A diffusion approximation based on renewal processes with applications to strongly biased run–tumble motion - DTU Orbit (09/11/2017)

A diffusion approximation based on renewal processes with applications to strongly biased run–tumble motion

We consider organisms which use a renewal strategy such as run–tumble when moving in space, for example to perform chemotaxis in chemical gradients. We derive a diffusion approximation for the motion, applying a central limit theorem due to Anscombe for renewal-reward processes; this theorem has not previously been applied in this context. Our results extend previous work, which has established the mean drift but not the diffusivity. For a classical model of tumble rates applied to chemotaxis, we find that the resulting chemotactic drift saturates to the swimming velocity of the organism when the chemical gradients grow increasingly steep. The dispersal becomes anisotropic in steep gradients, with larger dispersal across the gradient than along the gradient. In contrast to one-dimensional settings, strong bias increases dispersal. We next include Brownian rotation in the model and find that, in limit of high chemotactic sensitivity, the chemotactic drift is 64 % of the swimming velocity, independent of the magnitude of the Brownian rotation. We finally derive characteristic timescales of the motion that can be used to assess whether the diffusion limit is justified in a given situation. The proposed technique for obtaining diffusion approximations is conceptually and computationally simple, and applicable also when statistics of the motion is obtained empirically or through Monte Carlo simulation of the motion.

General information

State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Living Resources, Centre for Ocean Life
Authors: Thygesen, U. H. (Intern)
Pages: 556-579
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information

Journal: Bulletin of Mathematical Biology
Volume: 78
Issue number: 3
ISSN (Print): 0092-8240
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.4 SJR 0.684 SNIP 0.833
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.768 SNIP 0.76 CiteScore 1.34
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.668 SNIP 0.728 CiteScore 1.32
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.787 SNIP 0.984 CiteScore 1.68
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.953 SNIP 1.195 CiteScore 2.06
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.95 SNIP 1.112 CiteScore 1.95
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.93 SNIP 1.113
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.872 SNIP 0.936
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.753 SNIP 1.169
Scopus rating (2007): SJR 0.877 SNIP 1.154
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.778 SNIP 1.088

Scopus rating (2005): SJR 0.583 SNIP 0.834
Scopus rating (2004): SJR 0.726 SNIP 1.014
Scopus rating (2003): SJR 0.73 SNIP 0.81
Scopus rating (2002): SJR 0.768 SNIP 0.759
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.807 SNIP 0.884
Scopus rating (2000): SJR 0.699 SNIP 1.033
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.695 SNIP 1.019
Original language: English
Agricultural and Biological Sciences (all), Biochemistry, Genetics and Molecular Biology (all), Environmental Science (all), Immunology, Mathematics (all), Computational Theory and Mathematics, Neuroscience (all), Pharmacology, Chemotaxis, Diffusion approximation, Movement models, Renewal process, Run–tumble strategy
DOIs:
10.1007/s11538-016-0155-3
Source: FindIt
Source-ID: 2303118340
Publication: Research - peer-review › Journal article – Annual report year: 2016