Abstract

To characterize the random walk of *E. coli*, several parameters have been studied, such as the motility speed, run interval, and random motility coefficient.

The probability distributions of these parameters are dependent on the presence or absence of a chemical gradient in the fluidic environment.

Although it is suggested that the parameter distributions change under biased conditions, there are contradicting reports of the actual distributions since they are usually derived from observations of cell movement.

We develop hypotheses for the parameter distributions from the literature and use them to simulate biased and unbiased random walks, in order to develop a method to detect a chemical from cell motility.

Parameters

- Parameters (to access the *E. coli* movement)
  - Running Speed (µm/s)
  - Run Duration (s)
  - The angle between the successive runs
  - Tumble frequency

- Parameters’ Distributions
  - Unbiased
    - Running speed: Nearly constant during run
    - Run duration: Exponential (λ₁)
    - The angle: Uniform U(0, π)
    - Tumble frequency: Poisson (λ₂)
  - Biased
    - Running speed: Nearly constant during run
    - Run duration: Exponential (λ₁)
    - The angle: Uniform U(0, π)
    - Tumble frequency: Poisson (λ₂)

Simulation

- Simulation of the random walks for *E. coli* under unbiased environment. There are 500 runs and tumbles in this simulation.

- Simulation of the random walks for *E. coli* under biased environment. There are 500 runs and tumbles in this simulation. The positive stimulator is an increasing chemoattractor gradient toward the positive direction of Y axis.

- Distribution of the simulated random motility coefficient under unbiased environment. There are 200 periods and during each period, there are 20 runs and 19 tumbles.

- Distribution of the simulated random motility coefficient under biased environment. There are 200 periods and during each period, there are 20 runs and 20 tumbles.

Future Work

- There are fewer references about some parameters’ distribution, such as the run speed, tumbling frequency, and the angle between two successive runs, we made some assumption about these.

- In the future, we will use a high-speed CCD camera (sampling rate reaches 1000 fps) to make the experiments.

- Our goal is to find the probability distributions for different parameters under biased and unbiased environment.

E. Coli & Random Walk

- *E. coli* (*Escherichia coli*) is a gram-negative, peritrichously flagellated bacterium that is present in the gut of many mammals.

- *E. coli* have several helical flagella, driven by a reversible rotary motor located at the base to enable it to swim (20 nm in diameter, 10µm in length).

- Run: the flagella rotate in the counterclockwise direction (as viewed from the distal end) and form a coordinated bundle, and as a result form a nearly constant propulsion and drive the cell in a smooth track.

- Tumble: the clockwise rotation of the flagellum destabilizes the left-handed helicity, the sum of propulsion become random and cause the cell to move chaotically.

- The rotation mode of the flagellar filaments (clockwise or counterclockwise) and the flagellar polymorphism determine the motility mode.

Random Motility Coefficient

- Random Motility Coefficient is used to access *E. coli* motility at microscopic level.

  \[ \mu_0 = \frac{\nu^2 \tau}{3(1 - \langle \cos \theta \rangle)} \]

  - \( \nu \) is the mean cell swimming speed
  - \( \tau \) is the mean run time
  - \( \theta \) is the turn angle
  - \( \langle \cos \theta \rangle \) is the mean of \( \cos \theta \)

  - At macroscopic level, the random motility coefficient is the operational equivalent of a diffusion coefficient. [length\(^2\)/time\(^{-1}\)].

- For favorable biased environment \( \lambda_2 < \lambda_1 \), for unfavorable \( \lambda_2 > \lambda_1 \)
- For favorable biased environment \( \lambda_3 < \lambda_4 \), for unfavorable \( \lambda_3 > \lambda_4 \)
- For favorable biased environment \( \lambda_5 < \lambda_6 \), for unfavorable \( \lambda_5 > \lambda_6 \)