Complex dynamics related to death cases of COVID-19 from Brazil

Leonardo Fernandes[1], Fernando de Araújo[1], and Maria Angélica Ramos Silva[2]

[1]Federal Rural University of Pernambuco
[2]Federal Institute of Education, Science and Technology of Paraiba

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Abstract

The SARS-CoV-2 pandemic has radically changed the sta tus quo of the global society. The fast spread of the new coronavirus is governed by nonlinear dynamics. The purpose of this paper is to investigate the complex dynamics inherent by the dissemination of COVID-19 into 27 Brazilian States. Because of this, we have investigated the time series of daily death caused by COVID-19. Our analysis taking into account the Bandt & Pompe method (BPM) to estimate the Information Theory quantifiers, the Permutation entropy (Hs), and the Fisher information measure (Fs). Based on the Information Theory quantifiers we build up the Shannon-Fisher causality plane, which made it possible to study the temporal evolution inherent of the phenomenology associated with the number of daily deaths by COVID-19, as well as their respective locations along the SFCP were mapped. Our results show that the number of death cases due to COVID-19 for Brazilian States present a dynamical behavior that tends to have their starting positions close to the lower-right region at the 2-D plane (Hs x Fs). Thus, the Brazilian States located in this region or its surroundings show high entropy and lowest disorder (highest efficiency). While the Brazilian States located in the middle region of the 2-D plane (Hs x Fs) or its surroundings are depicted by a less entropic and highest disorder (lowest efficiency). We also employed the Permutation entropy and the Fisher information measure to rank the conjuncture of the Brazilian States considering the number of daily death due to COVID-19 based on the complexity hierarchy. From a mathematical point of view, we found an inverse relationship between the Permutation entropy and Fisher information measure. Given this, we concluded that the higher value of the permutation entropy (Hs)the lower value related to the Fisher information measure (Fs).

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