Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **389** Type: **Oral Competition (Graduate Student) / Compétition orale (Étudiant(e) du 2e ou 3e cycle)**

Inferring potentials in a feedback-trap using machine learning

Thursday 10 June 2021 15:45 (3 minutes)

Optical tweezers are an essential tool in a broad range of fields, from biophysics to soft-matter and statistical physics. Using a feedback-based trap that can produce complex, time-dependent potential landscapes, we can experimentally realize situations in thermodynamics, such as finite-time bit-erasure, that were previously only thought experiments. To obtain quantitative results, however, it is crucial to know the optical tweezer' s original potential accurately. We use Gaussian process (GP) regression, a machine learning technique, to infer potentials in a feedback-trap. This method requires fewer data points to reach the same accuracy than more commonly used methods. GPs can estimate the potential without making prior assumptions on its shape and predict the sparsely explored regions. It also estimates the noise level in the data and provides uncertainties in the inferred potential. We trap a silica bead in different forms of potential using a feedback tweezer and record its displacement using two detectors simultaneously. We vary the amount of measurement noise in one of the detectors and then compare how accurately GP can estimate the potential in the presence of higher measurement noise. We find that GP performs better than standard methods to infer complex-shaped potentials in noisier situations.

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Session Classification: R3-5 Contributed Talks VI (DCMMP) / Conférences soumises VI (DPMCM)

Track Classification: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)