[Invited Talk]

Near-field Nanophotonics for Intelligent Information Functions

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Abstract– This paper reviews recent theoretical and experimental investigations toward realizing intelligent information functionalities by utilizing unique physical processes occurring at a scale below the wavelength of light, which is called nanophotonics.

There is a great demand for novel computing devices and architectures that can overcome the limitations of conventional technologies based solely on electron transfer, including the need to reduce energy consumption and solve computationally demanding problems [1-3]. Security is becoming ubiquitously important to safeguard against threats [4,5]. A promising solution is near-field nanophotonics [6], which has been extensively studied with the aim of unveiling and exploiting light–matter interactions that occur at a scale below the wavelength of light, and recent progress made in experimental technologies—both in nanomaterial fabrication and in characterization—is driving further advancements in the field.

We demonstrate that the dynamics of optical energy transfer mediated by near-fields interactions can be exploited to solve solution searching [7] and decision making problems [8]. By introducing simple state-filling mechanisms for controlling the energy transfer among multiple quantum dots, we successfully solved a constraint satisfaction problem [7] and the multi-armed bandit problem [8]. The emergent intellectual abilities of these near-field nanophotonic systems are attributed to the probabilistic and nonlocal nature inherent in the optical-near-field–mediated energy transfer dynamics.

Also, we theoretically and experimentally demonstrate information security applications, such as information hiding and authentication, by using hierarchical properties of optical near-fields [9]. Shape-engineered nanostructures can play a key role for security functionalities thanks to their abilities of, for instance, asymmetric polarization conversion [10].

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