Effect of Sampling rate and data source on rhythmicity computation

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Abstract

Rhythmicity computation is increasingly becoming a popular tool to measure the well-being of animals. By analyzing various data related to biological processes, behaviors, or activities, one can effectively assess the rhythmic patterns exhibited by animals. In our current study, we evaluate locomotor activity of horses from a group housing system using accelerometers to analyze their rhythmic patterns. We then apply a Fourier Transformation to the resulting time-series data. This allows us to calculate the Degree of Functional Coupling (DFC) [1] a proxy for rhythmicity of organisms. The DFC measures the degree to which organisms synchronize with their environment, particularly focusing on the harmonic components. This parameter measures the magnitude and intensity of the animals' circadian rhythm. Indeed, the majority of individuals exhibit circadian rhythms, indicating that their behaviors follow a 24-hour cycle. This rhythmic pattern is evidenced by the prominence of harmonic frequencies within the 24-hour cycle. Notably, these harmonics correspond to frequencies derived from dividing the 24-hour period by integers less than 24 (e.g., 24/1, 24/2, ...) [2]. Research suggests, that a good synchronicity with the environment reflects a good state of welfare. The DFC can take values ranging from zero to one, where a low value indicates a de-synchronization of the organism, whereas a value closer to one indicates more harmonic frequencies and a high synchronization of the individual with its environment [3]. The use of this parameter has been used to assess the welfare of extensively managed sheep [4] and housed dairy cows [5]. Moreover, it has been successfully used to evaluate how wild horses engage in activity and feeding [6].

However, data sources can vary giving very different information on animal rhythms. Feeding stations will measure the animals visits perhaps 3-15 times per day, whereas accelerometers can collect data at rates of up to 20Hz. Little research has addressed this issue; therefore, we investigated the effect of sampling rate and data source in a pilot study carried out on equine accelerometer data. Accelerometer devices were placed on the horse's front leg.

The x, y and z axis of equine locomotion were collected by a wireless MSR data logger at a frequency of 1 Hz. The data was collected within a different experiment, which was approved by ethical animal welfare commission of the Freiburg Cantonal authorities (2023-40-FR). The DFC was computed using the DigiRhythm R Package [2] with data settings: First we analyzed each axis of the same data set separately, as well as the squared sum of all three axis. After deciding, to proceed with the squared sum of all axis, we used this data to compare sampling rates. We used the resampling function in the DigiRhythm package to resample the data from 1 Hz to 1/60 Hz, 1/600 Hz and 1/900 Hz.

The results show that DFC values differed between both, data source and data frequency analyzed, see Figure 1. Therefore, we conclude that DFC computation is sensitive to data source and frequency, arguing that it's application without should be considered cautiously and validated in the specific setting.

We therefore encourage researchers to be aware of the impact sampling frequency and device used for data collection, and sensitize them to risk of comparing absolute DFC values between studies.

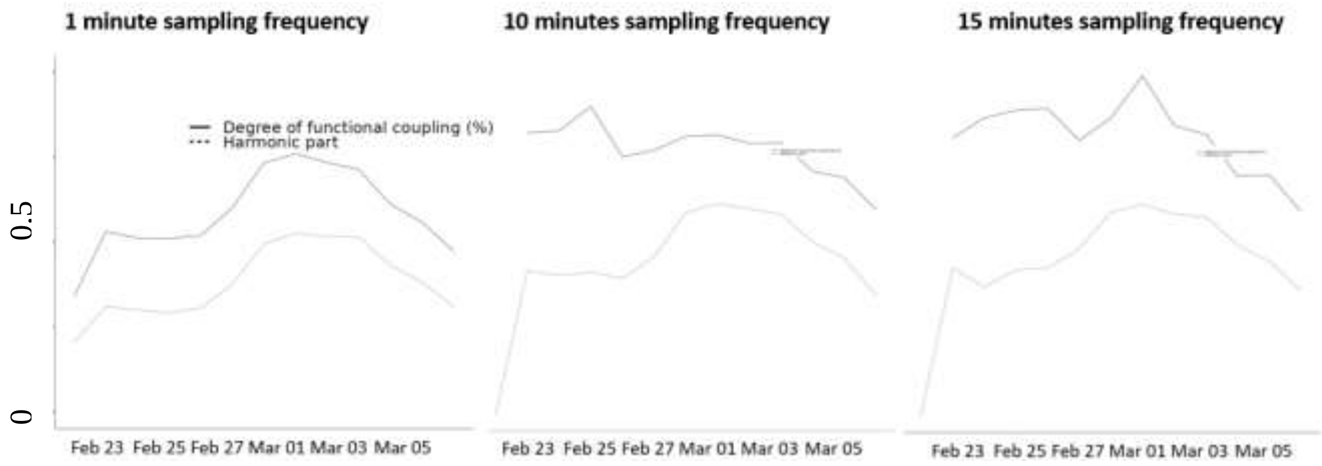

Figure 1. Degree of function coupling (DFC) (solid line) in function of time at 1 minute, 10 minutes and 15 minutes sampling frequencies respectively. Harmonic part is presented as a dashed line.

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