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Time-resolved force distribution analysis

Bogdan I Costescu, Frauke Gräter

Abstract— Background: Biomolecules or other complex macromolecules undergo conformational transitions upon exposure to an external perturbation such as ligand binding or mechanical force. To follow fluctuations in pairwise forces between atoms or residues during such conformational changes as observed in Molecular Dynamics (MD) simulations, we developed Time-Resolved Force Distribution Analysis (TRFDA).

Results: The implementation focuses on computational efficiency and low-memory usage and, along with the wide range of output options, makes possible time series analysis of pairwise forces variation in long MD simulations and for large molecular systems.

Conclusions: TRFDA can be used, among others, in tracking signal propagation at atomic level, for characterizing dynamical intermolecular interactions (e.g. protein-ligand during flexible docking), in development of force fields and for following stress distribution during conformational changes.

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Index Terms—Algorithms, Sequence alignment, Orthologous Genes, Software

1 BACKGROUND

Many biomolecular systems or other complex macromolecules can dynamically visit a broad range of conformational states. External perturbations such as a molecular interaction or a mechanical force can cause a molecule to dynamically transit between these conformational states. While the conformational space of biomolecules is typically analyzed by coordinate-based methods such as the detection of correlated motions, Force Distribution Analysis (FDA) has been recently developed as an alternative approach to analyze structure and structural transitions [1]. The advantages of analyzing internal forces instead of coordinates are two-fold. First, forces between atoms or residues represent internal coordinates, which consequently do not require any structural fitting. Secondly, forces are a more sensitive measure, as they are able

to reveal low-amplitude yet functionally important motions such as those in a stiff protein core [2]. Among others, internal forces obtained from FDA proved able to explain the mechanical robustness of immunoglobulin domains [3] and to reveal the pre-stress in ubiquitin [4].

FDA has been applied so far to averaged dynamical data from Molecular Dynamics (MD) simulations. However, the dynamics of the force distribution within proteins or other macromolecules, e.g. in equilibrium, under a constant load, a load varying in time, or upon binding of another molecule, can only be characterized by following the changes of the internal forces in time, which cannot be easily achieved with the previous implementation of FDA. We here introduce a Time-Resolved Force Distribution Analysis (TRFDA) method, which adds a temporal component to FDA to enable the analysis of pairwise forces associated with conformational changes.

2 IMPLEMENTATION

2.1 Overview

Time-Resolved Force Distribution Analysis (TRFDA) is based on the same concept of using pairwise forces as FDA,

* Bogdan I Costescu, Heidelberg Institute for Theoretical Studies, Schloss-Wolfsbrunnengasse 35, Heidelberg, 69118, Germany

* Frauke Gräter, Heidelberg Institute for Theoretical Studies, Schloss-Wolfsbrunnengasse 35, Heidelberg, 69118, Germany

CAS-MPG Partner Institute and Key Laboratory for Computational Biology, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences, 320 Yueyang Road, Shanghai, 200031, China, E-mail: frauke.graeter@itp.org

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Relating emotional intelligence to academic achievement among university students in Barbados

Grace A. Fyambó¹

University of the West Indies, Barbados

This study investigated the relationships between emotional intelligence and academic achievement among 151 undergraduate psychology students at The University of the West Indies (UWI), Barbados, making use of Baruch (2001)'s Emotional Intelligence Scale and an Academic Achievement Scale. Findings revealed significant positive correlations between academic achievement and six of the emotional intelligence components, and a negative correlation with negative expressivity. The emotional intelligence components also jointly contributed 48% of the variance in academic achievement. Amongst the students was the best predictor of academic achievement while positive expressivity, negative expressivity and empathic concern were other significant predictors. Emotional decision-making, motivation by and responsive distress did not make any significant relative contribution to academic achievement, indicating that academic achievement is only partially predicted by emotional intelligence. These results were discussed in the context of the influence of emotional intelligence on university students' academic achievement.

Keywords: academic achievement, emotional intelligence, university undergraduates

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Introduction

The term emotional intelligence was first described by Salovey and Mayer (1990) as a form of social intelligence that involves the ability to monitor one's own and others' feelings and emotions, to discriminate among them, and to use this information to guide one's thinking and action. It was made popular by Coleman (1995) who refers to it as the ability to sense, understand, value and effectively apply the power and acumen

¹Email: grace.fyamb@uwibb.uwi.edu

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AMPHIBIAN CHYTRID FUNGUS (*BATRACHOCHYTRUM DENDROBATIDIS*) IN COASTAL AND MONTANE CALIFORNIA, USA ANURANS

GARY M. FELLERS¹, REBECCA A. COLE², DAVID M. REINTZ^{3,4}, AND PATRICK M. KLEEMAN¹

¹U.S. Geological Survey, Western Ecological Research Center, Point Reyes National Seashore, Point Reyes, California 94956, USA, e-mail: gary.fellers@usgs.gov

²U.S. Geological Survey, National Wildlife Health Center, 6505 Schroeder Rd., Madison, Wisconsin 53711, USA

³University of Wisconsin - Bismarck, 2115 Observatory Drive Madison, Wisconsin 53706, USA

⁴Present Address: Pathobiological Sciences, University of Wisconsin at Madison, Madison, Wisconsin 53706, USA

Abstract—We found amphibian chytrid fungus (*Bd* = *Batrachochytrium dendrobatidis*) to be widespread within a coastal watershed at Point Reyes National Seashore, California and within two high elevation watersheds at Yosemite National Park, California. *Bd* was associated with all six species that we sampled (*Bufo boreas*, *R. canorus*, *Pseudacris regilla*, *Rana boylei*, *R. sierrae*, and *Lithobates catesbeianus*). For those species sampled at 10 or more sites within a watershed, the percentage of *Bd*-positive sites varied from a low of 26.7% for *P. regilla* at one Yosemite watershed to a high of 78.6% for *P. regilla* at the Olney watershed at Point Reyes. At Olney, the percent of *Bd*-positive water bodies declined each year of our study (2005–2007). Because *P. regilla* was the only species found in all watersheds, we used that species to evaluate habitat variables related to the sites where *P. regilla* was *Bd*-positive. At Olney, significant variables were year, length of shoreline (perimeter), percentage cover of rooted vegetation, and water depth. At the two Yosemite watersheds, water depth, water temperature, and silt/clad were the most important covariates, though the importance of these three factors differed between the two watersheds. The presence of *Bd* in species that are not declining suggests that some of the amphibians in our study were innately resistant to *Bd*, or had developed resistance after *Bd* became established.

Key Words—Amphibian chytrid, *Batrachochytrium dendrobatidis*, *Bufo*, California, *Pseudacris regilla*, *Rana*, Sierra Nevada

INTRODUCTION

In 1998, a new infectious disease, chytridiomycosis, was described by Berger et al. (1998). The disease is caused by the fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*), which was described by Longcore et al. (1999). *Bd* has now been implicated in the decline of amphibian populations in many areas around the world (Berger et al. 1998; Bosch et al. 2001; Hopkins and Channing 2003; Ken et al. 2003; Woodhams et al. 2008). However, it is unclear under what circumstances outbreaks of lethal chytridiomycosis occur. The oldest records of *Bd* come from *Anaxyrus japonicus* (Japanese Giant Salamander) collected in 1902 in Japan (Goka et al. 2009), and from *Xenopus laevis* (African Clawed Frog) collected in 1938 in southern Africa (Weldon et al. 2004).

The first report of *Bd* in California, USA was from *Lithobates catesbeianus* (American Bullfrog) collected in 1961 in Palo Alto (Padgett-Flohr and Hopkins 2009). In the Sierra Nevada of California, *Bd* has been reported from *Bufo canorus* (Yosemite Toad) collected in 1976 (Green and Kagaire Sherman 2001), and *Rana sierrae* (Sierra Nevada Yellow-legged Frog) collected in 1993 (Fellers et al. 2001a). *Bd* has now been documented in at least 14 species of amphibians in California, nearly all

the species that have been examined carefully. However, the prevalence of *Bd* in wild populations in California is largely unknown except for *R. sierrae* (formerly part of *R. maculosa*; Vredenburg et al. 2007) in the Sierra Nevada (Briggs et al. 2005; Vredenburg et al. 2010), and in all six species of local amphibians in a set of ponds in Santa Clara County (Padgett-Flohr and Hopkins 2010).

In many areas around the world, chytrid-related amphibian declines have been most dramatic at high elevations (montane tropics, Sierra Nevada, Rocky Mountains, Pyrenees Mountains), and an association between chytridiomycosis outbreaks, high altitude, and low temperatures has been proposed (Daszak et al. 2003). The highest elevation sites that support amphibian populations in the Sierra Nevada are typically at or above tree line where ponds and lakes are largely devoid of vegetation. The lack of vegetation and the related lack of microhabitat diversity might influence the presence of *Bd* or the likelihood that frogs would be exposed to the fungus, if important components for the survival of *Bd* were missing from these less complex environments. Also, the deeper portions of high elevation ponds and lakes likely favor *Bd* because they are typically quite cool. Because *Bd* does not grow or

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