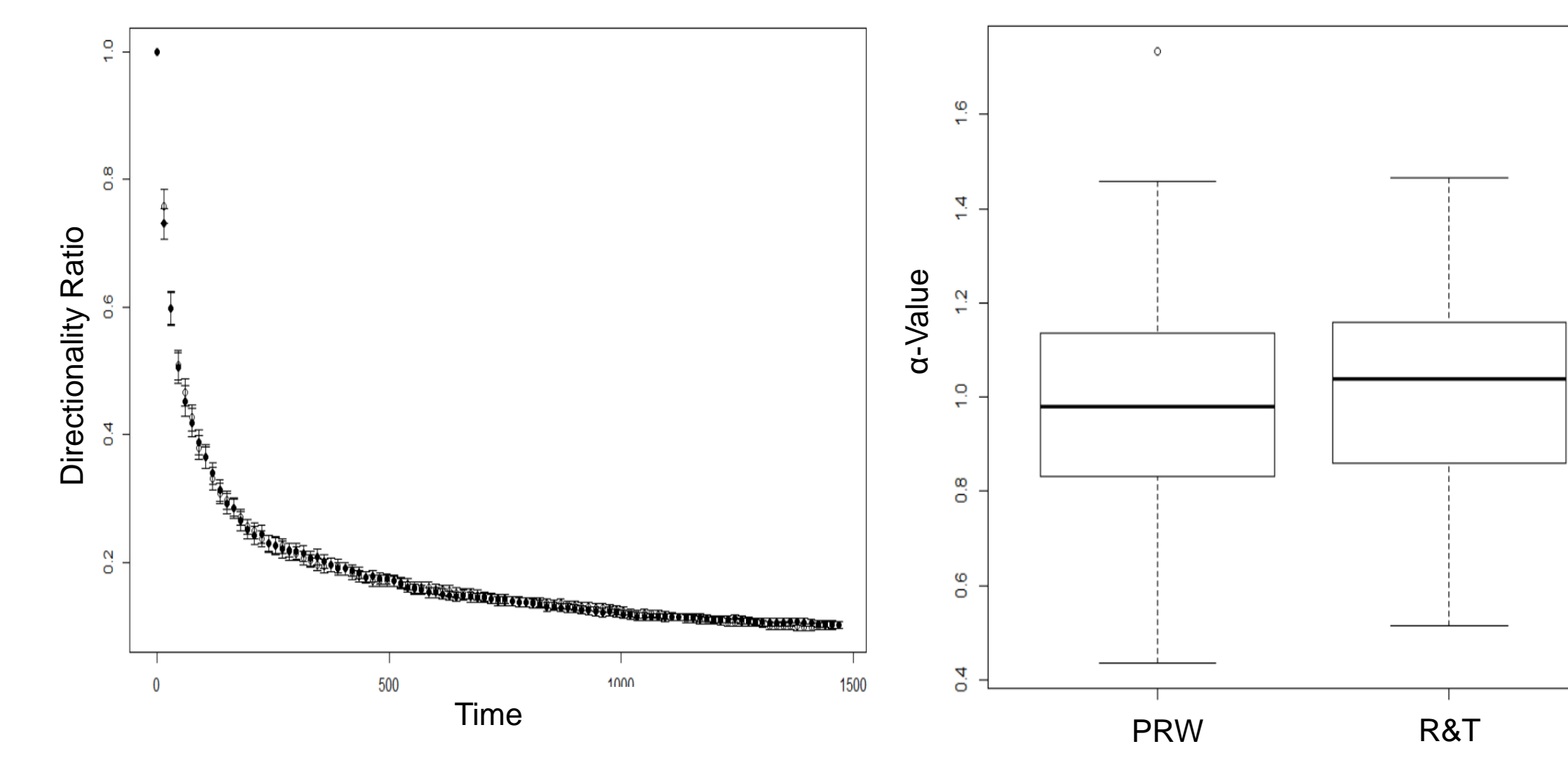


Figure2: Persistence measures

$$MSD(n) = \frac{1}{N - n + 1} \sum_{i=0}^{N-n} [(x_{(i+n)\Delta t} - x_{i\Delta t})^2 + (y_{(i+n)\Delta t} - y_{i\Delta t})^2]$$

n is the step size, where N is the total number of displacements per trajectories. Δt is the time interval between adjacent points.

Directionality ratio = $\langle d_t / D_t \rangle$

d_t denotes the straight-line distance between the start point and the current position at time t , whereas D_t is the actual length of trajectory.

For our limited synthetic data, we found the estimated speed and MSDs are significantly larger for the PRW than for the R&T model. The directionality ratio and the alpha value were not significantly different between the PRW and the R&T model.

Conclusions

PRW model is faster might because of the data merely capture the positions of the cells at relatively large time intervals. It is possible that we have missed some turns in R&T model.

The second analysis on persistency failed to tell us anything about the underlying mechanisms

Next, we can modify the time interval between adjacent points (minimum measuring frequency) and try to make the analysis meaningful.

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