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(G*) Diamond Nanothermometry Using a Machine Learning Approach

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Nanothermometry is a powerful tool that allows for controlling temperature at the nanoscale, and thus finds applications in research fields ranging from biomedicine to high-power microelectronics. Typical nanothermometry techniques employ secondary nanothermometers, where each individual nanosensor must be individually calibrated—ideally, both off- and in-situ. Here we utilize fluorescent nanodiamonds co-hosting germanium-vacancy and silicon-vacancy centers and a machine learning multi-feature linear regression (ML-MFR) algorithm to overcome this resource-expensive calibration requirement. By leveraging the temperature-dependent spectroscopy features of the diamond color centers (intensity, zero-phonon line wavelength, emission linewidth, etc.), we show that the MFR model yields more accurate temperature predictions than those produced, traditionally, by monitoring any one of these individual temperature-dependent observables. We observe nanoscale temperature readings with accuracy and resolution improved by factors of ˜1.3-10.1x and ˜1.2-8.3x, respectively. Importantly, the MFR algorithm does so without the need to calibrate every single nanothermometer prior to its use. The method is general, as it is suitable for any nanothermometry technique that uses nanosensors with at least two temperature-dependent observables, without requiring prior knowledge of the type of dependence. Furthermore, this approach is attractive for practical scenarios where calibration prior to employment is difficult or unfeasible, as the models can be pre-trained on similar nanosensors. This study demonstrates the practical benefits of a machine learning approach to nanothermometry which is applicable to a wide variety of research fields.

Keyword-1

Nanothermometry

Keyword-2

Machine Learning

Keyword-3

Primary authors: BRADAC, Carlo (Trent University); STONE, Dylan (Trent University); EKIMOV, Evgeny (Institute for High Pressure Physics & Lebedev Physics Institute); TRAN, Toan (School of Mathematical and Physical Sciences & School of Electrical and Data Engineering); CHEN, Yongliang (School of Mathematical and Physical Sciences)

Presenter: STONE, Dylan (Trent University)

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